MATERIAL AND EQUIPMENT STANDARD

FOR

PROGRAMMABLE LOGIC CONTROLLERS (PLC)

ORIGINAL EDITION

MAR. 1996

This standard specification is reviewed and updated by the relevant technical committee on Jun. 2002. The approved modifications are included in the present issue of IPS.

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1. SCOPE

This Standard Specification covers the minimum requirements for Programmable Logic Controllers (PLC) to be applied in Iranian Petroleum Industries Projects.

Since the volume of interlocking encountered and the severity of application dictates different requirements on the PLC equipment, this Standard specification has been divided in three basic categories, according to specific application, namely:

- Emergency Shut-Down (ESD) application

- Safety interlock application

- Sequence lunirul, batch and continuos control application.

Each one of the above mentioned parts applies to the relevant application only and shall not be considered for the other applications.

It shall be noted that; in a given project, not all of the above mentioned applications may be encountered. Therefore selection of the specification shall be made carefully according to the specific application.

Note:

This standard specification is reviewed and updated by the relevant technical committee on Jun. 2002. The approved modifications by T.C. were sent to IPS users as amendment No. 1 by circular No. 163 on Jun. 2002. These modifications are included in the present issue of IPS.

2. REFERENCES

Throughout this Standard the following dated and undated standards/codes are referred to. These referenced documents shall, to the extent specified herein, form a part of this standard. For dated references, the edition cited applies. The applicability of changes in dated references that occur after the cited date shall be mutually agreed upon by the Company and the Vendor. For undated references, the latest edition of the referenced documents (including any supplements and amendments) applies.

ANSI   (AMERICAN NATIONAL STANDARD INSTITUTE)

ANSI/EIA 310C	"Racks, Panels, and Associated Equipments" (R 1983)
ANSI/HFS-100	"Human Factors Engineering of Visual Display Terminal Workstations" (1988)
Y 32.11	"Graphic Symbols for Process Flow Diagrams in the Petroleum and Chemical Industries" (R 1985)

BSI   (BRITISH STANDARD INSTITUTIONS)

BS-381C	"Specification for Colors for Identification, Coding and Special Purposes" (1987)
BS 5760	"Reliability of Constructed or Manufactured Products, Equipment and Components Parts"

EIA   (ELECTRONIC INDUSTRIES ASSOCIATION)

RS 232C	"Interface Between Data Terminal Equipment and Data Communication Equipment Employing Serial Binary Data Interchange" (1969)

RS 422	"Electrical Characteristics of Balanced Voltage Digital Interface Circuits"
RS 423	"Electrical Characteristics of Unbalanced Voltage Digital Interface Circuits"
RS 449	"Physical Characteristics of the Connectors for RS 422A Interface Circuits"
RS 485	"2-wire, half-duplex, differential, multi-drop (32 nodes), communications standard for distances up to 4000 FT"
RS 511	"MAP'S Manufacturing Message Specification # ISO-9506"

CENELEC (EUROPEAN STANDARD COMMITTEE FOR ELECTRICAL APPARATUS)

EN-5O.018	"Flame-Proof Enclosures 'd'"

IEC   (INTERNATIONAL ELECTROTECHNICAL COMMITTEE)

# 529	"Ingress Protection for Electrical Apparatus"

JIC   (JOINT INDUSTRIAL COUNCIL)

	"Symbols for Logic Diagram Representation"

NEMA (NATIONAL ELECTRICAL MANUFACTURER'S SSOCIATION)

ICS 2	"Industrial Control Devices, Controllers, and Assemblies"
ICS 3-304	"Programmable Controllers" (1988)
ICS 6	"Enclosures for Industrial Control and Systems" (1978)

MIL STD (MILITARY STANDARDS)

MIL-HDBK-217	"Reliability Stress and Failure Rate Data for Electronic Equipment"
MIL-STD-1629A	"Procedures for Performing a Failure Mode Effects and Criticality Analysis"

UL   (UNDERWRITER LABORATORY)

# 508	"Industrial Control Equipment" (1984)

IEEE   (INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS)

802.2	"Logical Link Control" (1990)
802.3	"Carrier Senseple Multiple Access (CSMA) with Collision Detection (CD) Access Method and Physical Layer Specification"
802.4	"Bus Oriented Token Passing Network"
C 62	"Guides and Standards for Surge Protection" (1990 Edition)

(HEALTH AND SAFETY EXECUTIVE, HMSO, LONDON)

"Programmable Electronic System in Safety Related Applications, Parts 1 & 2" (1987)

ISO   (INTERNATIONAL ORGANIZATION FOR STANDARDIZATION)

    # 7498   "Information Processing Systems-Open System Interconnection"

    # 8348   "Information Processing System-Data Communication Network Service Definition" (1987)

    # 8473   "Information Processing Systems-Data Communication Protocol for Dividing Connectionless Mode Network Service" (1988)

    # 9506   "MAP's Manufacturing Message Specification"

3. UNITS

This Standard is based on International System of Units (SI), except where otherwise specified

4. PLC SPECIFICATION FOR EMERGENCY SHUT-DOWN (ESD) SYSTEMS

4.1 General

4.1.1 System requirements

4.1.1.1 The system shall be "fault tolerant" by employing three processors and voting logic, reliable fail safe configuration, to eliminate emergency maintenance under panic conditions.

4.1.1.2 The system shall be totally independent and dissimilar in design, hardware and software from the main control system, thereby eliminating susceptibility for both systems to fail under similar conditions.

4.1.1.3 Redundant components shall be of different manufacturing production runs, to minimize possible latent manufacturing defects within the redundant components, preferably.

4.1.1.4 The processors shall be provided with both internal and external watch-dog timers, to check the program execution. The PLC shall also be provided with internal self-checking programs, to be executed regularly as part of the normal start up/running sequence.

4.1.1.5 The system shall be protected against nuisance trips; that is a trip caused by a factor which is not intended to trip the system, such as; short power outages.

4.1.1.6 All precautions shall be undertaken to keep the shutdown and process control systems independent of each other, to simplify operation and maintenance.

4.1.1.7 The shutdown system shall be provided with an integral annunciator with a retained, first-out sequence. Each event shall be annunciated even if the acknowledge push button is defeated intentionally. Where system is supplied in conjunction with DCS, pre-shut-down alarms may be transmitted to DCS via suitable gateway.

4.1.1.8 The proposed PLC shall be of distributed architecture enabling to network different PLC's, each of them serving as an area shut-down system.

4.1.1.9 The system shall be modular, multiple processor, industrial type Programmable Logic Controller mounted in standard 19" rack according to EIA 310C standard.

4.1.1.10 The PLC system shall provide adequate self-diagnostic capability for system hardware and software. The PLC Vendor shall provide the following minimum diagnostic programs:

    - Self-checking diagnostic on start-up

    - Cyclic self-checking diagnostic routine

    - User initiated diagnostic program

4.1.1.11 Critical I/O system components shall be provided with sufficient redundancy to ensure reliable operation under fault conditions.

4.1.1.12 Any single fault in PLC shall not prevent a shutdown on a genuine input demand nor initiate a nuisance shutdown.

4.1.1.13 The PLC system shall have a reliable redundant components for all inputs, logic, power supplies, outputs, and communication hardware.

4.1.1.14 Each critical PLC input and output module must be fully tested and fault diagnosed automatically by the PLC system. This must include turning the input and output module off and on routinely, with the necessary logic verifying successful operation of the module.

4.1.1.15 Each PLC processor must be fully tested and fault diagnosed. The failure of a processor must not interfere with the system operation. Each processor data base must be continuously updated.

4.1.1.16 The failure of a single component, card, module, communication link, power supply, equipment rack, etc. shall not result in an unsafe operating condition or the failure of the portion of the process connected to that input or any other input or the process connected to. The system shall continue it's operation and remain available after such a failure.

4.1.1.17 The PLC redundant inputs, outputs, and processors shall be located in different equipment racks with separate power supplies and communication hardware. On loss of communication to the output module, the outputs shall go to a "safe" state.

4.1.1.18 PLC's interconnecting highways shall be redundant, with both highways continuously tested and alarmed in case of failure. Highway switching devices shall be tested on a routine basis. The testing and diagnostics shall be performed by the PLC system automatically.

4.1.1.19 The system shall be provided with an alarm/report printer.

4.1.1.20 The Vendor shall provide a detailed failure mode and effect analysis (cause and effects analysis) to ensure compliance with this Standard.

4.1.1.21 The system components and subsystems shall be capable to operate in the environmental conditions as specified in project documentations.

4.1.1.22 The PLC system Cards shall be capable to be inserted or withdrawn while the system is operating with no need to disconnect the power to the system.

4.1.2 Reliability requirements

4.1.2.1 Since hardware reliability is an essential feature for a trip system to avoid spurious tripping and trip fail danger faults, only components with predictable reliability and known performance shall be used. For more details reference shall be made to article 7.0 herein.

4.2 Processor Unit

4.2.1 General requirements

4.2.1.1 The Central Processing Unit (CPU) shall continuously scan the application program stored in memory, along with the status of all inputs, and execute specified commands to the appropriate outputs.

4.2.1.2 Quick-Reference chart shall be permanently attached to the inside surface of the PLC's enclosure front door. The chart shall clarify the proper module or PCB placement and assist in the interpretation of the status indicators.

4.2.1.3 The processor shall be of modular design employing EIA 310C 19" rack installation principle.

4.2.1.4 The processor shall have the remote I/O system connection capability.

4.2.1.5 The processor shall be capable to be equipped with local/parallel I/O system for high speed processing applications.

4.2.1.6 The processor shall be capable to be organized as a multi-processor configuration system.

4.2.1.7 The I/O memory scan time shall be better than 1 m sec/KB for parallel I/O's.

4.2.1.8 The processor shall be equipped with the following interfacing modules, as required:

>   - PLC to PLC
>
>   - Data Highway
>
>   - MAP/OSI multivendor interfacing

4.2.1.9 A key-operated modeselect switch shall be provided to select the CPU operating mode. These shall include:

>   PROGRAM LOAD/DEBUG (outputs disabled to allow alteration of memory by an engineering workstation).
>
>   RUN (application program executing and all outputs enabled).
>
>   REMOTE (foselect program load and run remotely).

The selected operating mode shall be visually indicated on the PLC front panel and/or the engineering workstation.

4.2.1.10 The processor shall be capable to accept APC or programmer device and printer for program entry and documentation of the application program stored in the PLC memory (i.e., ladder diagram, I/O cross-reference and memory listing).

4.3 Memory Requirements

4.3.1 General

4.3.1.1 The internal memory shall be sized such that at least 50% spare memory is available after definition of the I/O tables and entry of the application program. Once the application program has been entered into the memory, it shall remain resident until deliberately changed. A power failure or power-off condition shall not-affect the content of memory.

A keylock memory-protect feature shall be incorporated to prevent accidental or unautorized alteration of the application program.

4.3.1.2 Safeguarding against incorrect memory alteration should be considered by employing permanent memories back-up, in which the information is stored as a physical property which cannot be lost, i.e., UVPROM (Ultra Violet Erasable Programmed Read Only Memory).

4.3.1.3 EAPROM's (Electrically Alterable Programmed Read Only Memories) shall be avoided on all tasks which is related to safety.

4.3.2 Random access memory (RAM)

4.3.2.1 Dynamic RAM shall be considered for processor internal memory as scratch pad memory.

4.3.3 Read only memory (ROM)

4.3.3.1 ROM with sufficient capacity shall be provided stored with the executive program (Operating System).

4.3.3.2 UVPROM shall be provided as program and data table storage medium.

4.4 I/O System

4.4.1 General

4.4.1.1 All field instruments and equipment, external to the PLC, shall be terminated in terminal strips located in marshalling rack cabinets (equipped with safety barriers, if requested in Purchase

Order). Cabling from the Vendor supplied marshalling rack cabinets to the PLC interface modules shall be via cord sets with plug and socket connections. Detail of the cord sets shall be supplies by the Vendor in his bid proposal.

4.4.1.2 The I/O interface shall be modular in design. Terminations shall be connected to the I/O chassis, not to the I/O modules.

4.4.1.3 It shall be possible to install the I/O module in any configuration within each I/O chassi, regardless of the signal voltage level. Anyhow the I/O cards shall be arranged according to the voltage levels, inside the I/O chassy and/or enclosure.

4.4.1.4 All I/O modules shall be plug-in type in EIA 310C 19" rack chassis and shall permit insertion or removal from the chassy without disturbing the external wiring.

4.4.1.5 There shall be no need to disconnect the power to faulty or other modules for removing and/or replacing the cards.

4.4.1.6 All modules shall be capable to operate with either 24 V dc power to the I/O, as specified in the project Purchase Order.

4.4.1.7 All modules shall be made of printed circuit board with a permanent front cover with identification labels and status indicators.

4.4.1.8 The status of all inputs and all outputs and the location of any fault within the I/O, shall be indicated on the visible front edge of the I/O modules.

4.4.1.9 The I/O interface shall be of bus-oriented system. Application of parallel I/O system shall be limited to the local I/O's housed in the same enclosure as the processor.

4.4.1.10 Each I/O rack shall be provided with an I/O interface with sufficient redundancy to suit triple redundant processor system and meet Availability requirements mentioned herein.

4.4.2 Discrete input module

4.4.2.1 All field sensor devices shall be connected to the PLC via the discrete input modules. The modules shall be available in 8, 16, and 32 points type for greater flexibility and cost saving.

4.4.2.2 Vendor shall submit his filtering method, complete with his input module circuit diagram with his bid proposal for Company's evaluation. Filtered input modules shall only be used for noisy input signals.

4.4.2.3 LED status indicators shall be provided on the front edge of module, as a troubleshooting aid, to indicate status of inputs.

4.4.2.4 The DC or AC inputs shall be of opto-coupler isolated type with fault indication on the front edge of module.

4.4.2.5 Adequate redundancy shall be provided for input modules to meet availabililty requirements.

4.4.2.6 All input modules shall withstand a dielectric test voltage of 2500 V dc or 1000 V ac rms plus twice the working voltage of the circuit for at least one minute, according to UL 508 standard.

4.4.3 Discrete outputs

4.4.3.1 All field output devices shall be activated by the PLC via the discrete output modules, such as; Motor Control Centers (MCC), pilot lights, alarm annunciators, solenoid valves, relays, and/or valves.

4.4.3.2 The output modules shall be fused for protection of system and shall be capable of withstanding an inrush current of ten times the rated output load for a short period of time.

4.4.3.3 All output modules shall be of isolated type and shall withstand a dielectric test voltage of 2500 V dc or 1000 V ac rms plus twice the working voltage of the circuit for at least one minute according to UL 508 standard.

4.4.3.4 The modules shall have self-diagnostic capability with LED displays on the front edge of module to signify the probable faults in the module.

4.4.3.5 Modules shall be available with 8, 16, and/or 32 points per card.

4.4.3.6 Sufficient redundancy shall be foreseen in the output modules to meet the safety application involved and availability requirements.

4.5 Power Supply Unit(s)

4.5.1 General

4.5.1.1 Power supplies shall be redundant and monitored type. Upon a drop in the supply voltage below it's minimum rated level, proper action shall be taken to bring the process into a safe condition.

4.5.1.2 The redundant power supply unit may be mounted in the same enclosure as the CPU, or may be a separate unit connected via a heavy-duty cable. Additional power supply units may be used to extend the I/O capacity. Power supply units shall be identical to minimize spare parts requirements.

4.5.1.3 Internal critical fusing on power supply modules and field inputs and outputs shall be duplicated to avoid a spurious plant trip due to fuse aging. Fuses shall be of the alarming type wired to annunciator to alarm on malfunction. These alarm counts shall be included in the active I/O count.

4.5.1.4 Incoming line voltage monitoring shall be provided. Should the line voltage drops below it's minimum rated level for more than one half cycle, the power supply unit shall signal the CPU to stop communication with the I/O interface module before the loss of logic-level power to the CPU occurs. Fail-safe design shall insure that, an invalid output command transmission does not occur during a power dip.

4.5.1.5 Automatic shutdown of the power supply unit shall occur whenever overvoltage, undervoltage, and/or overcurrent conditions are detected at the output side of the unit. Such a status shall be indicated on the ESD annunciator and on the front edge of reach power supply unit.

4.5.1.6 The power supply input circuit shall have independent overcurrent protection, as well as transient overvoltage protection.

4.5.1.7 The PLC design shall preclude incorrect commands to the field output devices when main system power is applied or restored, i.e., power to the logic circuitry shall be applied well before I/O circuits, and when all circuits have been reset.

4.5.1.8 Redundant processor power supplies shall not be loaded 100%, but rather around 70%.

4.6 Programming PC Device

4.6.1 Programming PC device shall be of standard IBM-compatible personal computers.

4.6.2 The program loader shall consist of 3 floppy disk, CD drives a board to interface to the PLC, min of 60 GB hard disk (as specified in specification sheets), svga ....

4.6.3 The loader terminal shall permit to address ladder logic by label in addition to numbered address.

4.6.4 The terminal shall provide full ladder logic documentation on floppy disk for back-up purpose. In the event that PLC memory is purposely cleared, memory may be reloaded from the back-up copy.

4.6.5 The terminal shall be capable to monitor the status on ladder logic as it is executed (real-time). Also, a search function shall be provided to locate contacts quickly, using either line number or contact type.

4.7 Software Requirements

4.7.1 General

4.7.1.1 ESD software shall be of high quality to ensure reliable operation throughout its life.

4.7.1.2 The programming device shall be equipped with a compiler to translate user's programs into the machine language software to be loaded into the processor.

4.7.1.3 The programming device shall be equipped with necessary softwares to accept user programs in different languages, i.e., ladder diagram, Control System Flowchart (CSF) statement list, ETC.

4.7.1.4 The programming language shall be of structured type, in a manner to enable software rationalization, for easier manageability, transparency, and cost efficiency.

4.7.1.5 The programming device shall be equipped with suitable software, to allow monitoring of the status of the PLC as specified in 4.6.5.

5. PLC SPECIFICATION FOR SAFETY INTERLOCK APPLICATIONS

5.1 General

This application includes shutdown or startup of a single equipment to prevent it from working under extreme conditions which may damage the equipment.

In plants employing DCS, this function usually will be incorporated in DCS. Anyhow, in plants with Single Loop Digital Controller (SLDC), conventional electronic controllers, or pneumatic controller technology, such a function usually is implemented via relay logic. In the latter cases, PLC is specified herein as a substitute of the conventional relay logic technology.

5.1.1 General hardware requirements

5.1.1.1 The processor, I/O System, and power supplies shall be of dual hot stand-by type. The dual stand-by processors shall have a common data base, staying fully informed of each other's status at all times.

5.1.1.2 Switching time of faulty controller to the back-up shall be insignificant in comparison to the process changing time.

5.1.1.3 The system shall be of; modular, multiple processor, industrial, controller type. The PLC hardware shall be mounted in 19" standard rack according to ANSI/EIA 310C.

5.1.1.4 The PLC system shall be provided with self-checking diagnostic on initialization and on each cycle. The errors revealed by diagnostic program shall be classified as "fatal" and "non-fatal" to be stored in a designated table. Fatal errors shall energize a failure notification and necessary protection, i.e., taking in action of the redundant unit.

5.2 Processor Unit

5.2.1 General requirements

5.2.1.1 The processor shall be capable to accept; remote, local, and intelligent I/O system, together or independently.

5.2.1.2 The processor shall preferably employ industrial backplane data bus for connecting different modules of the PLC.

5.2.1.3 The processor's CPU shall continuously scan the user's control program, stored in the memory, along with status of all inputs and execute specified commands to the appropriate outputs.

5.2.1.4 The processor's CPU shall be provided with a "Watchdog" timer to measure the time that CPU consumes to execute the user's program. If the consumed time exceeds a predetermined value, the watchdog timer shall cause the processor to indicate a fault condition and shuts down the processor in a safe manner with switch-over to stand-by processor.

5.2.1.5 The processor shall have preferably, the following types of memory:

   - Executive Memory (ROM type)

   - Internal RAM (Processor's Scratch Pad Memory)

   - User's Program Memory of Electrically Alterable Programmed Read Only Memory (EAPROM) type.

   - I/O Image Memory.

5.2.1.6 The processor system shall be of a genuine distributed architecture design allowing distributed multiprocessor application. This feature is specially required to distribute functionally and geographically the PLC system for different units of the plant. This feature is an advantage besides the intelligent I/O system.

5.3 Memory Unit

5.3.1 Random access memory (RAM)

5.3.1.1 Dynamic RAM shall be provided for each dual redundant processor for storage of data tables, application program and processor scratch pad memory. Minimum capacity of RAM shall be sized according to the application involved plus 50% spare capacity.

5.3.2 Read only memory (ROM and PROM)

5.3.2.1 ROM with sufficient capacity shall be provided for storing the executive program (Operating System).

5.3.2.2 Electrically Alterable Programmable Read Only Memory (EAPROM) shall be provided in conjunction with the dedicated application program RAM, as a backup media for storage of programs and data tables.

5.3.2.3 The dedicated RAM and corresponding EAPROM capacity shall be sized according to the application involved plus 50% spare capacity.

5.4 I/O System

5.4.1 General requirements

5.4.1.1 The I/O system shall be modular in design and shall comprise of one or more heavy duty chassis. Terminations of the I/O shall be to the I/O chassy, not to the I/O modules.

5.4.1.2 The I/O interface shall be of bus-oriented system preferably. Serial I/O system shall be employed for remote I/O's. Application of parallel I/O shall be limited to local I/O's housed in the same enclosure as the processor.

5.4.1.3 The I/O chassis shall be rack-mounted in an EIA 310C standard 19" rack.

5.4.1.4 Local I/O's shall be connected to the processor by backplane data bus. Remote I/O's shall be connected to the processor by means of serial data highway.

5.4.1.5 The serial I/O interface shall provide a serial outgoing bus which is emanated from the processor and connected to the processor parallel backplane bus through a serial-to parallel converter. The serial interface shall be resident in the processor unit chassy.

5.4.1.6 Each parallel I/O rack shall be provided with a parallel interface module to communicate with

processor parallel I/O interface or other parallel I/O interface modules. An LED shall be provided on the front panel of the module to indicate proper communication from the preceding module. The interface module shall be provided in full redundant hot standby configuration.

5.4.1.7 Each serial I/O rack shall be provided with a serial I/O interface module for connecting the remote I/O modules to the serial link. The serial I/O interface module shall be provided in full redundant hot stand-by configuration.

5.4.1.8 I/O modules shall be capable to operate with 24 V dc ac power to the I/O field according to the specific project requirements, as indicated in data sheets.

5.4.1.9 The modules shall be replaceable while the system is hot. An offset backplane connector in the Printed Circuit Board (PCB) shall prevent installation of a module in wrong direction.

5.4.1.10 All modules shall be made of Printed Circuit Board with a permanent front cover with identification labels and status LED indicators.

5.4.1.11 All I/O modules shall be capable to operate in the environmental conditions as stated in the project data sheets.

5.4.1.12 Modules that need to be calibrated, e.g. analog input modules, shall have defect and test facilities that allow in-situ calibration by a single maintenance personnel.

5.4.1.13 Each output module shall control a separately fused supply to each associated actuator. The output fuses shall be individually accessible.

5.4.2 Discrete input modules

5.4.2.1 All field sensor devices shall be connected to the PLC via the discrete input modules. The modules shall be limited in variety for ease of maintenance, spare parts stock, and economical justification.

5.4.2.2 LED status indicators shall be provided on the front edge of module, as a troubleshooting aid, to indicate status of inputs and fuse blow-out fault condition.

5.4.2.3 The DC or AC inputs shall be of opto-coupler isolated type with fault indication on the front edge of module.

5.4.2.4 The module shall withstand a dielectric test voltage of 2500 V dc or 1000 V ac rms plus twice the working voltage of the input circuit for at least one minute according to UL 508 standard.

5.4.3 Discrete outputs

5.4.3.1 All field output devices, activated by the PLC, shall be via the discrete output modules.

5.4.3.2 The output modules shall be fused type for the output circuit, and shall be capable to withstand an inrush current of ten times the rated output load for a short period of time. The modules shall withstand a dielectric test voltage of 2500 V dc or 1000 V ac rms plus twice the working voltage of the circuit for at least one minute according to UL 508 standard.

5.4.3.3 The modules shall have self-diagnostic capability.

5.4.3.4 Sufficient redundancy shall be foreseen in the output modules to meet the smooth and reliable operation of the PLC system.

5.4.3.5 An LED status indicator shall be provided on the front edge of module, to indicate status of the output and fuse blowout fault, as a troubleshooting aid.

5.4.4 Communication modules

5.4.4.1 Network communication modules shall be provided for both Master/Slave and Peer-to-Peer networking of the PLC's in a multi processors PLC system.

5.4.4.2 The Peer-to-Peer network communication shall have an access determination protocol based on either IEEE 802.4 token bus or Carrier Sense Multiple Access with Collision Detection

(CSMA/CD) protocol according to IEEE 802.3 standard.

5.5 Power Supply Unit(s)

5.5.1 General

5.5.1.1 Power supplies shall be redundant and monitored type. Upon a drop in the supply voltage below it's minimum rated level, proper action shall be taken to bring the process into a safe condition by the PLC system.

5.5.1.2 The redundant system's power supply unit may be mounted in the same enclosure as the CPU, or may be a separate unit connected via a heavy-duty cable. Auxiliary power supply units shall be used to extend the I/O capacity. Both types of power supply units shall be identical, to minimize spare parts requirements.

5.5.1.3 Internal critical fusing on power supply modules and field inputs and outputs shall be duplicated to avoid a spurious plant trip due to fuse aging. Fuses shall be of the alarming type wired to annunciator, to alarm on malfunction. These alarm counts shall be included in the active I/O count.

5.5.1.4 Incoming line voltage monitoring shall be provided. Should the line voltage drops below it's minimum rated level for more than one-half cycle, the power supply unit shall signal the CPU to stop communication with the I/O interface modules, before the loss of logic-level power to the CPU occurs. Fail-safe design shall insure an invalid output command transmission does not occur during a power dip.

5.5.1.5 Automatic shutdown of the power supply unit shall occur whenever overvoltage, undervoltage, and/or overcurrent conditions are detected at the output side of the unit. Such an status shall be indicated on the front edge of each power supply unit.

5.5.1.6 The power supply input circuit shall have independent over current protection, as well as transient over-voltage protection.

5.5.1.7 The PLC design shall preclude incorrect commands to the field output devices when main system power is applied or restored, i.e., power to the logic circuitry shall be applied well before I/O circuits and when all circuits have been reset.

5.5.1.8 Redundant processor power supplies shall not be loaded 100%, but rather around 70%.

5.5.1.9 The Cards of the logic power supplies shall be so arranged as to permit any one of them to be removed for maintenance while the system stays on-line and under power.

5.6 Programming PC Device

5.6.1 Programming PC device shall be of standard IBM-compatible personal computers.

5.6.2 The program loader shall consist of 3 floppy disk, CD drives a board to interface to the PLC, min of 60 GB hard disk (as specified in specification sheets), svga ....

 5.6.3 The program loader programming device shall permit to address ladder logic by label in addition to numbered address.

5.6.4 The terminal shall provide full ladder logic documentation on floppy disk for backup purpose. In the event that PLC memory is purposely cleared, memory may be reloaded from the backup copy.

5.6.5 The terminal shall be capable to monitor the status of ladder logic as it is executed (real time). Also, a search function shall be provided to locate contacts quickly, using either line number or contact type.

5.6.6 The terminal shall be capable to force the output contacts to required position by the operator command.

5.7 Software Requirements

5.7.1 General

5.7.1.1 The software shall be of high quality to ensure reliable operation throughout its life.

5.7.1.2 The programming device shall be equipped with a compiler to translate user's programs into the machine language to be loaded into the processor.

5.7.1.3 The programming device shall be equipped with necessary soft wares to accept user programs in different languages, i.e., ladder diagrams, Control System Flowchart (CSF) statement list, ETC.

5.7.1.4 The programming language shall be of structured type, in a manner to enable software rationalization, for easier manageability, transparency, and cost efficiency.

5.7.1.5 Software facilities shall be provided to test the logic of the program at regular intervals, in order to check the performance of the system.

6. PLC SPECIFICATION FOR SEQUENCE AND BATCH CONTROL APPLICATIONS

6.1 General

6.1.1 Batch process control

6.1.1.1 The batch control shall be performed by a; packaged, preconfigured, PLC based control system.

6.1.1.2 The package shall be capable to control, from simple, single product/single-stream processes to complex multiproduct/ multi-stream processes.

6.1.1.3 The system shall comprise of Programmable Logic Controller (PLC) for process control and an industrial micro-computer for operator interface, recipe management, and plant control.

6.1.1.4 The batch control package shall have the following features:

- Recipe control to be developed and altered off-line and loaded into the batch control package.

- A recipe formula which can be altered on-line to accommodate unexpected changes.

6.1.1.5 The PLC shall have a high-level instruction set in addition to Sequential Function Chart (SFC) programming to allow segmenting the control scheme and programming it into the PLC memory.

6.1.1.6 The PLC proposed for batch control shall be of distributed architecture type in a manner that several PLC's may be networked together with pertinent workstation and programming terminals.

6.1.2 Continuous and discrete control strategies

6.1.2.1 The PLC system proposed for batch control system shall contain control strategies for both continuous loops and discrete devices, to perform the continuous control of the required batch operations.

6.1.2.2 The continuous control loop strategies shall range from simple regulatory PID control to advanced userdefined algorithm controls.

6.1.2.3 The continuous and discrete control strategies shall be capable to be configured by means of the operator interface terminals.

6.1.2.4 The number of controller loops available in the PLC system shall be equal to the numbers defined in the project data sheets plus 50% more control loops for future expansion and trimming of the control system.

6.1.3 Redundancy requirements

6.1.3.1 The processor shall be provided on One-for-One hot stand-by basis.

6.1.3.2 Both processors of the PLC shall share a common data base, staying fully informed of each other's status at all times. One PLC's processor shall act as a lead, with the other ready as a backup.

6.1.3.3 When a fault occurs, the backup controller shall resume the control, smoothly and automatically.

6.1.3.4 Parallel and serial I/O, or a combination of both configurations shall be incorporated into the redundant system as may be required in each specific project.

6.1.3.5 Switching time between controllers shall be insignificant considering the nature of the process encountered.

6.1.4 System general requirements

6.1.4.1 The system shall be modular, multiple processor, industrial controllers in standard 19" rack according to ANSI/EIA 310C standard.

6.1.4.2 The operator consoles shall be designed and constructed according to ANSI/HFS 100 considering the human engineering factors.

6.1.4.3 The PLC vendor shall provide the following diagnostic programs on his proposed system:

- self-checking diagnostic on initialization (start-up)

- user-initiated diagnostics

6.1.4.4 The errors revealed by above mentioned diagnostics shall be classified as "fatal" or "non-fatal" and stored in a specially designated table. Fatal errors such as; memory failure or low power supply, shall cause a "fatal relay" action to energize a failure notification and failure protection scheme, i.e., taking in action the redundant unit.

6.1.4.5 The failure designated table shall be capable to be examined, by programming tools provided in the PLC, for specific failure area and shall be capable to be diagnosed accordingly.

6.1.4.6 The PLC system shall be capable for use within a multivendor environment by employing, MAP/OSI interface.

6.1.4.7 The system shall be capable to operate in the project environmental conditions, as specified in project data sheets.

6.2 Processor Unit

6.2.1 General

6.2.1.1 The processor shall have built-in remote I/O capability .

6.2.1.2 The processor shall be equipped with advanced instructions set including file handling, sequencers, diagnostic, shift register, and program control instructions.

6.2.1.3 The processor shall be capable to be equipped with local parallel I/O system for high-speed processing applications.

6.2.1.4 The processor shall have suitable programmable input interrupts and global status flags.

6.2.1.5 The processor shall be capable to be organized as a multiprocessor system to perform the following tasks,minimally:

- Run a single program where a complex task requires; fast, parallel processing, to optimize the performance.

- Run individual programs while communicating with each other for close-coupled multi-process coordination.

6.2.1.6 Each processor in a multi-process configuration shall support a main application program while performing background tasks for non-time-critical functions.

6.2.1.7 The I/O memory scan time shall be better than 1 mSec/KB for local (parallel interface) I/O unit. The scan time for remote I/O (serial interface) shall be better than 4 mSec per rack of remote I/O.

6.2.1.8 The processor unit shall be equipped with the following interfacing modules:

- Host computer

- PLC-to-PLC

- Data highway

- MAP/OSI interfacing to DCS

6.2.1.9 The CPU shall have multiple contexts for storing more than one program in memory.

6.2.1.10 The processor unit shall be equipped with both parallel and serial I/O interface units to be used for I/O system.

6.2.2 Central processing unit (CPU)

6.2.2.1 Each processor module shall be equipped with 32-bit microprocessor and suitable built-in Random Access Memory (RAM). The built-in memory size shall be minimally 40 KWord.

6.2.2.2 The CPU unit shall have RS-232/RS-423, RS-449/RS-422, RS-485 connection port, in addition to the data highways for remote I/O scanner connection.

6.2.2.3 The CPU shall have parallel I/O port in addition to above mentioned ports for connecting local I/O units to the processor.

6.2.2.4 The CPU of the PLC shall preferably be an 80486-based multiprocessing computer with one processor card to emulate the PLC function.

6.2.2.5 The CPU module shall be capable to support Operating Systems.

6.2.2.6 The CPU shall preferably employ industrial backplane for connecting different modules of the PLC. The backplane shall use Extended 32-bit Industrial Standard Access (EISA) bus system preferably.

6.2.2.7 The CPU shall continuously scan the application program stored in memory, along with the status of all inputs, and execute specified commands to the appropriate outputs.

6.2.2.8 The CPU operating mode shall be visually indicated on the CPU module front panel. The fault conditions of the CPU shall also be indicated.

6.2.2.9 The CPU shall be capable to be connected to a computer device for program entry and a printer and other aunilary device (as specified)

6.2.2.10 The CPU shall be provided with a "Watchdog" timer to measure the time that CPU consumes to execute the user's program. If this time exceeds a predetermined value, the Watchdog timer shall cause the processor to indicate a fault condition and shuts-down the processor in a safe manner.

6.2.2.11 The CPU shall be equipped with four distinct types of memory, preferably. These memories are:

- Executive Memory (Read Only Memory type)

- Internal RAM (Scratch Pad Memory, as indicated in 6.2.2.1)

- User Memory (EAPROM)

- I/O Image Memory (CMOS-RAM)

6.3 Memory Units

6.3.1 Random access memory (RAM))

Dynamic RAM shall be provided with suitable battery back-up; to retain program integrity, for storage of application programs, data tables, and scratch pad memory. Minimum capacity of RAM memory shall be considered to be 8 K Words.

6.3.2 Read only memory (ROM)

6.3.2.1 ROM with sufficient capacity shall be provided for storing the executive program (Operating System).

6.3.2.2 Electrically Alterable Programmable ROM (EAPROM) shall be provided in conjunction with a dedicated RAM. The logic application program shall be executed from a current copy in the PLC RAM. A second copy of logic application program shall be held in EAPROM to enable loading back this copy into the RAM on command or automatically.

This procedure is necessary to provide protection against program loss by power failure. The dedicated RAM and corresponding EAPROM capacity shall be considered 16 K Words minimally.

6.4 I/O System

6.4.1 General requirements

6.4.1.1 All field instruments and equipment external to the PLC shall terminate in terminal strips located in marshalling enclosures specified in article 8 herein.

6.4.1.2 Cabling from the PLC vendor supplied marshalling enclosures to the PLC interface module shall be via cord sets with plug and socket connections. Details of the cord sets shall be supplied by the Vendor for Company's approval.

6.4.1.3 The I/O system shall be modular in design and comprise of one or more heavy duty chassis. Terminations shall be to the I/O chasssis, not the I/O modules. The I/O chassis shall be rack-mounted, of EIA-310C 19" rack type, and shall be connected to the processor by backplane data bus.

6.4.1.4 The I/O interface shall be of bus-oriented system preferably. Serial I/O system shall be employed for remote I/O. Application of parallel I/O system shall be limited to local I/O's housed inside the same enclosure as the processor module.

6.4.1.5 The serial I/O interface shall provide a serial outgoing bus which is emanated from the processor and connected to the processor parallel backplane bus through a serial-to-parallel converter resident in the processor unit.

6.4.1.6 Each parallel I/O rack shall be provided with a parallel interface module to communicate with processor I/O interface or other parallel I/O interface modules. The I/O interface module shall have two D type connectors; the male connector shall be the IN port and the female connector shall be the OUT port. An LED shall be provided on the front panel of the module to indicate proper communication from a preceding I/O interface module.

6.4.1.7 Each serial I/O rack shall be provided with serial I/O interface module for connecting the remote I/O modules to the serial link. The serial I/O interface module shall be provided in full redundant hot stand-by configuration.

6.4.1.8 All types of I/O modules shall be provided with either 24 V dc or 115 V ac power to the I/O, as specified in the project.

6.4.1.9 All modules shall be made of Printed Circuit Board (PCB) with a permanent front cover with identification labels and status indicators. The PCB shall be simply inserted into the desired slot of the EIA 19" rack unit. An offset backplane connector in the PCB shall be provided to prevent installation of a module upside-down.

6.4.1.10 There shall be no need to disconnect the power to the faulty or other modules for removing and/or replacing the modules.

6.4.1.11 All I/O modules shall be capable to operate in the specified project environmental conditions.

6.4.2 Discrete input module

6.4.2.1 This modules shall be provided to sense the status of limit switches, push-buttons, and other discrete sensors.

6.4.2.2 Since, noise suppression is of great importance in preventing false indication of inputs (e.g., turning on and off because of noise), the Vendor shall submit his filtering methods complete with input module circuit diagrams with his bid proposal to be examined and evaluated by the Company. Filtered input modules shall be employed only for noisy signals; since, the more noise immune an input is, the slower it will be because of all the filtering required to reject noise signals.

6.4.2.3 As a troubleshooting aid, LED status indicators shall be provided on the front cover of the module to show inputs and fuse blown-out status.

6.4.2.4 Modules shall be available with 8, 16, and/or 32 points for greater flexibility of selection and cost savings.

6.4.2.5 There shall be no need to disconnect the pertinent wirings in order to replace modules.

6.4.2.6 The DC or AC inputs shall be of isolated type with optical isolation and LED indication of the opto-coupler status on the front cover of the module.

6.4.3 Discrete output modules

6.4.3.1 This module shall be provided to interface to ON/OFF output devices, such as; motor starters, pilot lights, solenoid valves, relays, and valves.

6.4.3.2 Discrete output modules shall be capable of withstanding an inrush current of ten times the rated load for a short period of time without failure, since output loads are usually highly inductive and exhibit a large inrush current. The output module shall be fused for system protection.

6.4.3.3 All output modules shall be of isolated type and shall with-stand a dielectric test voltage of 2500 V dc or 1000 V ac rms plus twice the working voltage of the circuit (minimum) for at least one minute according to UL 508 standard.

6.4.3.4 The discrete output modules shall provide self-diagnostic assurance. Each module coverplate shall have display LED's to signify the faults probable in the circuit, as a troubleshooting aid, in a manner to reduce maintenance time.

6.4.3.5 Modules shall be available with 8, 16, and/or 32 points for greater flexibility and cost savings.

6.4.3.6 There shall be no need to disconnect the pertinent wirings, in order to replace faulty modules.

6.4.4 Analog I/O

6.4.4.1 This module shall be intelligent, microprocessor-based and shall be provided to sense and/or drive analog signals. Analog inputs may come from devices, such as; thermocouples, strain gages, pressure sensors or any other process variable that provides signal voltage or current. Analog outputs shall be of standard industrial signals and may be used to drive devices, such as; voltmeters, x-y recorders, servo motor drives, control valves, and so on.

6.4.4.2 The analog I/O module circuit shall consist of either Digital-to-Analog (D/A) converters for outputs or Analog-to-Digital (A/D) converters for inputs, to directly interface analog signals to the programmable controller.

6.4.4.3 The analog input module shall be capable to measure analog signals connected to its input

and converts this signal to high resolution value (minimally 12- binary value).

6.4.4.4 The analog input module shall be selectable (by the range jumpers or thumbwheel switch) for unipolar or bipolar voltage inputs (0 to 5 V, 1 to 5 V, 0 to 10 V, -5 to +5 V, -10 to +10 V). The current mode for 0 to 20 mA, 4 to 20 mA, or 0 to 50 mA input devices may be employed by installing a 250 ohm resistor in parallel with the input on the marshalling rack.

6.4.4.5 The analog input module shall be equipped with a front accessible span and offset potentiometer for calibration purpose.

6.4.4.6 The I/O modules shall provide isolated inputs and outputs.

6.4.4.7 The analog output ranges shall be user selectable among the following values;

1-5 V dc, 0-10 V dc, 10 V dc, 4-20 mA dc, 0-50 mA dc.

6.4.4.8 The I/O module shall accept and/or deliver eight differential inputs or outputs per module, preferably.

6.4.4.9 The module shall be equipped with LED diagnostic lights on the front plate of the PCB. If A/D or D/A conversion do not occur in a predefined time a fault condition shall be indicated by the LED indicators.

6.4.4.10 Vendor shall quote the following information with his bid proposal:

      1) conversion time or loop update time

      2) accuracy

      3) drift

6.4.5 PID loop module

6.4.5.1 The PID, I/O module shall be intelligent, microprocessor based and shall perform closed loop PID control. The module shall be capable to control one or two PID loops independently or linked together by cascading (cascade the output of loop 1 into the setpoint of loop 2) or decoupling.

6.4.5.2 The PID loop I/O module shall meet the requirements setforth in the following paragraphs;

      6.4.4.2, 6.4.4.3, 6.4.4.4, 6.4.4.6, 6.4.4.7, 6.4.4.10.

6.4.5.3 The PID module shall be capable to be used with all variety of I/O devices that operate in the 4 to 20 mA or 1 to 5 V dc range.

6.4.5.4 The following control features shall minimally be foreseen in the PID loop module;

      - monitoring the process variable, comparing it with the desired setpoint, and calculating the required analog output based on its internal programmable control algorithm,

      - select direct or reverse acting control,

      - set an alarm on the deviation,

      - perform error dead band (zero crossing),

      - downloading a setpoint from the PLC processor,

      - perform lead/lag filtering on the feedforward term.

6.4.5.5 The module shall provide the following input conditioning;

      - read the process variable (PV), applying a user programmable normalization and digital filtering to the PV,

      and detecting the loss of the PV.

6.4.5.6 The module shall provide the following output conditioning;

      - limit and/or set an alarm on the PID algorithm output,

      - interface directly with a manual control station with bumpless automatic to manual transfer,

- hold the PID algorithm output and/or feedforward output for independent loop tuning.

6.4.5.7 The module shall be capable to accept two discrete inputs for MAN/AUTO status of each controller resident in the module.

6.4.5.8 The PID loop module shall perform the following interfacing with PLC processor and/or the Operator Station;

- Manual fault status request (fault detected in the module),

- Manual/Auto status command from Operator Station,

- Analog input (process variable) transmission to the Operator Station,

- Analog output (controlled variable) transmission to the Operator Station,

- All necessary interfacing to the PLC processor to perform the integrated control operation.

6.4.5.9 PID loop module shall be provided for the batch control loops specified in project data sheets.

6.4.6 Remote I/O adapter module

6.4.6.1 Remote I/O adapter module shall be provided to serve as an interface between I/O modules in remote I/O racks and the PLC serial I/O interface.

6.4.6.2 The adapter module shall be of multi-drop type. The modules shall be of dual redundant, hot stand-by configuration.

6.4.6.3 The module shall be capable to support minimally 16 I/O racks and shall have electrical (physical) connection made by two RS-232C (25 pin) D type connectors. The vendor shall provide all cablings (ready to install type) and terminations according to the project specific requirements.

6.4.6.4 The adapter module front plate shall contain status LED's to indicate channel and module operating status.

6.4.6.5 The module shall have DIP switch on the printed circuit board to set the starting address for each channel and perform other addressing selections of the module channels.

6.4.6.6 The module shall have internal self-test routines to be activated at; start-up and/or initialization by the processor. A pass LED on the front plate shall indicate a successful module self-test. Channels connected to this module shall have LED's to indicate "active" link or link "fault".

6.4.6.7 One remote I/O adapter module shall be provided for each remote I/O rack, minimally.

6.4.7 Parallel (local) I/O adapter module

6.4.7.1 The local I/O adapter module shall control the local I/O rack modules and communicate with the processor parallel I/O interface or other local I/O modules, to be used for increasing the quantity of local I/O modules.

6.4.7.2 The module shall have two D type connectors, one male connector as IN port and one female connector as OUT port to be connected to other local I/O modules.

6.4.7.3 The adapter module front plate shall contain status LED's to indicate "active" link or link "fault".

6.4.7.4 The module shall be capable to connect up to 16 independent I/O racks together, minimally.

6.4.7.5 The module shall allow disconnection of a rack from the bus without shutting the system down.

6.4.7.6 The module shall have DIP switch on the Printed Circuit Board to set the configuration, output handling functions, and module configuration.

6.4.7.7 One resident I/O adapter module shall be provided for each local I/O rack, minimally.

6.4.7.8 Sufficient redundancy shall be considered in providing local I/O adapter modules by the Vendor, to meet the availability requirements.

6.4.8 ASCII interface module

6.4.8.1 ASCII interface module shall be provided in the PLC system as an interface between the programmable logic controller and any peripheral device that generates and/or receives ASCII characters, such as; terminals and printers.

6.4.8.2 The interface shall provide RS-232C transmission with D-type 25 pin connectors.

6.4.9 MAP/OSI compatible gateway

6.4.9.1 The PLC system shall provide MAP/OSI gateway to be used for connecting the system to other vendor's PLC's and/or to DCS.

6.4.9.2 The gateway communication to other systems shall be implemented by means of two RS-232C, 25-pin, D-type connectors.

6.4.9.3 Diagnostic routine alarms of the PLC shall be transmitted to DCS, by this gateway.

6.4.9.4 The gateway shall accept continuous READ and WRITE commands from the DCS and shall provide mapping of the PLC registers into the DCS.

6.4.9.5 The MAP gateway shall be capable to work as a node in multi-drop network.

6.4.10 Communication modules

6.4.10.1 Network communication modules shall be provided for both Master/Slave and Peer-to-Peer networking of the PLC's in a multi-processor PLC system.

6.4.10.2 In a Master/Slave PLC networking configuration, there will be only one master processor which sends commands out to other slave processors, and they respond appropriately. The Vendor shall quote the deterministic access time in his bid proposal (basically for remote intelligent I/O system).

6.4.10.3 The Peer-to-Peer network mechanism shall allow any processor on the network to initiate messages. The access determination protocol on the network shall be either token-passing protocol employing IEEE 802.4 token bus or Carrier Sense Multiple Access with Collision Detection (CSMA/CD) protocol according to IEEE 802.3 standard.

6.5 Operator Interface

6.5.1 Operator workstations

6.5.1.1 Two industrial type workstations shall be provided for each PLC system as operator interface complete with all accessories mounted in operator console.

6.5.1.2 The operator interface shall be; modular, multipurpose color graphic workstaion. The workstaion shall be directly connected to the PLC processor via data highway and shall have the capability to be networked with remote PLC's and I/O devices using interface modules.

6.5.1.3 The workstation shall be IBM PC compatible with min of 60 GB hard disk (as specified in spec.sheet), CD and 3.5" dual high density floppy disk drives with 1.44 MB capacity. The workstaion shall be used as general-purpose graphic-based program loader for the PLC processor.

6.5.1.4 The CRT of the workstation shall be of 19-inch flat, color and svga type.

6.5.1.5 The workstation shall have 32 MB of CPU board memory, minimally.

6.5.1.6 The workstation shall be provided with NEMA type 4 front panels.

6.5.1.7 The workstation shall be provided with QWERTY-101 keyboard and additional functional keyboard for control diagram programming.

6.5.1.8 The workstation shall be provided with two serial and one parallel communication ports.

6.5.1.9 The power voltage of the workstation shall be as specified in data sheet, 50 Hz.

6.5.1.10 The operator console design shall be in accordance with the best human engineering factors, in a manner; to reduce the effects of human errors, and shall be easy to operate type.

6.5.1.11 The operator console shall perform basically the following functions:

- Indication of analog and digital controlled or non-controlled variables.

- Manipulation of control set-point and alarm setting values and also Manual, Auto, or Cascade operation for PID loops.

- Performing hourly, shift-end, daily and monthly average and historical trends.

- Displaying custom displays, such as; interactive schematics.

- Presenting reports and print-outs including display hard copies.

- Receipe generation.

- System diagnostics reporting.

- Generating or editing ladder diagram, SFC, or any other language as specified.

- Provide limited access to the PLC process for the purpose of maintenance. With this feature, maintenance personnel can gain limited access to do monitoring and change preset for counters and timers.

- Provide an environment for entering programs and generating customer's programs.

- Provide an environment for monitoring program execution in real-time.

- Provide program storage function in some machine readable format on floppy disks.

6.5.1.12 The workstation should be provided with Ethernet Local Area Network (LAN) to be connected to other workstations either in the same console or elsewhere.

In case of employing LAN, the Vendor shall provide necessary dedicated hardware and software for File Server.

In case of employing other LAN protocols, Vendor shall provide detail information with his bid proposal for Company evaluation.

6.5.2 Printer

6.5.2.1 A color printer shall be provided in conjunction with the workstation.

6.5.2.2 The printer shall be microprocessor based; high speed type with excellent letter quality.

6.5.2.3 Connection of the printer to the system shall be made by an integral serial interface port with RS-232C, 25-pin, D-type connectors.

6.5.2.4 The printer shall support printing of block, character, and line graphics.

6.5.2.5 The device shall accept all types of ribbons, such as; four color, red/black and black only type. The ribbon of the device shall be of commercially available brands.

6.6 Software Requirements

6.6.1 Programming tools software

6.6.1.1 The programming software shall be provided on the workstation and shall be menu driven software package for programming, documenting and printing programs on-line.

6.6.1.2 The program shall be either DOS, Windows, or unix compatible and shall include a universal programming interface to the PLC processor.

6.6.1.3 The program shall create, edit, and monitor any user program.

6.6.1.4 The program shall allow the operator to force any I/O point on the logic diagram and shall

display any data file starting with the Operator requested address.

6.6.1.5 The software shall display program documentation both on-line and off-line and store program on disk for archiving or downloading to other processors.

6.6.2 Operating system

6.6.2.1 The Operating System program for the workstation shall be multi-tasking employing either MS-DOS, UNIX, OS/2, or VMS and shall be of the version to work in conjunction with Windows soft ware. Windows NT may be proposed for workstation Operating System as specified in data sheet .

6.6.2.2 The PLC processor shall be provided with an executive program to control the functionality of the PLC, and shall control the action of CPU to perform the following tasks:

- perform the diagnostic checks on start-up, by calling the diagnostic software;

- scan inputs;

- solve the logic operations;

- scan outputs;

- perform all necessary communications;

- perform the diagnostic checks cyclically, on-line, by calling specially written diagnostic software, while the user's logic program is being solved.

6.6.2.3 The executive program shall set outputs to a safe state when a fault detected by diagnostic program and wait for fault clearance before putting the processor to the start condition.

6.6.2.4 If a power fail has been occurred, the executive program shall turn all outputs to off state and prepare the processor for power-up starting.

6.6.3 User software

6.6.3.1 This type of software shall be provided, by Vendor, enabling the control engineer to write and store application softwares in the user memory, in order to; perform the required control over the batch process.

6.6.3.2 User software shall contain batch configuration data for PLC's with software configuring facility language programs.

6.6.3.3 The configuration program (if applicable) shall typically consist of assigning I/O points to particular I/O rack, defining the processor how much memory and I/O is available, assigning specific memory for tasks, determining "fatal" versus "nonfatal" faults, and other items to be performed interactively on the program loader.

6.6.3.4 The user program shall typically implement operator interfacing, communications, data acquisition and supervisory control.

The program shall also aid in generating the reports on logic diagrams, I/O image chart, data table map, file operation summary, cross reference report, instruction comments and index. Vendor shall submit the language programs available on his system with his bid proposal for Company's evaluation and appraisal.

6.6.3.5 For permission to change any parameter in system configuration password shall be implemented for authorized person(s).

6.6.4 Diagnostic software

6.6.4.1 The diagnostic software shall be provided on the system workstation as a complete hardware/software diagnostic package that; gathers data from the processor to pinpoint the problems as they occur.

6.6.4.2 The software shall communicate machine/process diagnostic information to MMI software to be displayed in high-resolution color graphics.

6.6.4.3 The workstation shall receive data table information once every control program cycle to ensure faults are detected quickly.

6.6.4.4 The software shall be of menu-driven, Fill-In-The-Blanks configuration, preferably, in an easy to use manner.

6.6.4.5 The diagnostic package shall provide self-diangostic tests in the following categories:

- system power-up self test

- program memory integrity check

- on-line checks every scan for processor, main memory, integrity of memory module, I/O system test, and data buses.

6.6.5 Interactive color graphic interface software

6.6.5.1 An interactive color graphic operator interface shall be provided in the system to provide all "plant floor" information through color graphic displays. The package shall be complete with graphic editor, program, and an interface program to create, edit, display and update graphics.

6.6.5.2 The color graphic displays shall represent the plant operations using ANSI Y 32.11 symbols, enabling the operator to monitor and control the process through the workstation.

6.6.5.3 The software shall be capable of alarm handling according to the user defined arrangement. The alarm handling shall automatically signal the operator through a dedicated screen window on the display. Alarms shall also be recorded in an alarm summary page.

6.6.5.4 The software shall perform; batch process management, recipe management, batch procedure control and batch data logging functions.

6.6.5.5 The software shall provide archiving on disk facility for all alarms and operator commands.

6.7 Power Supply Unit(s)

6.7.1 System power supply

6.7.1.1 The system power supply shall be provided to operate the PLC's processor. The power supply shall be in redundant hot stand-by configuration to provide power directly to the system chassis backplane, by inserting in two slots of the chassy.

6.7.1.2 A battery compartment in the power supplies shall contain lithium batteries to provide backup power to the memory and registers of the processor.

6.7.1.3 The power supply modules shall provide necessary power for use by processor rack modules. Other voltages as required by the processor modules shall also be provided by the power supply modules.

6.7.1.4 At least two status indicators shall be provided on the front plate of the power supply module to indicate the power is being applied to the module, and the battery is in good condition and power is applied to it.

6.7.1.5 The modules shall contain a front-accessible fuse holder, for ease of maintenance.

6.7.1.6 Processor power supplies shall not be loaded more than 70% of their ratings.

6.7.2 I/O rack power supply modules

6.7.2.1 Slot power supplies shall be provided in each I/O rack chassy to provide power directly to the chassy backplane. The power supply shall be directly insertable into the I/O chassis backplane.

6.7.2.2 The power supply module for each chassi shall be in dual redundant hot standby configuration.

6.7.2.3 The input voltage to the power supply shall be either 24 V dc as specified in the project data

sheets.

6.7.2.4 The power supply shall contain output power indicators to indicate if the voltage is being supplied to the backplane.

6.7.3 Auxiliary power supplies

6.7.3.1 The auxiliary power supplies shall be provided in dual redundant hot stand-by configuration in each I/O chassy or enclosure to serve the field mounted instruments, and to extend PLC's I/O capacity.

6.7.3.2 The power supply output shall be fused type with operating voltage of either 24 V dc as specified in the project data sheets.

6.7.3.3 The Vendor shall size the most suitable power supply system for each enclosure of the I/O system, to operate at 70% maximum rating in normal operation.

6.7.3.4 The power supply unit shall have a front accessible fuse holder for ease of maintenance.

6.7.3.5 Auxiliary power supply units shall be identical to other power supplies, as much as possible, in order to minimize spare parts stock requirements.

6.7.3.6 The auxiliary power supplies shall be redundant and of operator interface monitored type.

7. RELIABILITY REQUIREMENTS

7.1 The reliability for PLC system shall establish measuring guidelines to determine compliance with requirements set-forward in this Standard specification and shall indicate risk as well as need for redundancy, fail-safe design, spare part stocking, and any other protective measures available. Details of definition and equations are included in AppendixA.

7.2 Software reliability aspects of the system should be discussed and approved by Company.

7.3 The equations indicated in Appendix A shall be used by the PLC vendor to perform detail calculations report of his proposed system Availability and shall be submitted by his bid proposal to the Company.

7.4 The reliability report, in addition to the Availability result, shall contain the following:

- The study boundary

- The assumptions

- The Availability block diagram

- A summary of the techniques or Computer software employed

- A data table listing all equipment failure rates (or probabilities of failure) and restoration times with reference to the data source.

8. ENCLOSURE AND CABINET REQUIREMENTS

8.1 General

8.1.1 The structure of the enclosures shall be made of heavy duty metal, suitable for self-support mounting.

8.1.2 The depth of the enclosure shall be consistent with the maximum depth of greatest contained control device plus the electrical clearance. Anyhow the depth shall not be considered less than 500 mm.

8.1.3 All seams of the structure and surfaces of the body shall be continuous welded without any holes or knockouts, permitted in it.

8.1.4 Stiffeners made of heavy steel shall be welded to the enclosure backs and sides to maintain

flatness and rigidity of the enclosure surfaces.

8.1.5 Maximum overall height of the enclosure shall not be more than 2200 mm.

8.1.6 A minimum of 20% clear sub-panel space surface shall be provided for each enclosure.

8.1.7 Each enclosure shall be equipped with removable sub-panels, made of 3.5 mm thick plates, mounted on collar studs, for installing the equipment on this panel.

8.1.8 Terminals shall be mounted on the sides of the enclosure or cabinet. Minimum distance of terminals from bottom of enclosure shall be 460 mm. Terminals shall be supplied with screw type wire connectors and durable marking strips.

8.1.9 The wiring of the enclosures and cabinets, shall run in suitable wireways, protected with wireway doors. The wireway shall be sized so that the sum of the cross-sectional areas of all contained conductors do not exceed 50% of the interior cross sectional area of the wireway.

8.1.10 The wires used shall be of extra flexible, stranded copper type. The size of each conductor used shall be in accordance with the application encountered. In no circumstances, the wires shall be considered less than 1.5 mm².

8.2 Enclosures

8.2.1 The enclosure shall have access doors for maintenance purpose.

8.2.2 The height and width of the enclosure doors shall be at least fifteen millimeters (15 mm) greater than the corresponding height and width of enclosure opening.

8.2.3 Enclosure doors shall have sufficient rigidity to conserve alignment between mating parts (i.e., door fasteners and locking devices).

8.2.4 A permanent metal drawing pocket shall be attached inside the door. This pocket shall be at least 300 mm wide and shall be of sufficient depth to accommodate all pertinent drawings.

8.2.5 The width of the doors of an enclosure shall not exceed 600 mm.

8.2.6 Door swing shall be 165º minimally and shall be attached to the enclosure body with a continuous hinge.

8.2.7 A gland plate shall be incorporated at the bottom of the enclosure. This plate shall be made of steel plates with 5 mm thickness and shall be removable by suitable screws.

8.2.8 The enclosure shall have suitable EIA 19" rack mounting facilities for installing PLC rack modules.

8.2.9 A suitably sized circulation fan with removable anti-dust filters shall be incorporated in the enclosure for heat removal.

8.2.10 The enclosure ingress protection shall comply with IEC-529/IP 56.

8.2.11 The enclosures shall be welded steel enclosure type.

8.2.12 The enclosures shall house all PLC rack modules and necessary power supplies. The enclosures shall be arranged in a manner that; one enclosure to house all PLC system modules.

8.2.13 The enclosures shall have the following nominal dimensions:

Height $\leq$ 2200 mm

Width $\leq$ 1200 mm

Depth $\geq$ 500 mm

8.2.14 The structure of the enclosure shall be made of heavy duty, minimally 2.5 mm thick metal plates.

8.2.15 The enclosures shall have additional top cable tray entrance, covered by suitable screwed metal sheet plates.

8.2.16 Provisions shall be made for grounding of the enclosure.

8.2.17 Quick reference charts shall be permanently attached to the inside of each enclosure front door. The chart shall clarify proper module or PCB placement and assist in the interpretation of the status indicators.

8.3 Operator Interface Consoles

8.3.1 The operator console, if provided by the PLC vendor, shall be complete with all modules, systems and subsystems in full accordance with the intent of this specification.

8.3.2 The width of the console shall be 600 mm approximately.

8.3.3 The depth of the console shall be 800 mm approximately.

8.3.4 The height of the console shall be 1500 mm approximately, with top cover sloping to end side.

8.3.5 The console shall have a writing surface to accommodate the keyboard and function key with nominal depth of 300 mm at the height of 800 mm measured from the floor.

8.3.6 The console frame-work shall be made of sheet steels with minimum thickness of 3 mm. The side panels and doors shall be made of minimally 1.5 mm thick sheet steel plates.

8.3.7 The console shall be painted by stove enameled method with texture finish in Sea Green (BS-381C, shade 217) color.

8.3.8 The power and control cables shall enter from the bottom of the console by means of removable gland plates.

8.3.9 The console shall be equipped with a cabinet at lower part to accommodate all electronic modules in standard EIA 19" card file rack. The cabinet shall have access doors from the front and back of the console.

8.3.10 The console shall be in accordance with the best human engineering factors corresponding with ANSI/HFS- 100.

8.4 Packaging

8.4.1 General

The manner in which a PLC and it's pertinent I/O system is packaged is critical in determining whether or not a particular PLC system is feasible for a given application. Several of the factors involved in designing the package for a PLC system are included herein, which shall be considered by the PLC Vendor.

8.4.2 Heat removal

8.4.2.1 Venting shall be used to transfer heat from the PLC to the environment where the enclosure is located in clean areas, such as; control rooms. For proper operation, the vents should be near the top of the enclosure. Additional venting of the package at the bottom allows airflow through the enclosure, thereby increasing the efficiency of heat removal.

Vents shall be designed so that items like screws, nuts, etc., cannot inadvertently fall inside the equipment.

8.4.2.2 Forced air cooling technique shall be employed for heat removal where required, using fans, blowers, and filtering.

Since, as a mechanical device, fans and blowers are prone to failure and filters may clog with time, the PLC packaging shall be capable to operate reliably without these devices, in case of their failure.

8.4.2.3 Heat sinking shall be used to remove heat of heat producing devices, such as; power supply transistors. The heat sink radiating surface shall preferably be located outside the enclosure.

8.4.3 Wiring

8.4.3.1 Fixed wiring with suitable terminal blocks shall be provided for power supplies and field side of marshalling racks.

8.4.3.2 Removable wiring shall be typically used for I/O modules. In this case, the field wiring from the marshalling rack shall be done to a removable terminal block. In order to remove an I/O module for repair or fuse replacement, the terminal block on the I/O shall be detachable, to enable the module to be unplugged from the I/O rack backplane.

9. SHOP INSPECTION AND TESTING

Inspection and testing is divided in two main categories which shall be performed by Vendor/Contractor and witnessed by Company's representative. These categories are:

- Factory Acceptance Test (FAT)

-Site Acceptance Test (SAT), specified in IPS-G-IN-290

The PLC Vendor shall submit his own test procedures (Factory Acceptance Test) for all hardware, software, and firmware supplied, based on the requirements specified here-in. No material or equipment shall be shipped, unless all required tests conducted successfully and certified by the Company assigned inspector.

There are two broad test categories which shall be performed; functional test and Structural test.

Functional test shall be performed with software under test as a "black box". The test shall contain sets of data (both legal and illegal) and checking of the corresponding outputs. The functional test shall concentrate on the external behavior of the system to detect functions that have not been implemented or does not operate properly. The "functional test" procedure shall be submitted by Vendor for final Factory Acceptance Test (FAT).

"Structural Test", on the other hand, are the "white box" tests where detailed knowledge of the structure and coding of software is required. This type of test shall be proposed by Vendor for quality assurance tests.

9.1 Factory Acceptance Test (FAT)

9.1.1 General

9.1.1.1 The tests shall demonstrate the functional integrity of all hardware and softwares. Company assigned inspectors shall inspect the performance of all tests and they shall have access right to all facilities involved in the manufacturing of the equipment purchased under this specification. The vendor shall maintain and/or replace any hardware or modify the softwares, if the specified functions are not satisfactorily performed in Factory Acceptance Test on the Company's inspector judgment. A detailed factory test procedure shall be submitted in the bid proposal by Vendor and shall be agreed upon before starting the test. Vendor shall provide all necessary personnels and test equipment to perform the tests as, and when required with the costs included in the bid price and separately indicated.

9.1.1.2 The basic goals of the Factory Acceptance Tests shall be as follows:

- To confirm proper design and implementation, demonstrating to the Company's inspector that the system meets the Company specifications.

- To establish that the system performs properly under load and under conditions of stress.

- To confirm proper system configuration and organization. This may involve; setting program priorities (for example, which program runs first when several should be run), interconnection of system modules, etc.

- To look for unanticipated interaction between modules, such as; those which might be caused by two programs inadvertently sharing the same memory location for different data.

9.1.2 Quality assurance tests

9.1.2.1 Quality control shall be as per manufacturer's quality control standard to assure the good performance of components/ modules used in the system.

9.1.2.2 The sampling procedure for the tests will be defined by Company's assigned inspectors.

9.1.2.3 The Vendor shall perform all routine tests on the modules in the system or a subsystem prior to power-up of the system.

9.1.2.4 Functional tests for the system may be performed as a rehearsal for the Factory Acceptance Test at this stage.

9.1.2.5 Structural tests shall be performed to find defects in isolation and concentrates on missing paths, wrong paths, and wrong actions within and between software modules. These tests shall be performed by Vendor's engineers and programmers intimately involved in the design and implementation of the system and inspected by Company's representative.The tests shall involve all possible paths in an set of sequence logic.

9.1.2.6 "Functional" and " Structural" tests are both required to prove that a control system works correctly. "Structural tests" shall be done as the software modules are coded, whereas "Function tests" shall be performed after the system or the major subsystem is integrated. The final testing of the total system shall be Functional.

9.1.3 Procedures for factory acceptance test

9.1.3.1 The Factory Acceptance Tests shall be performed when all the application software and data bases have been coded and installed and the Structural tests of individual modules have been successfully completed.

9.1.3.2 The testing shall be performed with simulation system.

9.1.3.3 The Company's assigned inspector will perform this phase of the test and shall be applied to all hardware and softwares of the system. The necessary workmanship and co-operation shall be provided by the Vendor, in addition to all measuring instruments. All the subsystems shall be interconnected as "per-actual" interconnecting configuration in the field.

9.1.4 Requirements of final factory acceptance test

The following paragraphs describe requirements for testing to be performed by Vendor and witnessed by the Company assigned inspectors. The Company's inspectors shall have the right to perform any test; themselves, ask for reperforming any test, or ask for additional test as included in the Vendor's approved proposal test procedure.

9.1.4.1 Visual and mechanical tests

Company's inspectors will carry out visual and mechanical testing principally to assure; correct, proper, and good workmanship of the equipment.

9.1.4.2 Functional tests

When all procedures mentioned here-to-fore has been met, as a minimum, and all utility programs loaded, testing shall proceed preferably with the following steps:

- First, the ability of the system to correctly read the field inputs must be confirmed.

- Secondly, these inputs shall be manipulated, preferably by appropriate signal sources connected to the input terminals, and proper operation of the interlock levels checked.

- The ability of the operator to access the system will be very important at the computational safety level (level 2). The interlocks at this level which may have multiple operating modes, shall be tested separately by application of a tester replacing the higher levels for the purpose of these testings.

- The proper operation on the regulatory level shall be checked by suitable tester and by changing the set-points and other directives, through the operator interface.

- The sequence levels of a batch control system shall be tested. First, the shared units shall be tested with their local operator interface, if available, or the central operator interface. When this operation is confirmed to be correct, testing shall proceed to more higher level functions, as they exist, until it is established that the shared units all respond correctly to the simulated input signals from the process.

- In batch control, the logic for the main process vessels shall be tested (at this point, the logic is supported by all functionality for the levels below and for the shared units).

- Outputs to files for logging and reporting shall be tested; the logging and reporting programs themselves may be tested later, independently, after it is confirmed that the data received from the logic are correct.

- Software for production scheduling and other higher level functions shall be tested along with the other batch control software.

- All process and equipment failure must be simulated and tested during this period, since many failure conditions are difficult and/or time consuming to simulate when the system is connected to the actual process for the field acceptance test.

- Software testing shall start with Operating System, then control programs and finally utility programs.

9.1.4.3 Test plan schedule

1) The Vendor shall submit his test plan at a suitable time before starting of the test. The test plan shall demonstrate the properly execution of the functions, features, performance, and reliability of the system. The tests shall avoid non relevant duplication and shall provide greatest coverage with fewer test cases.

2) Plans are required for both "Structural" and "Functional" tests. The plans should specify the sequence in which a module or a function is to be tested, the required inputs and the anticipated results.

3) The plan for the "Structural test" shall cover all possible paths of logic in a module, and an appropriate subset or combinations of the logic paths, by the Vendor's designer and programmers judgment.

4) Company's representative shall witness all "Structural tests" performed on the modules at any stage of manufacturing. Therefore, the test plan shall be suitably timed, to enable the Company's representative to take part in the tests.

9.2 Tests Records

Each test carried out shall be formally recorded. Any deficiency or problem found in equipment shall be corrected by the Vendor and exactly recorded. Any changes in configuration, software or data shall be clearly recorded in test log books.

9.2.1 Performance test

9.2.1.1 After completion of tests mentioned here-above, the entire system shall be remained energized for 72 hours continuously, with hands-off the system. The system performance for given simulated I/O shall be observed during this 72 hours.

9.2.1.2 Any malfunction of any kind shall be noted as "Observations" in the Final Acceptance Test report and submitted to the Company for decisions.

9.2.2 Configuration documentation

All the latest changes in programs and data-bases, as performed during acceptance test shall be transferred on floppy diskettes (four copies). Two copies shall be shipped separately by express mail to Company and two other copies shall be shipped with the PLC system.

9.2.3 Final conclusion of tests

The Company assigned inspectors shall sign all Factory Acceptance Test (FAT) reports and log books and consequently issue a certificate of shipment on satisfactory completion of witnessing tests. Vendor shall properly pack the system according to shipping instructions and packaging specifications furnished to him by Company and forward all equipment to the Company's site.

9.3 Site Acceptance Test (SAT)

The procedures for Site Acceptance Test are specified in "PLC Construction Standard" IPS-G-IN-290.

10. TRAINING REQUIREMENTS

10.1 The system supplier shall provide Company's personnel with adequate training for equipment maintenance and operation, to get them familiar with the system. The Supplier/Vendor shall provide a description of the training courses available for his system with the duration and cost of each course by his bid proposal for evaluation. The training courses shall minimally provide the following subjects:

      a) Operation of the system for operators.

      b) Maintenance of the system.

      c) System introduction and basic configuration for engineers.

10.2 The training shall be provided before the work is installed on site. The courses shall be scheduled so as not to be concurrent; so that a single person may attend all courses.

10.3 Each course shall be described in terms of;

      - location,

      - duration,

      - schedule,

      - pre-requisites,

      - training facilities provided.

11. DOCUMENTS AND DRAWINGS

11.1 General

Documentation of the PLC shall be provided in accordance with, but not limited to, the general requirements as mentioned in this section and as listed in the Purchase Order.

Vendor drawings shall be prepared by Computer Aided Drafting (ACAD) system, preferably. Minimally five copies and one reproducible of all system drawings shall be provided to the Company. Two copies of ACAD drawings shall also be provided on 3.5" diskettes.

All documents shall be in English language.

11.2 Drawings

11.2 1 All system design drawings shall be prepared and submitted for Company's approval in accordance with recognized standards. Every effort shall be made to minimize the total number of drawings prepared by applying of common drawings wherever practicable, without loss of clarity.

11.2.2 Prior to start of manufacturing, the Vendor shall submit all drawings for Company's approval.

11.3 As-Built Drawings

11.3.1 Vendor shall prepare and issue a complete set of updated drawings incorporating all modifications, additions or other changes that have been made during manufacturing and site precommissioning, before final Site Acceptance Tests.

11.3.2 Each drawing issued at this stage shall be clearly marked with "as-built" stamps and dated accordingly.

11.4 Design Interfacing

11.4.1 PLC Vendor shall incorporate logic design, provided by the company, into his system.

11.4.2 The Company will provide control building, auxiliary rooms and data highway support details to the Vendor. Vendor shall consider all these constraints in his PLC system design.

11.4.3 Company's requirements for graphic displays, report format details, DCS compatibility, tabular displays and drawing numbering system shall be considered by PLC Vendor.

11.4.4 Grounding, power supply and other interfacing details, as required, for each project, shall be fulfilled by PLC Vendor.

11.5 System Configuration Documents

11.5.1 Document to be supplied by vendor

11.5.1.1 Complete listings of the PLC programs, including; system configurations, I/O configurations, ESD configurations, and safety interlock or any other configuration encountered, shall be provided by PLC Vendor.

11.5.1.2 The documentation shall be provided both on paper and F.D. or C.D. readable by P.C.

11.5.1.3 List of all equipment items giving type, manufacturer, etc., shall be provided by the Vendor.

11.5.1.4 Dimensions, weight, power requirements (start-up and running) for all equipment items shall be provided.

11.5.1.5 In addition to above mentioned documents, the following shall also be provided:

- layout drawings

- cabling and termination drawings

- I/O summary and interface specification

- list of all spare parts, tools, test equipment and installation equipment

- packing & transportation specification including storing requirements.

11.6 Operation and Maintenance Manuals

11.6.1 System hardware description

11.6.1.1 The system hardware description shall generally meet the following format:

- Full technical description of the hardware subsystem and its components, supported by diagrams and discussions of the operating principle.

- Troubleshooting, test and maintenance procedures.

- Index of supporting drawings, indicating location and major components.

11.6.2 System software/firmware descriptions

11.6.2.1 For every software module a full written description of its functions with detail of objectives shall be provided. The details of descriptions shall be sufficient to allow the determination of the functions of each module.

11.6.2.2 Printed listings of configuration in conjunction with machine readable media configuration codes shall be provided by the Vendor for the system and each module of the system. The listings shall include comprehensive comments to allow a programmer to make any adjustment to the module for any reason. The appropriate module maintenance techniques shall also be provided.

11.6.2.3 Vendor shall provide all informations required to perform editing and loading of the configuration programs into the system. Additional information on amendment and replacement of configuration program shall be provided by Vendor.

11.6.2.4 Two copies of the system database listings on the F.D. or C.D. shall be provided to the Company prior to the Site Acceptance Test. After completion of the acceptance test, sufficient quantities of "as-built" version shall be submitted to the Company, as specified in the project specification.

11.6.2.5 In addition to above mentioned configuration programs, two complete sets of "master" control system configuration on the F.D. or C.D. shall be provided for PLC batch control system.

11.6.3 Typical project manual structure

11.6.3.1 Typical project manual structure shall consist of 6 volumes, namely:

Volume 1   Operating procedures

Volume 2   System hardware description

Volume 3   System software description

Volume 4   Repairs, test, maintenance and preventive maintenance

Volume 5   Spare parts, tools, and test equipment

Volume 6   Drawings

APPENDICES

APPENDIX A

RELIABILITY ESTIMATION DEFINITIONS AND ASSUMPTIONS

The measurement for reliability estimation shall be expressed in terms of Availability, Failure rate, Mean Time Between Failure and repair duration time (Mean Time To Repair). The data used to calculate the above mentioned terms shall be universally accepted predictions (i.e. Mil-STD-Handbook 217 predictions), which quantifies expected useful life of components, utilized under real service conditions.

a) Mean time between failure (MTBF) estimation

MTBF shall be calculated by the following equation:

$$\textbf{MTBF} = \frac{1}{R1 + R2 + ... + Rn}$$

R_1 through R_n are the failure rates of components used in the   equipment or system.

The MTBF calculation for each equipment used and the whole components shall be submitted for evaluation in each bid proposal.

b) failure rate estimation

The cumulative probability of failure shall be expressed as an exponential decay function, in the form of:

$$\textbf{R = e}^{-rt}$$

Where R is the probability that the system operates without failure in a duration indicated by time t, and r is the failure rate for the class of device as extracted from generally accepted predictions (i.e. Mil-STD. HDBK 217).

c) repair duration time (MTTR)

The DCS vendor shall provide his certified (MTTR) which will be the measure of repair duration time. Such a document shall indicate the skills, test instruments and repair spare stocks required to achieve the stated MTTR.

d) availability

Steady state availability shall be calculated as a fraction of time which the system is operational and shall be expressed as:

$$\textbf{A = MTBF/ (MTBF + MTTR)}$$

For serial subsystems the overall availability shall be calculated by the equation:

$$\textbf{A = A1.A2................An}$$

and for parallel subsystems the net availability will be estimated by the equation:

$$\textbf{A = 1 - [(1-A1) (1-A2).....(1-An)]}$$