MATERIALS AND EQUIPMENT STANDARD

FOR

PROCESS CONTROL SYSTEM (PCS)

SECOND EDITION

MARCH 2014

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FOREWORD

The Iranian Petroleum Standards (IPS) reflect the views of the Iranian Ministry of Petroleum and are intended for use in the oil and gas production facilities, oil refineries, chemical and petrochemical plants, gas handling and processing installations and other such facilities.

IPS is based on internationally acceptable standards and includes selections from the items stipulated in the referenced standards. They are also supplemented by additional requirements and/or modifications based on the experience acquired by the Iranian Petroleum Industry and the local market availability. The options which are not specified in the text of the standards are itemized in data sheet/s, so that, the user can select his appropriate preferences therein

The IPS standards are therefore expected to be sufficiently flexible so that the users can adapt these standards to their requirements. However, they may not cover every requirement of each project. For such cases, an addendum to IPS Standard shall be prepared by the user which elaborates the particular requirements of the user. This addendum together with the relevant IPS shall form the job specification for the specific project or work.

The IPS is reviewed and up-dated approximately every five years. Each standards are subject to amendment or withdrawal, if required, thus the latest edition of IPS shall be applicable

The users of IPS are therefore requested to send their views and comments, including any addendum prepared for particular cases to the following address. These comments and recommendations will be reviewed by the relevant technical committee and in case of approval will be incorporated in the next revision of the standard.

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GENERAL DEFINITIONS:

Throughout this Standard the following definitions shall apply.

COMPANY:

Refers to one of the related and/or affiliated companies of the Iranian Ministry of Petroleum such as National Iranian Oil Company, National Iranian Gas Company, National Petrochemical Company and National Iranian Oil Refinery And Distribution Company.

PURCHASER:

Means the “Company” where this standard is a part of direct purchaser order by the “Company”, and the “Contractor” where this Standard is a part of contract documents.

VENDOR AND SUPPLIER:

Refers to firm or person who will supply and/or fabricate the equipment or material.

CONTRACTOR:

Refers to the persons, firm or company whose tender has been accepted by the company.

EXECUTOR:

Executor is the party which carries out all or part of construction and/or commissioning for the project.

INSPECTOR:

The Inspector referred to in this Standard is a person/persons or a body appointed in writing by the company for the inspection of fabrication and installation work.

SHALL:

Is used where a provision is mandatory.

SHOULD:

Is used where a provision is advisory only.

WILL:

Is normally used in connection with the action by the “Company” rather than by a contractor, supplier or vendor.

MAY:

Is used where a provision is completely discretionary.

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1. SCOPE

This Standard specification defines the minimum requirements for functions, hardware, and firmware/software of PCS. The detailed requirements will be specified for each individual project as a supplement to this Standard specification.

Note 1:

This is a revised version of this standard, which is issued as revision (1)-2004. Revision (0)-1996 of the said standard specification is withdrawn.

Note 2:

This is a revised version of this standard, which is issued as revision (2)-2014. Revision (1)-2004 of the said standard specification is withdrawn.

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.

API (AMERICAN PETROLEUM INSTITUTE)

RP 500	"Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Division 1 and Division 2"
RP 554-1	"Process Control Systems Part 1: Process Control Systems Functions and Functional Specification Development"
RP 554-2	"Process Control Systems Part 2: Process Control System Design"
RP 554-3	"Process Control Systems Part 3: Project Execution and Process Control System Ownership"

ANSI (AMERICAN NATIONAL STANDARD INSTITUTE)

ANSI/HFS-100	"Human Factors Engineering of Visual Display Terminal Workstations" (1988)
Y 32.11	"Graphical Symbols for Process Flow Diagrams"

BS (BRITISH STANDARD INSTITUTION)

BS 5760	"Reliability of Constructed or Manufactured Products, Systems, Equipment and Components" Part 5
BS 381C	"Specification for Colors for Identification, Coding and Special Purposes"

EIA (ELECTRONICS INDUSTRIES ASSOCIATION)

ANSI/TIA/EIA-232-F	"Interface Between Data Terminal Equipment and Data Circuit-

	Terminating Equipment Employing Serial Binary Data Interchange"
EIA/ECA-310-E	"Cabinets, Racks, Panels, and Associated Equipment"
ANSI/TIA/EIA-422-B	"Electrical Characteristics of Balanced Voltage Digital Interface Circuits"
ANSI/TIA/EIA- 423-B	"Electrical Characteristics of Unbalanced Voltage Digital Interface Circuits"
ANSI/TIA/EIA-530-A	"High Speed 25 Position Interface for Data Terminal Equipment and Data Circuit-Terminating Equipment, Including Alternative 26-Position Connector"

IEC (INTERNATIONAL ELECTRO-TECHNICAL COMMISSION)

60516	"A Modular Instrumentation System for Data Handling; CAMAC System"
DIN IEC 60625-1	"An Interface System for Programmable Measuring Instruments (Byte Serial, Bit Parallel); Part 1: Functional Specifications, Electrical Specifications, Mechanical Specifications, System Applications and Requirements for Designer and User"
DIN IEC 60625-2	"An Interface System for Programmable Measuring Instruments (Byte Serial, Bit Parallel); Part 2: Code and Format Conventions"
60068-2	"Environmental Testing-Tests"
60297-3	"Mechanical Structures for Electronic Equipment - Dimensions of Mechanical Structures of the 482,6 mm (19 in) Series"

IEEE (INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS)

C 62	"Guides and Standards for Surge Protection"
488	"Higher Performance Protocol for the Standard Digital Interface for Programmable Instrumentation"
802.2	"Information Technology - Telecommunications and Information Exchange between Systems - Local and Metropolitan Area Networks - Specific Requirements-Part 2: Logical Link Control"
802.3	"Information Technology - Telecommunications and Information Exchange between Systems Local and Metropolitan Area Networks - Specific Requirements Part 3: Carrier Sense Multiple Access with Collision Detection (Csma/Cd) Access Method and Physical Layer"
802.4	"Information Processing Systems - Local Area Networks - Part 4: Token-Passing Bus Access Method and Physical Layer Specifications"
802.5	"IEEE Standard for Local Area Networks: Token Ring Access Method and Physical Layer Specifications"

ISA (INTERNATIONAL SOCIETY OF AUTOMATION)

S 18.1	"Annunciator Sequence and Specification"
S 61.1	"Industrial Computer System FORTRAN"
S 61.2	"Industrial Computer System FORTRAN Procedure for File Access and Control of File Contention"
S 5.3	"Graphic Symbols for Distributed Control/Shared Display

Instrumentation, Logic and Computer Systems"

ISO (INTERNATIONAL ORGANIZATION FOR STANDARDIZATION)

7498-1	"Information technology-Open Systems Interconnection - Basic Reference Model: The Basic Model"
8348	"Information technology - Open Systems Interconnection - Network service definition"
8473	"Information technology - Protocol for Providing the Connectionless-mode Network service"
8802-2	"Information Technology - Telecommunications and Information Exchange between Systems - Local and Metropolitan Area Networks - Specific Requirements - Part 2: Logical Link Control"
8802-4	"Token-Passing Bus Access Method and Physical Layer Specifications" (1990)
8802.5	"Information Technology -Telecommunications and Information Exchange between Systems - Local and Metropolitan Area Networks - Specific Requirements - Part 5: Token Ring Access Method and Physical Layer Specifications"
8072	"Information technology - Open systems interconnection - Transport service definition"
8073	"Information Technology - Open Systems Interconnection - Protocol for Providing the Connection-Mode Transport Service"
9506	"Industrial Automation Systems - Manufacturing Message Specification"

MIL-STD (U.S. MILITARY STANDARD)

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

NEMA (NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION)

ICS6	"Industrial Control and Systems: Enclosures"

IPS (IRANIAN PETROLEUM STANDARDS)

IPS-G-GN-210	"General Standard for Packing and Packages"
IPS-M-IN-220	"Material and Equipment Standard for Control Panels and System Cabinets"

3. UNITS

This Standard is based on International Systems of Units (SI), as per IPS-E-GN-100 except where otherwise specified.

4. SYSTEM REQUIREMENT

4.1 General

4.1.1 The PCS shall be totally distributed microprocessor based control, communication networks and data acquisition system with shared display. The PCS shall be of "open system type" according

to ISO 7498-1.

4.1.2 The PCS shall be furnished with a unified data-base enabling implementation of all types of control strategies. Basic system shall be made of four building block subsystems naming operation and monitoring functions, engineering functions, control functions and a network communication system. The system shall be configured hierarchical architecture capable of integrating into higher automation levels as illustrated in Appendix A.

4.2 System Architecture

The Process Control System shall provide both geographical and functional distribution by means of highly optimized modular architecture for simple, cost effective future expansions. The following levels shall be incorporated into the PCS architecture.

4.2.1 Process control level (level 1)

This level shall cover all microprocessor based controller, input/output connection terminals, A/D and D/A converters, and signal conditioning circuits. Each module in distributed architecture shall include a microprocessor with its own firmware and data-base. Each building block module shall be task partitioned and shall be tailored to perform a specific dedicated task, such as; process interface, control strategy implementation, data highway interface, etc. Each task shall be performed in each block independently of other blocks.

Interconnection between controllers and shared display shall be implemented by means of a data highway which shall be a part of basic system's communication network.

4.2.2 Process supervision level (level 2)

The next level above the process control level just described is process supervision level. At this level, operator interface to the process and to the higher levels will be performed.

4.3 System Configuration

4.3.1 The PCS system shall be comprised of a family of hardware and software to implement all types of process control systems. The system shall provide a distributed intelligence architecture with shared display, in a manner to combine; operator interfaces, process controllers and input/output modules into an operating integrated system effective at the loop, unit and plant control levels.

4.3.2 PCS modules shall be integrated together through a data bus oriented communication link system. Alternatively, communication link employing IEEE 802.3 and/or IEEE 802.4 standards may be proposed.

4.3.3 The system configuration shall basically comprise of the following building block sub-systems:

- Communication system
- Controllers
- Process interface and data acquisition system
- Human Machine Interface (HMI)
- Data highway ports for interfacing with PLCs and other microprocessor based systems
- Network interface to higher level automation computer systems.

4.3.4 The system shall be sized to contain 40% spare I/O capacity, 20% of them installed in the system, unless otherwise specified. The system shall maintain the same real-time system response, and shall maintain an adequate traffic load within communication network after full expansion.

4.4 System Design

4.4.1 The system design shall be based on highly modular components at all levels using the state of the art technology.

4.4.2 The following points shall be considered in the system design by hardware and software/firmware configurations:

- Function distribution shall be used to minimize the consequences in the event of a failure occurrence in the system and to simplify maintenance.

- The system display should be divided in hierarchical pages, with each page of the hierarchy providing more detail information about a specific item or area in a manner that the following pages to be available for the operation of the process:

  - Overview display of overall plant status with arriving alarm annunciation
  - Plant process area overview with arriving alarm indication
  - Portions of the process area (depending on the size of process area), with arriving alarm indication
  - Equipment overall display (group display) with alarm indication
  - Single loop or point detail display showing process value, set-point, tuning parameters and all information about the loop

4.4.3 The system shall also provide a dynamic display hierarchy based on alarm priorities to ease quick access to the highest priority alarm for the process area involved.

4.5 Reliability

4.5.1 The reliability for PCS 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 Appendix B.

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

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

4.5.4 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.

4.6 Failure Recovery Requirement

The system shall be fault tolerant to achieve the availability measures mentioned herein and the system shall utilize the following failure recovery measures to exceed 99.99% availability minimally.

4.6.1 Redundancy

-Uninterrupted automatic operation desired in the system, shall be achieved by suitable redundant devices, such as power supplies, controllers, displays, communication system,

sequence and interlock system. In order to take full advantage of a redundant system, it shall be possible to repair a fault in the redundant parts while the others are kept on-line.

4.6.2 Manual over-ride

The operator will be considered as ultimate back-up for the control of the process, but such a measure shall not be considered in availability estimation stated here-to-fore. Such a capability shall fulfill the following requirements:

- Manual over-ride shall be made available for all process outputs.

- Manual over-ride shall be available through a hierarchy of redundant and supplementary independent paths to ensure prompt action to be taken as required. Various operator interfaces shall be connectable and removable to the system without affecting other stations or disturbing other control actions.

- Sufficient quantity of separate portable or local manual control/display stations may be provided for the system to be used for various modules of the system. These devices will be used as stand-by devices to program and/or operate controller modules independently of the communication system, if specified.

4.6.3 Maintainability

- The modules of the PCS shall be designed, in a manner to be replaced without hampering regular operations.

- Repair policy shall be based on replacing boards from a small quantity of recommended spare boards. The vendor shall have the capability to provide complete After-Sales-Services for repairing or replacing the cards and to provide enough spare boards for ten years, minimally based on project job specification.

4.6.4 Automatic self-diagnostics

- The process control system shall continuously monitor itself for failure of its components (modules, processors, buses, etc.) and shall provide prompt advice to the operator when a failure is detected, by means of, automatic self-diagnostics program. All devices operating within the PCS shall be under continuous surveillance by self-diagnostic programs.

- Upon any malfunctioning, a designated back-up device shall be switched into operation automatically.

- System overloads such as memory capacity, scan rate etc., shall be alarmed at the operator console. The status of failed module(s) shall be made available as a hard copy print-out.

- The system shall be equipped with suitable diagnostic software and hardware to locate and identify faults and malfunctions with details such as time of failure occurrence, identities of faulty devices, major components malfunctioning and the back-up system which are activated automatically.

4.6.5 Off-Line diagnostic programs

System shall be provided with off-line diagnostic programs to perform a through detailed check of the equipment. The Vendor shall submit detailed description of his off-line diagnostic programs with his proposal to be evaluated by the Company. Diagnostic program shall be capable to perform integrity checks to determine if a hardware or software error has occurred in the system.

4.7 System Continuity

The system shall have continuity of design and updating, that is the system shall be capable to

accept all new developments and updating of the system without any need to obsolete the existing system in favor of the new one.

4.8 Alarm Handling

4.8.1 For alarm annunciation the following items shall be considered:

- Alarm annunciation shall not cease without acknowledgment when points return to normal.
- Audible annunciation is not required when points return to normal.
- The Alarm Silence Key shall immediately silence the audible annunciation of any alarm.

For more details reference may be made to ISA S18.1.

4.8.2 Acknowledgment of any alarm shall be inhibited until sufficient detail is presented on the display to identify the nature of the problem to the Operator (e.g. Detail Display or Group Display including the annunciating alarm points).

4.8.3 A means of quickly and easily guiding the Operator to displays of annunciating points must be provided. This could be a list of displays with unacknowledged alarms or a key for directly accessing the appropriate displays.

4.8.4 A quick and easy mean for inhibiting and restoring all configured annunciation capabilities of any Operator Station at a time must be provided. Access must be restricted to authorized Engineering Personnel only. This requirement will allow same configuration to be used for all Operator Stations while permitting authorized Engineering personnel to randomly select the Operator console to be used for alarm annunciation.

4.8.5 The system shall support the following features:

- Minimum of 4 alarm priority levels
- Configurable event logging on printer with the following information, as a minimum:

  Tag number, description, timestamp, and reset time

4.9 System Security

Security considerations that affect the topology of the control system include firewalls, DMZs (demilitarized zone), communications servers and restricted data links. Most of these issues must be identified and addressed during the process control system functional specification.

It is highly desirable that the security system allow the user to define levels of security based upon user defined general rules and by exception to general rule.

The security system should not interfere with normal operator tasks.

5. SYSTEM HARDWARE REQUIREMENTS

The hardware configuration shall be divided in the following sub-systems as minimum:

- Communication system
- Controllers
- Process interface units and data acquisition
- Human-Machine-Interface (HMI)

The hardware units shall be manufacturer standard as "Off the Shelf" items.

5.1 Communication System

5.1.1 General

5.1.1.1 Communication links of the PCS shall basically conform to Manufacturer Automation Protocol (MAP) based on ISO 9506. Preference will be given to International Organization for Standardization (ISO), Open System Interface (OSI) data communication concept as outlined in clause 4. In this regard BS-EN-61784 may be referred.

5.1.1.2 Communication modules to connect to third party sub systems (such as SCADA, tank gauging system and PLCs) via industrial standard protocols shall be provided. Industrial Ethernet, Modbus and Profibus protocols may be considered as a minimum.

5.1.1.3 The PCS communications system shall consist of Dual Redundant Highways consisting of independent paths/electronics. Both highways shall be used during normal operation but shall be capable of carrying the total system communications without adversely affecting the response of the system.

5.1.2 Communication medium

The communication media shall consist of fully redundant cable trunk running plant-wide to transfer data between different process controllers and shared display operator stations. Connection between components shall be made by means of flexible drop cables branched off the main cable.

5.1.2.1 The trunk cable may be made of semi-rigid, twisted pair, coaxial or fiber optic cables, as required.

5.1.2.2 The shields of all trunk and drop cables shall provide an effective shielding factor of 100%.

5.1.2.3 Redundant trunk bus media shall be provided for the PCS. These redundant media shall function correctly for all PCS data communication demands independent of the main trunk.

5.1.2.4 Separate connectors shall be provided for jabber-inhibit monitoring for each communication media. Received signal source selection circuit shall be capable of selecting any one of the redundant media automatically and it shall be possible to enable or disable each single transmitter independently of the other redundant transmitter when the source of received signal is one of the redundant media.

5.1.2.5 The physical layer design entity shall be, such that the probability of a communication error, causing malfunction of other controllers connected to the medium to be minimized. The probability of a communication error value shall be submitted for Company approval.

5.1.2.6 The link media shall provide total electrical isolation between plant areas, to minimize the ground loop problems.

5.1.2.7 The media shall not be prone to problems arising due to moisture and corrosion.

5.1.2.8 Provision shall be made for the redundant link medium to operate normally without upsetting overall operation or requiring any modifications in the link, in case that; any number of connected modules fail or for removing and replacing any connected device.

5.1.2.9 The communication link shall be capable to service in hazardous area classified environment.

5.1.2.10 The communication interface cards in each sub-system shall be galvanically isolated from the Bus.

5.1.2.11 The communication interface card shall also be provided with a hardware timer which disables communication if transmission time exceeds abnormal values.

5.1.2.12 Bus control shall preferably be performed by token passing or CSMA/CD method in accordance with one of the following standards:

IEEE 802.2

IEEE 802.3

IEEE 802.4

IEEE 802.5

5.1.2.13 The access cycle time to the Bus will be dependent on communication load and the number of system equipment connected to the Bus, but anyhow in all circumstances, this access time shall not be greater than 500 m Sec.

5.1.2.14 All communication failure shall be reported suitably to the operator station. Such failures shall be logged in the system's diagnostics list. Continuous communication routine shall detect the communication system failure for alarming and switching to the redundant medium automatically.

5.1.2.15 Request for internal PCS information exchanges shall be generated from one of the following sources:

- Real time clock
- System error detection procedures
- Status changes
- Or any combination of these sources.

5.1.2.16 In periods with high communication load, the system shall consider priority for alarm transmissions over system information request.

5.1.2.17 The data protocol used shall safeguard against false data transmission and shall detect transmitted data errors.

5.1.3 Multiple data highways

5.1.3.1 Necessary interfaces shall be provided in the system to link 16 data highways in Bus, Ring or Star architecture or any combination of them, as a minimum.

5.1.3.2 Routing of data among multiple highways shall be handled, in a manner that; error detection on one communication path results an intelligent re-routing along other possible communication paths.

5.1.3.3 Multiple highways shall preferably work on the basis of IEEE 802.4 or IEEE 802.5 (ISO 8802.4 and ISO 8802.5 respectively) standard.

5.2 Controllers

The controller for the process control system gathers information from the I/O modules and other devices in the system. The processors within the controller perform the required functions needed to provide information to the final control devices or other systems/devices. These functions are configured into the controller by the system integrator, design engineers or owners control staff.

Typically, controllers should be able to execute commands using the following functions and parameters. For more information refer to API RP 554-1:

- PID and process control functions;
- Alarming functions; system, analog and discrete;
- Batch and sequencing control;
- Logic and math functions;
- Time delays, counters, and timers.

Some additional design considerations for controller include the following:

- The controller shall retain its memory in the event of power loss;
- The controller shall be modular and removable for maintenance;
- The controller real-time clock shall be synchronized to a common system clock and have resolution capable of supporting required time tagging of events;
- The controller should be capable of scanning and updating the I/O, executing logic and analog functions, and supporting communication interfaces to achieve required performance (typically, logic functions- ten times per second and analog functions-four times per second);

5.2.1 The controller shall be micro-processor based digital type using at least 32 bit industrial type microprocessor to provide multifunction process control.

5.2.2 Scaling, filtering, conversion to engineering units and alarm checking of analog measurement values shall also be included through standard predefined functional blocks.

5.2.3 Special function blocks shall be made available for floating point calculations. All control calculations and reporting shall preferably be performed by floating point arithmetic to avoid scaling problems. Measured values, as well as, calculated variables shall be accessible to these calculation function blocks.

5.2.4 Executive routines and control logic shall be stored, by suitable Memory, in a manner that; setting values and tuning constants are not lost or altered if the module fails or when a power surge or power interruption occurs.

5.2.5 Control routines shall permit on-line changes to be made in any parameter of the controller, including reassignment of input or output signals. This task shall not affect the operation of other loops implemented in the same microprocessor and shall not create any plant control upsets.

5.2.6 Output and set-point tracking shall be automatic and shall be available for all types of controllers for bumpless transfer of mode changes.

5.2.7 Each controller module shall have a dedicated data-base, containing information on the performance of the device and the status and history of the process variable in non-volatile memory for protection against power outages.

5.2.8 Controllers shall function autonomously, in a manner that, failure of one of them does not take others out of service.

5.2.9 Controller set-points and output ramping speeds shall be adjustable through operator console or portable maintenance terminal.

5.2.10 Controllers shall be equipped with the following modes of operation minimally, selectable from the operator console:

a) Manual

- The output will be manipulated directly from the operator station.

b) Automatic

- The output will be computed by the DCS controller.

c) External/Internal set-point (Cascade)

- The set-point will be the output from another controller or the same controller loaded with another control algorithm. Bumpless transfer between different modes shall be provided in the controllers.

5.2.11 Autodiagnostics shall be run in the controllers to detect sensor faults (bad PV) or operations out of tolerances, as well as, failure of component blocks, such as:

- A/D and D/A converters

- Memories
- Power regulators
- Communication system interfaces
- Central Processing Unit (CPU)

5.2.12 When the above mentioned problems identified by the autodiagnostic routines, the system shall place the affected loops in a safe state to prevent any incorrect final element positioning. The detected error shall trigger appropriate alarms, diagnostics codes, and status displays at HMI and pertinent module(s).

5.2.13 The controller shall be dual hot standby redundant type.

5.2.14 Controller parameters shall be checked to prevent entering of unreasonable values by the operator and to detect erratic signals obtained from other loops. The checked parameters, in addition to, the set-points, shall include:

- Any parameters which affect tuning or control strategies
- Parameters establishing alarms
- Output limits

5.2.15 During the program modifications, all process outputs shall be placed on hold and parameters shall be checked with unreasonable entries alarmed.

5.2.16 Each controller block shall be capable to accept customer selected equations or algorithms, without affecting other loops via operator console.

5.2.17 The controller including the back-up shall have a real-time database to perform actual control and monitoring functions. The data stored in this database shall be, minimally, as follows:

- Operating parameters, such as; the current process value, set-point, valve output, and mode (automatic or manual)
- Tuning parameters including values, such as gain, reset, derivative, and alarm trip-points.

5.2.18 The variety of controller modules to perform all control functions shall be limited types to ease the maintenance and spare parts stocking of the system. The vendor shall furnish detail technical document for his proposed controller modules to be evaluated by purchaser.

5.2.19 Controller configuration data shall reside in non-volatile memory media.

5.2.20 Special indicators shall be incorporated in the design of modules to ensure rapid detection of malfunctions and current status by maintenance personnel to be used for isolation of failures and performing the repairs. These indicators may be LED on the modules to reduce the need for test equipment.

5.2.21 The modules shall be replaceable while the system is hot.

5.2.22 The configuration/programming may be developed in “offline” mode on a standalone personal computer or in “online” mode on a PC connected to the control system either directly or through a network. On-Line control configuring capability shall be considered for the controllers.

5.3 Process Interface System

5.3.1 General

The PCS shall provide a comprehensive set of I/O conversions to interface with all types of standard analog and digital input/output signals encountered in the process. The requirements for this kind of interface will be specified under "process interface modules".

In addition to process interface modules, a "data acquisition system" shall be furnished with serial data communication to PCS -BUS, to achieve a truly integrated process control system with all packaged unit instrumentations in the plant, if specified.

5.3.2 Process interface modules

5.3.2.1 The process interface modules shall be capable of interfacing with the following types of input signals from field sensors, transmitters and digital systems.

a) 4-20 mA from transmitters.

b) 1-5 Volt from different electronic sensors

c) Millivoltage with cold-junction temperature compensation for thermocouples.

d) Resistance measurements from RTD sensors

e) Pulse inputs from turbine-meters, rotational speed measurements, etc. in the range of 0-1 or 0-10 Volts at frequency range of 1-2000 Hz.

f) Floating dry contacts, with 24 V dc power supply by a source external to the process interface unless otherwise specified in project job specification.

g) BCD signals from inductive position sensors.

h) Direct digital signal from smart transmitters.

i) I/O modules for communications with various digital systems such as Fieldbus, HART or other serial data communications.

5.3.2.2 The input cards shall be solid state electronics employing the state of the art technology.

5.3.2.3 Digital input/output cards shall have LED On/Off status indication for all inputs/outputs.

5.3.2.4 Any input or output Module shall be replaceable without turning-off the power to the system or disturbing the operation of the rest of the system (hot swap), in any way.

5.3.2.5 LED shall be provided in process interface cards for indication of errors occurring within the unit and for confirmation of correct operation of the system.

5.3.2.6 The input/output cards shall perform all necessary conversions, such as; A/D, D/A, code conversion, filtering, etc. required to perform interfacing to the process.

5.3.2.7 The process interface module shall accept low level input signals and apply any necessary conditioning to them, such as the following.

- Square root extracting
- Thermocouple cold junction compensation
- Noise suppression filtering
- Linearization for non-linear signals
- Open or grounded thermocouple detection

5.3.2.8 The vendor shall quote conversion repeatability and accuracy of A/D and D/A in his proposal to be evaluated for each specific application. The sampling rate shall be suitable for system scanning time.

5.3.2.9 The input/output circuitry shall be provided with suitable over-voltage protection.

5.3.2.10 The I/O system shall supply the operating power to the field instruments connected to PCS via power supply units installed in the same cabinet.

5.3.2.11 The I/O system shall provide required electrical isolation, noise rejection, transient suppression, to ensure clean, accurate information to the controllers for monitoring and control. Signal conditioning, isolation, and surge protection for analog and discrete I/O shall be performed by signal conditioning modules.

5.3.2.12 The I/O system shall contain high quality terminals to allow easy installation of field wiring and labeling of terminations.

5.3.2.13 The I/O system shall be capable to be operated durably in wide ranges of temperature, humidity, dust, atmospheric corrosion, and contaminants which are present in typical oil industry

installation. The specific environmental condition will be specified for each project.

5.3.2.14 In hazardous locations where isolation or energy limitation to field devices are essential, the I/O system shall be capable to be equipped with safety barriers.

5.3.2.15 The I/O system termination panels shall be separated from the I/O modules to provide enough space for ease of wiring installation.

5.3.2.16 Redundant I/O system shall be provided for critical loops using the back-up I/O to keep the process running, if the primary one is damaged or malfunctioning , unless otherwise specified.

5.3.2.17 The I/O modules shall be fused type. LED status indicators shall be provided as a troubleshooting aid, to indicate status of fuse blow-out fault condition for each channel.

5.3.2.18 Fuses and relays of the I/O modules shall be readily accessible and can be changed without disrupting service of any other channels.

5.3.2.19 The I/O system shall be equipped with signal conditioning to perform scanning, filtering, and alarm implementation on all field instrument analog measurements.

The signal conditioning shall provide the following features on per channel basis:

- Selectable signal conditioning
- Suitable filtering
- High/Low limit alarming
- Bad or faulty signal alarming

5.3.2.20 The overall accuracy of I/O system shall be better than 0.05% F.S. at 25^{o}C.

5.3.2.21 Any electronic components located on the I/O system modules shall be capable of operation with the specified performance during repeated shock loading of 1.0 g trapezoidal pulse of 30 msec. duration.

5.3.2.22 The data cable and cable attached connectors shall be capable of surviving at a repeated shock loading of 7.0 g trapezoidal pulse of 30 msec. duration.

5.3.2.23 I/O system component modules located on test slot shall be capable of operation within the specified performance during exposure to sinusoidal vibration of 2.5 mm. peak-to-peak at frequencies from 10 to 60 Hz., with 0.5 g maximum acceleration.

5.3.2.24 All calibration parameters of the I/O cards may be handled using software. As a result, replacement of an I/O card shall not require any recalibration.

5.3.2.25 When a field transmitter falls or its output raises above 22 m A, the I/O system module shall detect and segregate the fault without any affect on other input of the same module.

5.3.2.26 Digital inputs and outputs shall be electrically isolated from internal electronic circuits by dedicated devices, such as optocouplers.

5.4 Human-Machine Interface (HMI)

5.4.1 General

5.4.1.1 Each HMI station shall consist of two independent operator workstations, one engineering workstations and two printers minimally. The exact number of workstations and accessories shall be indicated in architectural configuration sheet for each project.

5.4.1.2 The HMI stations shall permit access in different levels, such as:

- Operator: The station shall provide possibility to have rapid access to all display pages defined for the engaged operator and shall provide access to all HMI functions necessary to perform the control of the process.

- Supervisor: The station shall provide access to all workstations of the system connected,

with possibility to monitor and define the responsibilities of each operator station by the supervisor.

- Engineer: The station shall provide possibility of start-up and control of particular diagnostic programs, modifying the configuration data, creating new display pages and new control loops by means of a password.

5.4.1.3 The operator workstations shall acknowledge all operator actions and indicate acceptance or rejection, in order to, circumvent problems arising by incorrectly pushed buttons, improper entry of point tags or data. For each continuous control loop, the operator interface must allow the operator to perform all of the normal control functions and monitoring the results of these actions.

5.4.1.4 All variables shall be referred by their pertinent tag number through a data base entry interactively. The following human-machine functions shall be provided in all operator workstations;

- The frequently used operator functions such as start/stop, controller mode selection, set-point adjustment, output adjustment, etc., shall be provided with dedicated functional keys.

- It shall be possible to have access to the various PCS sub-systems by any operator workstations.

5.4.1.5 The following human engineering factors shall be minimally foreseen in the workstations design:

- Monitor color saturation and light intensity shall be continuously variable and adjustable, and shall be made accessible to the operator by suitable means.

- The scan frequency and power supply filtering design shall be, in a manner that, stroboscopic effects arising between RF/electromagnetic interferences and screen up-dating be negligible.

- Operator keyboards and monitor positions shall be adjustable to different working positions physically, if specified.

- New monitor display pages invocation shall be completed in one second maximally, static data acquired from disk shall be invoked in three seconds maximally.

- Each workstation shall be equipped with electronic beeper for audible alarm annunciation. The beepers shall be of variable intensity type for identification of selective alarms.

5.4.1.6 The monitoring system shall support user selectable colors for defining colors of process variables, set-points, outputs, messages, etc. A minimum of 16 colors shall be available.

5.4.1.7 Automatic time synchronization shall be provided among monitor workstations by real-time clock.

5.4.1.8 Devices operating within the PCS shall be under continuous surveillance by diagnostic routines. In the event of malfunction detection, the operator shall be alerted at the workstation and the malfunctioning device. System over-loads, such as memory capacity, scan rate, etc., shall be alarmed at the operator station.

5.4.1.9 The HMI workstations shall be microprocessor based using 32-bit microprocessor minimally to operate in the multiprocessor environment. The processors shall employ an efficient real-time operating system as an environment for application software.

5.4.2 Operator workstation

5.4.2.1 Each workstation shall be fully independent of others and shall be stand alone type, with its own electronic circuits and dedicated peripherals, CPU, Raid1 hard disc and memory. The operator workstation shall minimally contain the following devices:

- High resolution, supper VGA type minimally 21" color monitor.

- Functional keyboard plus alphanumeric keyboard.

- Dual redundant hard disc drives

- Dual 3½" high-density, 1.44 Mbyte diskette drive (diskette drives for all consoles may be located in a unified compartment)

- Mouse, track-ball imbedded in the keyboard or Touch-Screen device if specified.

- CD/DVD drive

The workstations shall be fully interchangeable, in a manner that, a failure in any single workstation does not affect the performance of the operator workstation.

5.4.2.2 The operator workstations design shall be according to the best human engineering factors, to reduce the instances and effects of human errors, and shall be easy to operate.

5.4.2.3 The operator workstation shall perform basically the following functions minimally:

-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.

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

- Displaying custom displays (interactive schematics).

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

- Recipe generation for batch process control, if specified.

- System diagnostic reporting.

- Status monitoring of the command execution by the controllers.

- Provide a coordinated hierarchical set of displays, such as:

menu display, overview display for at least 64 loops per display page, unit display for at least 32 loops, group display for not more than 8 variables, detail displays, trend group displays for 8 variables, single trend displays, interactive, color dynamic control configuration graphic displays, alarm summary display with list of displays, alarm processing and display, controller tuning trend displays (protected by password), system self-diagnostic displays, system hardware status displays, real and historical trends, guide message display, help message display.

5.4.2.4 The overview display variables shall be represented by bar-graphs having a length proportional to their deviation value from the standard setting on a simplified graphic representation of the process. Alarm signals shall also be presented for each variable. Each alarm point shall have the tag number and status, shown in conjunction with the deviation indication.

5.4.2.5 Group display shall be displayed by pertinent information, such as; tag number, engineering unit, set-point, process variable, etc., as well as, pre-alarm, alarm status, and information on the setting values of the alarms, in a manner, to allow the operator to modify the alarm settings. This information shall also be displayed by bar-graph indications and color coding for visual recognition. Other information pertinent to each loop, such as; loop status (i.e. AUTO/MANUAL), and loop description (i.e. GAS FLOW) shall be made available on this type of displays.

5.4.2.6 Detail display shall show a bar-graph and tabular representation of the actual value of manipulated variable, control variable, set-point and relevant engineering information pertinent to a specific loop for each operating loop connected to the control system.

- At this level of display hierarchy, the engineering units and configuration values shall be allowed to be changed, by means of, password or hardware keylock to restrict unauthorized access to the loop tuning constants, process variable zero and span, alarm limits and any other configuration details, such as algorithms, signal types, or input sources.

- The following detail status condition displays shall be accessed by the operator for all discrete signals:

a) Type of device;

b) Tag-number;

c) On/Off or Open/Closed status;

d) Failure to operate;

e) Manual or automatic control mode;

f) Indication of shut-down command issue;

g) Device readiness for failure reset;

h) Instrument faulty condition;

i) Alarm setting;

j) Configuration data;

k) I/O device locations;

l) Indication of any input signal manual over-ride.

-The following commands shall be available to the operator through functional keyboard for analog variables pertaining to each loop:

a) Set-point and output shall be changeable in automatic and manual mode respectively with the following commands:

1) Up (open)

2) Down (close)

b) Set-Point and output ramping speeds shall be adjustable at operator's convenience.

5.4.2.7 Trend display shall support trends for one, two or three variables simultaneously on the monitor screen with the loop tag-number enabling the operator to monitor the inter-relation between variables (measured variables, calculated values, setpoints, and discrete inputs or states). The display time base shall be selectable and trends shall be automatically saved on the operator workstation storage media. The process variables specified in the function lists shall be sampled and the instantaneous values shall be stored at intervals of maximally ten second periods. The stored data shall be reproducible on the printer automatically once per eight hour shift and at any time according to the operator request if required.

5.4.2.8 Trending displays shall be made available for all specified loops in P&ID and the PCS function lists. The display shall have range expansion and compression, zero suppression and elevation, time base compression and expansion.

- Data shall be updated on point-by-point basis to ensure availability of a stored data at any time.

- Trend data points shall be connected with a continuous trace provided in accordance with pixel resolution of the monitor.

- Continuous scale expansion in 1% increments shall be provided for the operator enabling him to change the display scaling (i.e. going from 0-100% to 25-50%).

5.4.2.9 Dynamic graphic configured displays shall be considered for the system. These displays shall be fully interactive.

- The displays shall be organized in partitioned overlapped pages, in a manner that, each display page contains process information and related instrumentation for up to 64 unique tags, each having multiple dynamic variables presentation.

- The organization of different graphic display pages shall be hierarchical according to the following levels:

a) Overall process;

b) Individual process units;

c) Process unit sections.

-The following information shall be made available on the graphic displays:

a) Measured value for each analog variable;

b) Status of equipment such as; pumps, On-Off valves, packaged equipment, etc;

c) Analog and discrete variable alarms.

- The following interactive operations shall be made available to the operator by display pages;

a) Commands for turning On or Off the pumps, On-Off valves, packaged equipment etc.

b) Setting controller set-points and manipulation of process variables in Manual mode.

- The graphics shall be programmed by vendor based on ISA S5.3 for instrument symbols and ANSI Y32.11 for process symbols. Vendor shall prepare the graphics, on the basis of the simplified graphic display schematics supplied to him for the project after contract award. Multiple color coding (8 colors) shall be provided to indicate alarm points and operating status of motors, fans, valves, etc.

- The ISA S5.3 and ANSI Y32.11 in addition to any other symbols which are used in the graphics shall be made available as insertable block symbols in "system graphical library" for system modifications and future expansions.

5.4.2.10 Alarm summary displays shall present the latest plant alarms and their respective operator reset activation to the operator chronologically.

- Each line of the alarm list display page shall show one specific alarm. This alarm line shall minimally contain the following information:

a) Alarm occurrence and the time when the acknowledge command has been issued by the operator showing hours, minutes, and seconds.

b) The alarm priority such as High, Low, High-High, or Low-Low.

c) Alarm description showing the alarm group page number and the group display and control configuration page numbers which the alarm is associated with.

- The following separate lists with time stamp shall be provided for the system:

1) Active process alarms;

2) Acknowledged process alarms;

3) Returned process alarms;

4) Active hardware alarms;

5) Acknowledged hardware alarms;

6) Returned hardware alarms;

7) Active system alarms;

8) Acknowledged system alarms.

9) Returned system alarms;

5.4.2.11 Alarm display pages shall be provided for alarm handling by the operator. The alarms shall be grouped into the pages according to alarm groupings provided to the vendor in PCS alarm lists. The system shall manage the alarms and provide the following performance:

- The system shall provide at least four measurement and two deviation alarm levels for each control variable. The level of these alarms shall be definable by the process supervisor.

- The possibility of displaying the alarm status for discrete variables with their pertinent status or value.

- The alarm message shall show the point tag identification and description of the alarm.

- Alarms shall be prioritized by color. They shall preferably be prioritized by position as well.

5.4.2.12 The occurrence of any alarm within the control system and shutdown system shall result the following responses:

1) A change in color of the alarm point status indication in all displays in which it is present;

2) Flashing of the alarm point status indicator until it is acknowledged;

3) Audible annunciation;

4) Print out of the alarms in order of occurrence with details such as; tag number, alarm state indicator, alarm description, trip point value (if applicable), time and date of; occurrence, reset and return to normal.

5.4.2.13 Reports and listings

The HMI shall provide suitable means to document the reports and alarm listings with presentation of the time of occurrence of each item and pertinent designation of sequential events and operator entries. The following process record keeping features shall be provided in the system, as a minimum:

- Operator Entry Report

A list of all entries actions initiated by the operator affecting control of the process, minimally including; changes in control mode set-point, manual output or logic commands, with the identification of the console which the changes have been made from, with time stamp.

- Event List

A documentary list which presents all discrete events within the system, indicating the time and description of the events. The time stamp resolution of the events shall be less than 100 m Sec. The alarm messages shall be user definable and the length of them shall be minimally 80 characters. The system shall support 10 separate lists minimally.

5.4.2.14 Custom reports

All custom reports shall be stored on the console hard discs, to be recalled at any suitable time. All reports shall be made available by the system printer on operator request cyclic shift basis. The following type of reports shall be made available on the system:

- Standard Format Reports

These reports shall be user configurable with ability to include any selected information from any log, event or alarm list. This type of report shall be printable on-demand or periodically.

- Variable Format Reports

These reports shall be user configurable with ability to include any system data, such as; data stored in historical trend files or controller inputs/outputs. It is required that manipulation and calculation to be allowed to generate time-based averages, totalization, minimum values, minimum times, maximum values and maximum times.

5.4.3 Engineering workstation

5.4.3.1 All engineering parameters pertinent to the system configuration such as loop configuration, control strategies, control algorithms and HMI design and implementation shall be accessible by engineering workstation for engineering modifications interactively.

5.4.3.2 The workstation shall be either a dedicated engineering workstation or a multitask HMI workstation as specified in attached project data sheets, and shall be capable to perform the following tasks as minimum:

a) Customizing the system to meet any specific control objectives at start-up or at any time during operation and initial configuration generation;

b) Assigning tag-numbers to I/O channel to make them addressable by the control system;

c) Inserting scaling and tuning parameters;

d) Setting alarm limits;

e) Creating workstation display pages;

f) Running diagnostic routines;

g) Storage of configuration (including sufficient Bulk Storage Medium);

h) Copying system configuration onto Bulk Storage Medium;

i) Loading configuration from Bulk Storage Medium into the system;

j) Modifying configuration during system operation without interference to other devices or loops;

k) Help screens and sufficient blank configuration forms.

5.4.3.3 The engineering display shall provide the following types of displays, in fill-in-the-blank forms preferably or by a menu page selection to be configured on-line as minimum:

- Control strategy or algorithm configuration pages;

- Field controller parameter adjustment and tag number assignment pages;

- Different graphic display pages for their configuration editing;

- Trend generation displays;

- Configuring inputs to the system by filling the tag number, tag descriptor, system terminal number, type of signal characterizer, input alarm limits, alarm deadband and engineering units. Multiplexed inputs shall use a single configuration display format if applicable.

- Configuring output functions by filling the tag number, function description, system terminal number, output valve (including manual over-ride capability), reverse or direct acting selection and output fail-safe action selection.

- Configuring discrete output functions by filling the tag number, function description, output status, contact type, output hold option, fail-safe action selection and system terminal number.

5.4.3.4 The workstation shall provide on-screen forms to configure points and devices in the system by filling-in-the-blank. The spaces provided in front of data description headers generated by the system for all variety of control algorithms and strategies.

5.4.3.5 The engineering workstation shall provide an on-line Help facility to provide enough information to facilitate the programming and auditing tasks at any level encountered in the control system.

5.4.3.6 The auditing software shall be provided in the engineering workstation to perform checking of all configuration data entered and alert any missing information or any other potential errors made by Engineer.

5.4.3.7 The workstation shall provide special auditing software for specialized complex control strategies to recognize the type of instructions entered and prompts for information needed. This program shall also check the data entered for their correctness. Such an auditor shall provide on-line Help messages pertinent to all types of instructions on Engineer demand.

5.4.3.8 Graphic display elements shall be drawn by using library of symbols provided in the system-data base. The graphic software shall provide facilities for symbol rotation, size selection and ability to create new symbols as minimum.

5.4.3.9 The engineering workstation software library shall include a global data-base software to handle all points data, configurations, and adjustment parameters on hard disc.

5.4.3.10 All information entered shall be saved by engineering workstation in a global data-base.

5.4.3.11 The system shall be equipped with a relational data-base to store each type of data in a designated area, in a manner that, data retrieval and manipulation can be performed efficiently. The data-base shall permit incorporation of new types of data after original database is set-up at system

operation time. The system shall be capable to import/ export ASCII formatted data from commercially available data base and spread-sheet programs.

5.4.3.12 The system shall be equipped with necessary softwares to transfer configuration data to control system after completion of all configuration data in system data base or after auditing of the configuration data is completed and saved.

5.4.3.13 A menu selection shall be provided letting the Engineer to choose whether to download specific configuration data to several devices or only to a specific one. In addition, the system shall provide the Engineer with facilities to download the entire configuration data for a device or just the configuration changes since the last download at his own discretion.

5.4.3.14 In performing the downloading operation, the system shall extract pertinent information for the device concerned from relational data base and generate a separate file to be downloaded to the device with all requested options.

5.4.3.15 A language editor software shall be provided in the engineering workstation to facilitate database generation by cutting, joining, and copying the existing information for use in other parts of the database. The editor shall also provide the Search and Search-and-Replace functions to find and update data.

5.4.3.16 When modified configuration data is saved by the Engineer, the system shall store it as the current version. The previously downloaded version shall be still stored and made available on hard disk by the system. At downloading time of the new version, the system shall be capable to compare the old and new configurations and to send only the changes along the Highway to the devices, in order to decrease the data highway occupation time for on-line engineering applications.

5.4.3.17 The engineering workstation system shall be provided with an automatic tuning program residing on the hard disc unit. The program shall be capable to be run on-line by the Engineer request to tune individual control loops optimally.

5.4.3.18 The controller tuning parameter changes that have been made by automatic tuning program shall be uploaded to be visible on the monitory the Engineer and used to keep the data base up to date.

5.4.3.19 In addition to the automatic tuning software, a Trace-and-Tune software shall be provided in the system to allow off-line tuning of individual control loops and testing the performance of the pertinent control strategy without affecting the process control operations. Such a task shall be performed by entering simulated analog or discrete inputs for an on-line controller to the Trace-and-Tune routine and observe the controller output. All the key points within a complex strategy shall also be capable to be observed by this Trace-and-Tune program.

5.4.3.20 The system shall also be provided with a diagnostic software to perform the system diagnostics, identifying specific device errors and helping trace the source of intermittent faults. Diagnostic display pages provided by this diagnostic software shall provide extensive coverage of system conditions. The following features shall be provided by this software, minimally:

- A Communication overview display page to show the communication status of all data highway devices. (Primary and back-up communication links).

- Detailed integrity displays to examine suspected devices in detail, with sufficient information to identify faults down to the circuit board level.

- Indication of malfunctions that occurs, on the primary and backup control devices, primary and backup power supplies, peripherals, and continuous indication of throughput traffic on the communication link.

5.4.3.21 To prevent unauthorized access to the workstation, it shall be equipped with passwords to protect the process from unauthorized configuration changes. The security functions shall preferably provide the following features:

- The administration password shall be considered for system engineer. The owner of this password shall be the only person to create or delete databases or grant other levels of access right to other maintenance personnel.

- Approved user passwords shall be provided for maintenance personnel. Such level of users can use only the functions specified by the Engineer supervisor using administration

password. The extent of the approved user functions shall cover all available functions which some are listed bellow;

a) Creating, deleting, or updating items;

b) Applying diagnostic programs;

c) Using Trace-and-Tune programs;

d) Generating and downloading new configurations.

5.4.4 System keyboards

5.4.4.1 Each workstation shall be equipped with an alphanumeric keyboard plus necessary functional keyboards. The following requirements shall be foreseen in the keyboards minimally:

- The keyboard shall have a retractable cable to provide the user the capability to position the keyboard wherever he wishes for maximum comfort.

- The following type of keys shall be considered in operator keyboards:

a) QWERTY, ASCII alphanumeric keyboard for engineering workstations;

b) Alphabetic order, ASCIII, alphanumeric keyboard and numerical keypad for operator workstations;

c) Task oriented keys;

d) Control oriented keys.

- All workstations shall be provided with membrane type keyboards, preferably.

- The track ball or mouse pad may be considered.

5.4.4.2 The keyboard shall be partitioned in the following distinct functional zones:

a) Display select area;

b) Alphabetic and numeric entry area;

c) Cursor movement area;

d) Control area.

5.4.5 Hard copy devices

- The printer shall be microprocessor type, high speed and with excellent letter quality as specified in job specification.

- The ribbon/cartridge of the device shall be of commercially available brands.

- The printer shall be fitted with suitable cover.

5.4.5.1 Color printer shall minimally fulfill the following technical requirements:

- The printer shall have acceptable quality and reliability and shall be accessible from any workstation.

- The printer shall provide addressability of 600 dots per inch or better both horizontally and vertically with enough color composition.

- The printer shall use both selectable A4 and A3 non-sensitized papers.

- The printer shall perform the copying in a time interval not more than 5 seconds.

- The printer shall support printing of block, character, and line graphics, by means of four color.

5.4.5.2 Monochrome printer shall be provided to log events and alarms. The printer shall meet the following requirements minimally:

- The device shall preferably use parallel, nine wire array, matrix print heads to provide bi-directional printing.

5.4.5.3 The Bid documents shall identify any capability of generating customized format printouts, if included.

5.4.6 Hard disk memory device (Bulk Storage System)

The engineering and operator workstations shall equipped with hard disk drives with following considerations. The raid type shall be supported by the workstation mainboard.

5.4.6.1 The hard disc unit shall be industrial state of drive type. The hard disc unit shall be permanently sealed into the drive to be unaffected by environmental dust and smoke.

5.4.6.2 Motor and solid state type hard drives may be used.

5.4.6.3 A full shock protection counter-arm mounting shall be provided for the device to eliminate head/carriage damage during transportation.

5.4.6.4 The following data shall be provided for the Bulk Storage System:

- MTBF and MTTR
- Seek time, latency, etc.
- Back up recommendation or service offered
- Environmental limitations (temperature, humidity, smoke, dust, hydrogen sulfide, etc.)
- Asynchronous burst transfer rate
- Raw disk transfer rate

5.4.7 Removable and optical drives

5.4.7.1 Removable drives shall be used primarily to store and download the programs that:

- Setup the file management used in operator stations
- Store the configuration of operating information used by the remote electronic units (controllers)
- To organize the database/programs that setup the operator station group overview display
- To store archival trend values
- To store graphics and tabular displays.

5.4.7.2 The magnetic media employed shall be 3½" double high density diskette type preferably.

5.5 System Cabinets and Consoles Structure

5.5.1 General

The PCS consoles and cabinets shall be according to the following unless otherwise specified.

5.5.1.1 The cabinets and consoles shall be complete with all instruments, terminals, equipment, etc., ready for site installation. The Vendor shall provide all parts, components, and modules, necessary to provide tidy, complete workstations and cabinetry.

5.5.1.2 Marshaling cabinets shall be provided, if requested in purchase order.

5.5.2 System consoles

The consoles (including workstations and auxiliary console) shall be complete with all modules, systems, and sub-systems in full accordance with the intent of this specification.

5.5.2.1 Unless otherwise specified in project job specification the following dimensions shall be considered.

- The width of the console shall be around 600 mm.
- The depth of the console shall be around 800 mm.
- The height of the console shall be around 1500 mm.

5.5.2.2 The console shall be equipped with a cabinet to accommodate the electronics with a nominal height of 800 mm, measured from the floor. The cabinet shall have two access doors, one from the front of the console and the other from the back.

5.5.2.3 The steel-work shall be painted by stove enameled method with texture finish in sea green color. For detailed information refer to IPS-M-IN-220.

5.5.2.4 The power and control cables shall enter from the bottom of the consoles.

5.5.2.5 The vendor shall provide standard filler plates to make the consoles uniform and integrated as a complete operator station.

5.5.2.6 Unless otherwise specified in project job specification the thickness of console plate shall be 3 mm.

5.5.2.7 The console for electronic circuits and controller cards shall be provided with a suitable capacity circulation fan for cooling and thermostically anticondensation heater.

5.5.2.8 Unless otherwise specified in project job specification protection of console shall be IP-54.

5.5.3 System cabinets

5.5.3.1 The cabinets shall be steel enclosure type.

5.5.3.2 The cabinets shall house controller cards, remote mounting auxiliary equipment, plus any kind of rear panel mounted equipment, as well as, interconnecting wiring and instrument power supplies. Marshaling racks may be housed in the cabinets, when requested in purchase order.

5.5.3.3 The components inside the cabinets shall be located in an optimum position for operation and servicing.

5.5.3.4 The Cabinets shall be equipped with EIA 19" racks for housing electronic circuit cards.

5.5.3.5 The Cabinets shall have standard arrangement and the following nominal dimensions:

Height mm	Depth mm	Width mm
2000/2100	600	600
2000/2100	600/800	800
2000/2100	600/800	1200

5.5.3.6 The enclosure doors shall satisfy the following requirements:

- The height and width of the enclosure doors shall be at least fifteen millimeters (15 mm) greater than corresponding height and width of the enclosure opening.
- A permanent metal drawing pocket shall be welded to the inside surface of the door. The

drawing pocket shall be 300 mm wide with 70 mm deep.

- Doors of the enclosure shall be designed to have sufficient rigidity to conserve alignment between mating parts.

- Doors shall be equipped with door fasteners and locking devices.

- Opposite access doors shall be provided for cabinets, for ease of access.

- Doors swing shall be minimally 165° and shall be attached to the enclosure body with a continuous hinge.

- Neoprene door gaskets shall be attached to the doors with oil resistant adhesive materials and held in place by means of steel restraining strips to increase enclosure protection against dust and water.

5.5.3.7 Cable entrance shall be incorporated at the bottom of the panel by means of gland plate, made of steel plate minimally 5 mm thick and shall be removable with suitable screws.

5.5.3.8 All cabinets shall be provided with suitable temperature sensor with PCS alarm for detecting abnormal temperature inside the cabinets.

5.5.3.9 Minimum distance of terminals from floor shall be 460 mm for ease of maintenance.

5.5.3.10 Terminals on the terminal block shall be plainly and permanently marked with the identification tags shown on wiring diagrams correspondingly. Only two terminations per side of a terminal is permissible.

5.5.3.11 Conductors shall be identified at each termination by the same tag as the terminal by means of wire sleeves, made of oil resistant material.

5.5.3.12 Conductors and cables shall be run from terminal to terminal without splices.

5.5.3.13 The wiring of the cubicles shall be run in suitable duct type wireways.

5.5.3.14 Terminal blocks shall be mounted and wired so that the internal and external wirings do not cross over the terminals.

5.5.3.15 The conductors used shall be all of extra-flexible, stranded copper, PVC insulated, 75°C type.

5.5.3.16 Provisions shall be made for grounding of the enclosure. In this regard IPS-M-IN-220 shall be followed.

5.5.3.17 At least 40% of installed terminals, 20% of barriers and relays and 20% of installed card or module slot and 20% of free space shall be considered as spare for future expansion in each enclosure.

5.5.3.18 The cabinets shall be provided with louvers and removable anti-dust filters, and shall have a sealed bottom in order to avoid dust infiltration in final arrangement.

5.5.3.19 The cabinets shall be painted by stove enameled method with texture finish in Sea Green Color. For detailed information refer to IPS-M-IN-220.

5.5.3.20 The thickness of cabinet plate shall be at least 2 mm.

5.5.3.21 Protection of cabinet shall be IP-54.

5.5.3.22 The cabinet for electronic circuits and controller cards shall be provided with a suitable capacity circulation fan for cooling and thermostically anticondensation heater.

5.6 Network Interface to Higher Level Automation Computer System

5.6.1 The PCS shall be capable to be interconnected in higher level automation network by suitable interface module using industrial Ethernet protocol through a router. The interface shall be capable to perform the following functions minimally:

- The communication between computer and PCS shall be based on PCS master/computer

slave principle.

- The PCS shall allow for the full transfer of the data bases resident in the system to the computer system without any limitations.

- PCS shall be capable to accept the computer system messages and commands in a separate dedicated data-base to be further evaluated and transferred to the control system by specialized softwares; (reference shall be made to pertinent project requirements)

5.6.2 General computer interface

5.6.2.1 The PCS data highway computer interface shall use either Ethernet TCP/IP, synchronous X.25 or asynchronous ASCII or as specified the company, to interface to any type of computer supporting an ASCII terminal driver at minimum 31.2 K baud rate. The system shall support interface to any commercially available automation computers. This general computer interface shall be configured from the PCS console, so there is no need for two separate operator consoles.

5.6.2.2 In order to simplify the establishing of communication links between the computer and the PCS, the PCS vendor shall provide an extensive list of instructions, easily implemented in standard, C Language statements, or BASIC program statements. A sample program and a list of instructions shall be included in the vendor's proposal to be evaluated by Company.

5.7 Interface to Programmable Logic Controllers (PLC)

5.7.1 General

The purpose of the PLC interface is to provide operator with the required data from the PLC. This feature shall be accomplished by displaying the data, primarily in the form of custom-built graphics, at any DCS console. The DCS shall also be capable of displaying the PLC data in the form of trends or custom reports.

5.7.2 The PLC interface design and variety of the sub-system shall enable interfacing of the DCS to the most major manufacturers of the PLC, as listed in Company's approved vendor list. The interface shall preferably support MAP/ OSI standard as outlined under ISO codes in section 2 or Ethernet TCP/IP protocol.

5.7.3 The DCS communication with the PLC shall be implemented by means of RS-232C connectors. Communication between the interface card and the operator console shall be established via DCS data highway.

5.7.4 Diagnostic routine alarms of the PLC shall also be transmitted to the DCS and operator console by the same PLC interface card.

5.7.5 The PLC interface shall have continuous Read and Write capability to maximize throughput and shall support simple mapping of any PLC registers into the DCS.

5.7.6 A single PLC interface shall be capable of supporting multiple PLC's on multi-drop basis.

5.8 Electrical Requirements

5.8.1 Power supplies

5.8.1.1 The PCS shall be supplied with 110 V AC (Unless otherwise specified in project job specification), 50 Hz power from dual redundant UPS. The internal DC power supplies shall be designed to meet the power requirements of the PCS and all two-wire field instruments. Each power supply shall be sized, such that, not carry more than 60% load of its capacity under normal condition. Separate AC circuit breakers shall be provided for each power supply.

5.8.1.2 DC power sub-system, including inputs to the controller module and PCS sub-systems shall be dual redundant. Failed power supplies must be removable without disconnecting power from any part of the system or affecting control operations.

5.8.1.3 All DC power required to excite external transmitters and drive external transducers shall be derived from power supplies within the PCS I/O system.

5.8.1.4 The power supplies shall be over-current and over-voltage protected.

5.8.2 Power system monitoring

5.8.2.1 The PCS system shall be capable of monitoring and reporting the status of AC power supplies and battery back-up conditions to the operator. Output current of the power supplies shall be indicated, in order, to confirm that supply capacity has exceeded. Blown fuse indication shall be provided on the face of all system cards.

5.8.3 Transient, static and RFI protection

All PCS electronic circuits shall be internally protected against system errors and hardware damages resulting from the following causes.

5.8.3.1 Connecting and disconnecting devices, removing and inserting modules or cables including removal of data highway connections while the system is operational shall be limited to the loss of disconnected equipment only.

5.8.3.2 The Vendor shall quote and specify the following information in the bid proposal, regarding sensitivity to electromagnetic radiation;

- Frequency range,
- Transmitter power level,
- Distance or proximity of the source to transmitter,
- Effect on the control system operation,
- Methods used to determine the above results.

5.8.3.3 The control system shall not radiate any interference to any other equipment or system present in the plant.

5.8.4 Equipment connection

5.8.4.1 All interconnections between components of the system (including the Data Highway) shall be via prefabricated (to length) and predetermined cables supplied with the system.

5.8.4.2 All plugs, receptacles and cables shall be clearly, uniquely and permanently labeled.

5.8.4.3 All plugs, in cables and devices (including circuit boards) shall be keyed to prevent incorrect connection. A suitable locking device must also be provided to prevent accidental disconnection. Circuit boards shall be guided for insertion and include permanently attached extraction device to assist in removing the cards.

6. SOFTWARE REQUIREMENTS

6.1 Control Software

The following software subroutines shall be made available in the system, as a minimum:

A. Control algorithms

- PID (linear)
- PID (non-linear)
- PID (ratio)
- PID (floating)
- Adaptive tuning
- Differential gap control
- Proportional time control
- Motor control
- Supervisory control
- Auto-Manual mode control

B. Computational algorithms

- Summer
- Multiplier
- Function generator
- Dead time
- Median
- Lead/lag
- High select/Low select
- Mass flow
- Square root
- Log function
- Exponential function
- Accumulator
- Characterizer

C. PID functions

- Output limiting
- Output tracking
- Feed forward
- Anti reset wind-up
- Set-Point clamping
- Set-Point ramping
- Auto-scaling
- Cascade

D. Input/Output algorithm

- Analog
- Digital
- Multiple analog input
- On/Off output (MOV)

E. Logical function algorithm

- Combinational gates
- Sequential gates

6.2 System Software and Miscellaneous Applications

6.2.1 The PCS system software shall be capable of controlling system level activities and allow the operator to monitor and control the process through an interactive human interface.

The software shall allow concurrent execution of more than one program in a background, foreground or multi-tasking mode.

6.2.2 Human Machine Interface shall be through the use of fully interactive software modules. Such modules shall be target oriented using easily recognized icons or custom symbols or they shall be entirely menu driven using pull down menus. Selection choices shall be through the use of a cursor-positioning mouse and shall not require the use of an alphanumeric keyboard. The use of typed commands to move from module to module or from display to display is not acceptable.

6.2.3 All programs shall be self-configuring, such that they obtain the size and configuration of the system from parameters contained in the various files created during system generation.

6.2.4 The following application software/functions shall be provided by the Vendor, as minimum:

- Mathematical library
- Physical properties library
- Histogram software
- Report sheet producing
- Process modeling
- Batch plant management
- Real time data-base manager
- Steady-State optimizer program
- Real-Time self-diagnostics
- Off line simulation
- Alarm handling management
- Access level management

6.3 Operating System

6.3.1 The operating system of the PCS should be preferably of "Open" type such as UNIX and LINUX.

6.3.2 Microsoft Windows is a privilege in evaluating the vendor proposal since this OS allows application software and users to interact on "as need" basis.

7. DOCUMENT AND DRAWINGS REQUIREMENT

The Vendor shall supply documents and drawings at different phases of the project engineering execution with quantity and quality requested in this standard and the particular conditions of the project job specification.

7.1 Document and Drawing to be submitted by Bid Proposal

7.1.1 Tender documents including the documents mentioned in claus 4.14.6 IPS-G-IN-250 shall be carefully studied by the supplier and requested data marked as "by Vendor" in data sheets, shall be filled-in and submitted by bid documents.

The documents shall be completed with the requested data by vendor and submitted as technical part of the bid documents.

7.1.2 The supplier shall read this Standard and attached documents/drawings carefully and submit his deviations to these documents under the item, "supplier points and deviations to technical specification". The following documents shall be submitted by the bid proposal for evaluation;

a) Description of the system proposed, including a system configuration drawings indicating all components,

b) Technical descriptive catalogues for each component of the system proposed,

c) List of components proposed with specification, i.e. type, manufacturer, quantities, etc..

d) Electrical requirements such as; feeding voltages, absorbed power at start-up and at steady conditions (subdivided per each component), maximum time of electrical failure to conserve the system operations without shutdown or malfunction,

e) Software and functions proposed,

f) Generated heat (KJ/SEC.) for each major component of the system,

g) Dimensions and layout of each cabinet and consoles,

h) Maximum constructional load per square meter for cabinets and consoles,

i) Vendor’s subcontractors and suppliers,

j) Points count list,

k) Deviation list.

7.2 Documents/Drawings to be submitted for Approval

The following documents shall be submitted after contract award, according to the agreed time-schedule to be approved by the Company:

a) Feeding and earthing electrical diagrams,

b) Vendor suggested system configuration,

c) Proposed graphic display pages,

d) Proposed logging and report formats,

e) Detail factory acceptance test (FAT) procedure for the PCS system,

f) Sample page prints of all PCS pages,

g) Layout of cabinets and consoles,

h) Wiring references for interconnection between PCS cabinets and instruments or marshaling racks with I/O assignments in a tabular format.

7.3 Final Drawings/Documents to be supplied by Vendor

The Vendor/Supplier shall prepare the hereunder mentioned documentation in quantity of copies as requested in contract document/drawing schedule and contractual purchase order. All these documents shall be numbered according to the project documents numbering criteria.

7.3.1 Documents

Minimally five copies and one reproducible of the following Vendor documents shall be provided:

- Final loop diagrams developed on the basis of the tender documents incorporating all Company's comments, indicating all elements and information pertinent to field instruments and system's equipment.

- Final feeding and earthing electrical diagrams,

- Final electrical loads and dissipations,

- Final system configuration,

- Final logging and report formats,

- Final System technical specifications,

- Final graphic display pages

- Recommended spare parts list with their pertinent manufacturer's stock number for commissioning period and two years of operation.

All documents shall be in English language and searchable with navigation tools.

7.3.2 Softwares

7.3.2.1 Minimally five copies of the following information shall be provided on CD/DVD:

- Complete final system configurations,

- Complete system application softwares,

- Basic configuration softwares,

- Complete graphic display pages,

- Final logging and report formats.

7.3.3 Manuals

7.3.3.1 Minimally five copies and one reproducible of the following Manuals shall be provided;

a) Operator's manual, including operating guide for the system's softwares (both operating and application softwares),

b) Engineering and user's manual describing how the work may be modified in the future, and how the work is presently configured. This manual shall include all system components technical specifications,

c) Maintenance manual describing how Company's maintenance personnel can perform; preventive maintenance, troubleshooting, repairs, additions, deletions, and modifications of system configuration. This manual shall include spare parts list with their pertinent manufacturer's stock number. All error codes shall be comprehensively listed and explained in maintenance manual.

7.3.3.2 The manuals shall be provided for each component of the PCS, including operator's consoles, process control units, communication devices, peripheral devices. The following information shall be provided as minimum.

- Procedure for re-start after power failure,

- Procedure for periodic adjustments by operators and maintenance personnel,

- Technical description and theory of operation,

- Installation procedure,
- Maintenance and troubleshooting procedure,
- Editing procedure for graphics, report pages and logic diagrams,
- Procedure for calibration of all I/O,
- List and descriptions of all system error messages,
-Any drawings required for this maintenance and operation manual,
- Printed circuit board component layouts,
- Component interconnection procedures,
- Parts lists,
- Procedure for adding, deleting, and modifying I/O points,
- Procedure for board-swapping and component-swapping,

7.3.3.3 All Manuals shall be well-organized and easily understood, and shall contain comprehensive tables of contents and alphabetical indices. Topics for each of the hardware components shall include, but not limited to the following:

- Operation procedures,
- Commissioning and start-up procedures.

7.3.4 Drawings

7.3.4.1 Minimally five copies and one reproducible of the following drawings shall be provided:

a) System Configuration Drawing

This shall illustrate the central control configuration, the communications configuration, and the controller configurations, on one drawing, if possible;

b) Operator's Console Layout and Construction Drawing

This shall be scale drawing of the operator's console, showing front, side, and top perspectively. Locations of the various components (i.e. video displays, keyboards, communication panels etc.), shall also be shown with dimensions.

Electrical connections and wiring shall be illustrated and described on separate drawings.

c) Cabinet Layouts and Construction Drawing

Cabinet layout and construction drawings shall be provided for all cabinets supplied by the Vendor. This shall include each controller cabinet, computer, disk, communications, and terminations cabinet. The drawings shall be to scale, and shall illustrate all components in each cabinet and their electrical interconnections, and cabinet mechanical mounting specifications;

d) Termination Schedule

This drawing shall list and illustrate all terminations, indicating terminal/connector numbers, tag names, voltages, currents, polarities, and grounding/shielding requirements. This drawing shall be provided for all terminal strips and cables.

7.3.4.2 System Vendor shall provide reproducible Computer Aided Design (CAD) generated "as-built" mechanical and system interconnection drawings. These drawings shall identify I/O assignments by tag number in a tabular format.

7.3.5 Vendor documentation and drawings shall be also provided after completion of Factory Acceptance Test before shipment.

8. TRAINING

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

a) Operation of the system for operators

b) Maintenance of the system for technicians

c) Advanced system maintenance, configuration and programming for engineers

8.2 The training shall be provided before PCS installation on site. The courses shall be scheduled so as not to be concurrent; so that one person may attend all courses.

8.3 Each course shall be described in terms of;

- Location,
- Duration,
- Schedule,
- Prerequisites,
- Training facilities provided.

9. SERVICE AND PARTS AVAILABILITY

9.1 The system Vendor/Supplier shall have spare parts stock or guarantee to provide the required parts during a reasonable time.

The Vendor shall have qualified service personnel which can promptly assign them to the job site for repairs, adjustments, assistance in problem determination and trouble-shooting.

9.2 The Vendor shall be technically responsible for all installation, commissioning, and start-up work.

10. SHOP TESTS FOR PCS

The PCS Vendor shall submit his own test procedures for all hardware and software supplied based on the requirements specified herein. No material or equipment shall be shipped, unless all required tests successfully conducted and so certified by the Company's assigned inspector. Vendor shall include heat soak test in his test procedure, as well.

10.1 Preliminary Factory Acceptance Test (FAT)

10.1.1 General

The tests shall demonstrate the functional integrity of all hardwares 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 (FAT) on the Company's inspector judgment. A detailed, scheduled factory acceptance test (FAT) procedure shall be submitted in the bid proposal by vendor. Vendor shall provide all necessary personnel and test equipment to perform the tests as, and when required with the costs included in the bid prices and separately indicated.

10.1.2 Quality assurance tests

10.1.2.1 Quality control shall be as per manufacturer's quality control standards to assure desired performance of components/ modules used in the system.

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

10.1.3 System pretests

The Vendor shall check the workmanship and shall perform all the routine tests on the system prior to power-up of the system.

10.1.4 Vendor shall check all the functions of the PCS hardware and software including diagnostic software, at system and sub-system level by simulating system conditions, inputs and outputs.

The second check will be the calibration check of all signal conditioners, alarm setters, and other components which affect the accuracy of the loops for their correct calibration according to the requirements. All of these calibrations shall be performed and logged in the record book of power test to be reviewed by the Company.

10.2 Final Factory Acceptance Test (FAT)

The Company's assigned inspectors will supervise this phase of the tests to be performed on all hardware and software of the system. The necessary manpower and co-operation shall be provided by the Vendor, as well as, all measuring instruments. All sub-systems shall be interconnected as "per actual" interconnecting configuration in the field. PCS vendor shall use simulators to simulate the various inputs and measure the outputs through proper approved measuring instruments.

The following detailed tests are to be performed by the vendor and witnessed by the Company's assigned inspectors. The Company's inspectors shall have the right to perform any of these tests themselves, ask for re-performing any test, or ask for additional test as included in the Vendor's test procedure proposal.

10.2.1 Visual and mechanical tests

Company's inspectors will carry out visual and mechanical test in principle to assure correct, proper and desired workmanship of the equipment.

10.2.2 Functional tests

Functional test shall include simulation of each type of input/output to testify the proper function and response of the equipment. The following tests shall be included, as a minimum:

- Complete loading of the system configuration.
- Performance test of all controller functions.
- Measurement of scan-time of controllers and process interface units.
- Checking of data-bases configuration, range, alarm limits, engineering units, etc., to be in accordance with the specifications.
- Checking of all monitoring systems for their conformity to the drawings and proper quality.
- Checking the function keys to include all functions required and specified.
- Checking monitoring refresh time, data-base update rate, and display changing time to be adequate. The Vendor shall trim the configuration to meet the requirements, in case that, the above mentioned times are inadequate to meet the requirements.
- Checking of redundancy features as per the contract final specification.
- Checking of diagnostic routines for all sub-systems with the faults simulated by Company's

inspectors request, and reviewing the diagnostic alarms at console level and alarm log level.

- Checking the proper functioning of peripheral units.

- Checking all system features

- Checking of interfacing software for foreign devices, such as; tank gauging, packaged units, automation computer system, etc., by means of simulation.

- Simulation of power failure and restart procedures.

- Checking of all formats and reports for logging, alarm/event printings.

- Checking of spare capacity in terms of hardware, memory, and software to meet the requirements stated in the contract final specification.

- Checking of special control strategies and advanced control by connecting the PCS to the process automation computer (if applicable).

-Checking of maintenance functions and troubleshooting procedures.

- Random sample calibration check for I/O, signal conditioner, etc.

10.2.3 Performance test

After completion of checkings mentioned here-above, the entire system shall be remained energized for 72 hours continuously, with hands-off from the system. The system performance for given simulated I/Os shall be only observed during this 72 hour period.

Any kind of malfunction shall be reported as "Observations" in the final acceptance test report to the Company. If any fault is observed in performance test, the test shall be reconducted after maintaining of the fault.

10.2.4 Configuration documentation

All the latest configurations and data-bases, as performed during factory acceptance test shall be transferred on CD/DVD (two copies) and shipped with the PCS.

A complete list showing content, name, size and if multiple CD/DVD are used, which media contains what files shall be supplied.

10.3 Test Records

Each test carried out shall be formally recorded. Any deficiency or problem found in equipment shall be corrected by the Vendor with replacing brand new tested parts. Any change in configuration or data shall be clearly recorded in Test log books.

10.4 Conclusion

All FAT reports shall be presented to the Company's assigned inspectors for his signature and issuance of certificate of shipment on satisfactory completion of witnessing the tests.

11. PACKING AND SHIPMENT

Vendor shall properly pack the system according to Vendor shipping instructions and packaging specifications IPS-G-GN-210 and forward the equipment to the Company's site.

12. SITE ACCEPTANCE TEST

Test shall involve both process equipment and the control system. The site acceptance test is

functional test and may be carried out in stages with procedures similar to the Factory Acceptance Test, but, with the actual process input and outputs connected.

The Vendor shall submit SAT Test Procedures for Purchaser's approval prior to the Test. Vendor specialists shall then perform Site Acceptance Test (SAT) in agreed project work schedule.

The following items shall be considered as minimum requirements:

a) Full functional test shall be carried out.

b) The Vendor shall provide agreed as built documents and drawings following site Acceptance test and commissioning.

c) Vendor specialists shall be responsible to check that the following minimum requirements have been fulfilled:

- Correct installation of cabinets and stations.
- Connection and installation of all System cables and internal cable connections.
- Connection of all power and earthing cables and resistance checks.

d) Vendor shall be required to provide a site-based specialist to perform the following activities as minimum during SAT:

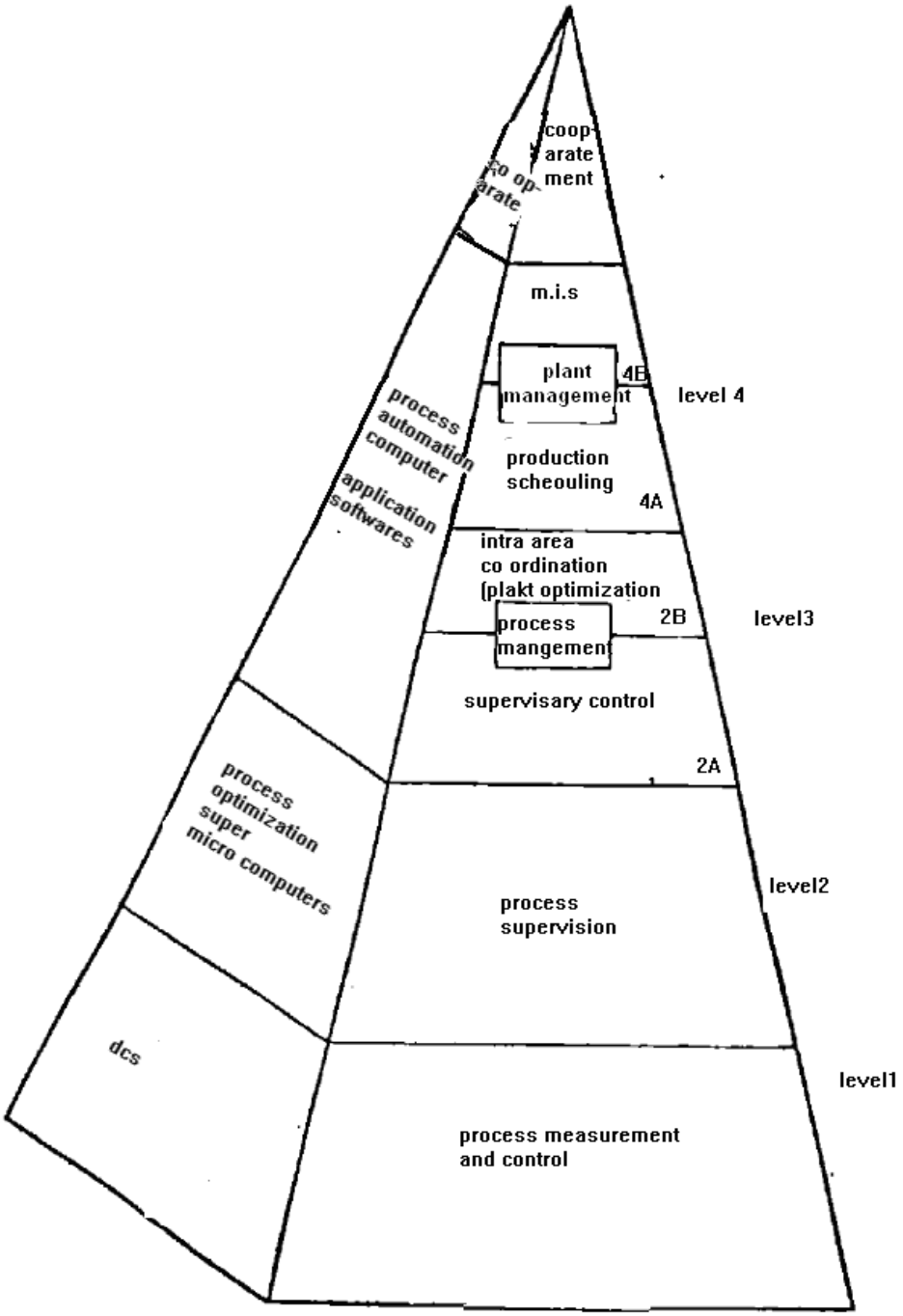
- Operator guidance.
- Loop tuning, Loop checking, Logic and sequence checking, alarm and event checking.
- Control loop configuration amendments.
- Resolve System faults.
- Redundancy check for all items such as power supplies, CPU, LAN, and others if required.
- Functional tests for trend, and history of control loops.
- Functional tests of all utility programs.
- System integration tests to confirm all functions are operational and dependency between functions is present.
- Functional tests of all vendor's supplied application software.
- Functional tests of communication with all third party equipment.
- CPU and memory maximum loading capacity checks.

Upon completion of the installation and pre-commissioning checks, the Site Acceptance Test (SAT) shall be performed. The SAT will be witnessed and signed off by Vendor, Contractor and Company.

APPENDICES

APPENDIX A

COMPUTER INTEGRATED MANUFACTURING (CIM) MULTIPLE LEVELS OF PROCESS EQUIPMENT AND INFORMATION



APPENDIX B

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:

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

R1 through Rn 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:

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

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:

A = MTBF/(MTBF + MTTR)

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

A = A1.A2 .....An

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

A = 1 - [(1-A1) (1-A2).....(1-An)]