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NATIONAL IRANIAN OIL REFINING & DISTRIBUTION COMPANY  
NATIONAL IRANIAN OIL ENGINEERING  
& CONSTRUCTION COMPANY

# NIOEC SP

## NIOEC SPECIFICATION FOR PROCESS CONTROL SYSTEM (PCS)

SECOND EDITION

DECEMBER, 2009

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**IN THE NAME OF GOD****FOREWORD**

By their very nature, technical Specifications are continuously subject to modifications and revisions. To strengthen their merit and usefulness, continuous improvements, addendum, deletion of disparate information and consequently provision of updated revisions are to be made in order to ascertain that such Specifications meet the current requirements, inclusive of Iranian Petroleum Standards (IPS) and the recognized and acceptable national and international Standards, as well as the optimal codes and practices based on the accumulated in-house know-how and plant knowledge and experiences.

However, in reality, due to several reasons, not to mention the complexity of the matter, the ultimate goal of continuous direct embedment of the required changes on the relevant Specifications may be far reaching. Therefore, in the interim periods between the officially issued revisions, the required changes will appear in other documents related to the engineering and design work of the ongoing projects.

In response to the initiative of the Design and Engineering Directorate, and considering that the task of the execution of several important and mega projects for the realization of the new oil refineries, pipelines and oil terminals as well as improvements of the existing facilities, has been assigned to NIOEC, it was decided to update the NIOEC Specifications and to issue new official revisions.

The Design and Engineering Directorate was itself entrusted to carry out this important task, and as such by forming several special technical committees, working in close co-operation and cohesion and sharing their expertise and knowledge, the updated and revised NIOEC Specifications were successfully prepared and complied.

These Specifications are intended to be used for Oil Refineries, Distribution Depots, Oil Terminals, Pipelines and Pump Stations within NIOEC's projects, and have been proven to be of high value for such purposes. It must however be appreciated that these Specifications represent the minimum requirements and should in no way be interpreted as a restriction on the use of better procedures, engineering and design practices or materials.

We encourage and highly appreciate the users and other clear sighted and experts to send their comments on the Specifications to the Design and Engineering Director of NIOEC for evaluation and approval.

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## NOTES:

- 1) THIS SHEET IS A RECORD OF ALL REVISIONS TO THIS SPECIFICATION.
- 2) WHEN APPROVED EACH REVISION SHALL BE CONSIDERED AS A PART OF THE ORIGINAL DOCUMENT.
- 3) NUMBER OF PAGES EXCLUDES THIS SHEET AND THE COVER SHEET.

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## 1. SCOPE

This specification defines NIOEC's minimum requirements for the design, manufacture, test and inspection of Process Control System (PCS).

Deviations from this specification will only be permitted on obtaining written approval from NIOEC.

Resolution on cases not explicitly stipulated in this Specification, or on cases where conflicts may arise among the requirements of the referenced IPS and the international standards, shall be made through written consent and approval of NIOEC.

## 2. REFERENCES

The following standards, codes, and specifications, to the extent specified hereinafter, shall constitute a part of this NIOEC Specification. Latest edition of the undated referenced documents and the cited edition of the dated references shall apply. The applicability of changes made to the dated references, after the cited date shall be mutually agreed upon between NIOEC and the Vendor/Contractor.

### **BASEEFA (BRITISH APPROVALS SERVICE FOR ELECTRICAL EQUIPMENT FOR FLAMMABLE ATMOSPHERES)**

#### **BSI (BRITISH STANDARDS INSTITUTION)**

|                    |                                                                                                         |
|--------------------|---------------------------------------------------------------------------------------------------------|
| BS 381C, shade 217 | "Colours for Identifications, Coding and Special Purposes"                                              |
| BS/EN 55022        | "Information Technology Equipment- Radio Disturbance Characteristics-Limits and Methods of Measurement" |

#### **CENELEC (COMITÉ EUROPÉEN DE NORMALISATION ELECTROTECHNIQUE)**

#### **DIN (DEUTSCHES INSTITUT FÜR NORMUNG)**

|              |                                              |
|--------------|----------------------------------------------|
| DIN EN 50170 | "General Purpose Field Communication System" |
|--------------|----------------------------------------------|

#### **EEC (EUROPEAN ECONOMIC COMMUNITY)**

|                           |                                 |
|---------------------------|---------------------------------|
| EMC- Directive 89/336/EEC | "Electromagnetic Compatibility" |
|---------------------------|---------------------------------|

#### **FM (FACTORY MUTUAL)**

#### **IEC (INTERNATIONAL ELECTRO-TECHNICAL COMMISSION)**

|                                                   |                                                                                |
|---------------------------------------------------|--------------------------------------------------------------------------------|
| IEC 60751                                         | "Industrial Platinum Resistance Thermometers and platinum temperature Sensors" |
| IEC 61000-4-2,<br>IEC 61000-4-3,<br>IEC 61000-4-4 | "Electromagnetic Compatibility (EMC)"                                          |

---

|                             |                                                                                                                        |
|-----------------------------|------------------------------------------------------------------------------------------------------------------------|
| IEC 61499-1,<br>IEC 61499-2 | “Function Blocks”                                                                                                      |
| IEC 61158-2                 | “Industrial communication networks – Fieldbus specifications<br>- Physical Layer Specification and Service Definition” |
| IEC 61131-3                 | “Programmable controllers –Part 3: Programming languages”                                                              |
| IEC 60332                   | “Tests on electric and optical fibre cables under fire<br>Conditions”                                                  |
| IEC 60529                   | “Degree of Protection Provided By Enclosures (IP Code)”                                                                |
| IEC 60068                   | “Environmental Testing”                                                                                                |
| IEC 60605                   | “Equipment Reliability Testing”                                                                                        |

**IEEE (INSTITUTE OF ELECTRICAL & ELECTRONICS ENGINEERS)**

|               |                                                                                                                   |
|---------------|-------------------------------------------------------------------------------------------------------------------|
| IEEE C37.90.1 | “Surge Withstand Capability (SWC) Tests for Relays and<br>Relay Systems Associated with Electric Power Apparatus” |
|---------------|-------------------------------------------------------------------------------------------------------------------|

**ISA (INSTRUMENTATION, SYSTEM AND AUTOMATION SOCIETY OF AMERICA)**

|                   |                                                                                                         |
|-------------------|---------------------------------------------------------------------------------------------------------|
| ISA-18.1          | “Annunciator Sequences and Specifications”                                                              |
| ANSI/ISA-5.1      | “Instrumentation Symbols and Identification”                                                            |
| ISA-5.2           | “Binary Logic Diagrams for Process Operations”                                                          |
| ISA-5.3           | “Graphic Symbols for Distributed Control/Shared Display<br>Instrumentation, Logic and Computer Systems” |
| ISA-5.4           | “Instrument Loop Diagrams”                                                                              |
| ANSI/ISA-50.00.01 | “Compatibility of Analogue Signals for Electronic Industrial<br>Process Instruments”                    |
| ISA RP 55-1       | “Hardware Testing of Digital Process Computers”                                                         |

**ISO (INTERNATIONAL STANDARD ORGANISATION)**

|          |                                                              |
|----------|--------------------------------------------------------------|
| ISO 9000 | “Quality Management Systems -Fundamentals and<br>Vocabulary” |
|----------|--------------------------------------------------------------|

**NAMURE (NORMENARBEITSGEMEINSCHAFT FÜR MESS UND REGELTECHNIK IN  
DER CHEMISCHEN INDUSTRIE)**

|              |                                                                                              |
|--------------|----------------------------------------------------------------------------------------------|
| NAMURE NE 43 | “Standardization of the Signal Level for the Failure<br>Information of Digital Transmitters” |
|--------------|----------------------------------------------------------------------------------------------|

**NFPA (NATIONAL FIRE PROTECTION ASSOCIATION)**

|         |                            |
|---------|----------------------------|
| NFPA 70 | “National Electrical Code” |
|---------|----------------------------|

**NIOEC SP (NIOEC SPECIFICATIONS)**

|                 |                                             |
|-----------------|---------------------------------------------|
| NIOEC-SP-00-10  | “Specification for Units”                   |
| NIOEC -SP-70-01 | “Specification for Instrumentation”         |
| NIOEC -SP-70-02 | “Specification for Instrument Installation” |
| NIOEC -SP-70-05 | “Specification for Cabling”                 |
| NIOEC -SP-80-02 | “Specification for Painting”                |

**NIOEC SIP (NIOEC SHOP INSPECTION PROCEDURE)**

|                 |                                             |
|-----------------|---------------------------------------------|
| NIOEC-SIP-70-01 | “Shop Inspection procedure for Instruments” |
|-----------------|---------------------------------------------|

**PTB (PHYSIKALISCH TECHNISCHE BUNDESANSTALT)****TIA (TELECOMMUNICATION INDUSTRY ASSOCIATION)**

|          |                                                                                                         |
|----------|---------------------------------------------------------------------------------------------------------|
| TIA -485 | “Electrical Characteristics of Generators and Receivers for Use in Balanced Digital Multipoint Systems” |
|----------|---------------------------------------------------------------------------------------------------------|

**UL (UNDERWRITERS’ LABORATORIES)****U.S. MIL HNBK U.S. MILITARY HANDBOOK**

|              |                                                  |
|--------------|--------------------------------------------------|
| MIL-HDBK-217 | “Reliability Prediction of Electronic Equipment” |
| MIL-HDBK-472 | “Maintainability Prediction”                     |

**3. UNITS**

International System of units (SI) shall be used in accordance with NIOEC-SP-00-10, unless otherwise specified.

**4. DEFINITIONS AND TERMINOLOGY**

This section contains definitions for the terms as they are used in this document.

**Advanced Control:** Multi-variable, constraint and optimizing controls will be labelled advanced controls. Controls that fall into this category will be those that are supervisory in nature, i.e., they normally, but not always, output to the set points of other control loops rather than to the valves directly.

**Auto Sense:** Capability by the system to automatically detect and recognize any hardware upon addition to or removal from the system without user intervention.

**Auxiliary System:** A control and/or monitoring system that is stand-alone, performs a specialized task, and communicates with the automation system.

**Call Up Time:** The time between when the operator initially enters a display request and when all objects, lines, values (good or invalid), trends and other parts of the display have been fully presented to the operator.

**Configurable:** The capability to select and connect standard hardware modules to create a system; or the capability to change functionality or sizing of software functions by changing parameters without having to modify or regenerate software.

**Configuration:** The physical installation of hardware modules to satisfy system requirements; or the selection of software options to satisfy system requirements.

**Cycle:** The scanning of inputs, execution of algorithms and transmission of output values to devices.

**Dead band:** The range through which an input signal may be varied without initiating an action or observable change in output signal.

**Discrete Control:** Control where inputs, algorithms, and, outputs are based on logical (yes or no) values.

**Equipment or System:** Process Control System (hardware/software)

**Faceplate:** A graphic element that mimics the front panel of an analogue controller instrument, hardwired push-button or switch. The same is true for the graphical representation on the Operator Interface

**Factory Acceptance Test (FAT):** The final test at the vendor's facility of the integrated system being purchased.

**Fieldbus Foundation:** An independent, non-profit organization established to support standardization of the ISA/IEC Foundation Fieldbus standard.

**Foundation Fieldbus:** A Fieldbus that conforms to all Fieldbus Foundation specifications.

**Foundation Fieldbus Segment:** Grouping of Foundation Fieldbus devices connected to the automation system through an H1 interface module.

**Foundation Fieldbus Trunk:** Main path of a Foundation Fieldbus. The trunk line connects the system H1 module to power supply / power conditioning assembly.

**Foundation Fieldbus Spur:** A spur branches off the Foundation Fieldbus trunk.

**Function Block Application Process:** Fieldbus Foundation specification defining the plant or factory applications that perform one or more automatic monitoring and control functions.

**H1:** Wiring which connects Foundation Fieldbus devices used for control applications such as temperature, level, and flow control. Devices can be powered directly from the Foundation Fieldbus and will operate on existing wiring that was previously used for 4-20 mA devices.

**Invalid Value:** The state of a tag value which indicates that the quantity being measured or calculated is out-of-range, not measurable or calculable.

**Logs:** Files or printouts of information in chronological order.

**Mode:** Control block operational condition, such as manual, automatic, or cascade.

**Module:** An assembly of interconnected components that constitute an identifiable device, instrument, or piece of equipment. A module can be disconnected, removed as a unit, and replaced with a spare. It has definable performance characteristics that permit it to be tested as a unit.

**OPC (Object Linking and Embedding for Process Control):** Software application which allows bi-directional real time data flow between two separate applications. These applications may be running on the same or on separate servers.

**Operational Data:** The statistical data such as alarm limits, tuning parameters, and clamping values, as opposed to process data such as input values, output values and setpoints.

**Operator Station:** A station used by an operator to perform the functions required to monitor and control his assigned units.

**Plant Area:** The designated points (inputs, outputs, and calculated values) that belong to a geographic or functional section of a plant.

**Plug and Play:** The ability of hardware equipment to automatically identify itself to the system. When the equipment is powered up it is automatically assigned a unique identity without the need to set any dip switches.

**Point:** A process variable derived from an input signal or calculated in a process calculation.

**Profibus:** Open bus system, standardized in the German DIN EN 50170.

**Purchaser:** In cases where this specification is part of a direct order, Purchaser shall mean the National Iranian Oil Engineering and Construction Company. Where this specification forms part of contract documents, Purchaser shall mean the Contractor. In references to inspection by Purchaser, when this specification forms part of contract documents, this shall be construed to mean that NIOEC shall also have the right of inspection.

**Redundant Configuration:** A system/subsystem configuration that provides automatic switchover, in the event of a failure, without loss of a system function.

**Regulatory Control:** The functions of process measurement, control algorithm execution, and final control device manipulation that provide closed loop control of a plant process.

**Reliability:** The probability that the system or component will perform its intended function for a specified period of time.

**Self-Diagnostic:** The capability of an electronic device to monitor its own status and indicate faults that occur within the device.

**Supervisory Control:** Higher level control functions that interface with regulatory controllers and other automation system equipment to provide for integrated control.

**System Access Restriction:** Access control by key lock, password or other equivalent method.

**System Alarm:** Alarm that occurs as a result of an automation system hardware or software fault.

**System Operating Software:** The vendor's standard software that performs the basic functions of the system.

**Tag:** A collection of attributes that specify either a control loop or a process variable, or a measured input, or a calculated value, or some combination of these, and all associated control and output algorithms. Each tag is unique.

**Tag ID:** The unique alphanumeric code assigned to inputs, outputs, equipment items, and control blocks. The tag ID might include the plant area identifier.

**Station:** A set of electronic equipment including, at a minimum, one PC, one monitor and one keyboard.

## 5. ABBREVIATIONS

**CPU:** Central Processing Unit

**CRC:** Cyclic Redundancy Check

**DDE:** Dynamic Data Exchange

**EMI:** Electromagnetic Interference

**ESD:** Emergency Shut Down

**FAT:** Factory Acceptance Test

**IS:** Intrinsically Safe

**MOV:** Motor Operated Valve

**MTBF:** Mean Time Between Failures

**MPC:** Model Predictive Control

**MTTR:** Mean Time To Repair

**OLE:** Object Linking and Embedding

**OPC:** OLE for Process Control

**PC:** Personal Computer

**PCS:** Process Control System

**RFI:** Radio Frequency Interference

**SAT:** Site Acceptance Test

**SQL:** Sequential Query Language

**UPS:** Un-interruptible Power Supply

## **6. PRODUCT HISTORY**

Equipment shall be of the same model and design as used in similar plants and operating/ambient conditions with at least three (3) years of satisfactory operational history.

## **7. CERTIFICATION AND APPROVALS**

The equipment shall bear CE marking in accordance with EMC- Directive 89/336/EEC, and the conformity certificates shall be provided.

The VENDOR shall also submit certificates/records of type test approval of the system, based on recognised national or international standards, which for CENELEC regulations shall be LCIE, TUV, PTB, BASEEFA and for NEC regulations shall be FM or UL.

## **8. GENERAL SYSTEM REQUIREMENTS**

### **8.1. General**

- a) The Plant shall be monitored, controlled and safeguarded from a central control room via a Process Control System (PCS) and Safeguarding System (SGS).
- b) Start-up and orderly shutdown shall be manually controlled via PCS by plant operators following the relevant instructions. However, the PCS shall be able to perform automatic sequences of start-up or orderly shut-down if required in a specific project.
- c) The PCS shall be considered as the first layer of safety, hence the pre-alarms shall be configured as low priority and ESD alarms are configured as high priority.

### **8.2. Electrical Power**

The equipment will be powered from dual redundant Un-interruptible Power Supplies (UPS). The UPS will provide 230 VAC  $\pm$  2%, 50 Hz  $\pm$  1%. However all system modules shall be

capable of operating during voltage variations up to  $\pm 10\%$  and frequency variations up to  $\pm 5\%$ .

The battery will be capable of sustaining all components of the system for a period of at least 30 minutes in the event of total power loss.

### 8.3. Environmental Data

Indoor temperature and humidity will be  $23\text{ }^{\circ}\text{C} \pm 3^{\circ}\text{C}$  and 30% RH to 65% RH respectively and shipping and storage conditions will be considered as  $-20\text{ }^{\circ}\text{C}$  to  $85\text{ }^{\circ}\text{C}$  and 0% RH to 100% RH.

However, as a minimum the following operating conditions shall not degrade the continuous operation of the system:

- o Min/max temperature:  $0^{\circ}\text{C}$  to  $40\text{ }^{\circ}\text{C}$
- o Min/max humidity: 20% to 90% RH non-condensing
- o Suspended Solids are dust and sand.

Allowable indoor noise level shall be 55 dBA, measured at one meter from equipment in question.

### 8.4. Ingress Protection and Hazardous Area Classification

Control and rack rooms shall be considered as non-hazardous areas. Both control and rack rooms will be air-conditioned and pressurized.

Indoor stations and system cabinets shall conform to IEC-60529, IP 42, as a minimum.

Electrical accessories and cabling in hazardous areas will normally be of intrinsically safe construction and execution suitable for NEC Class 1, Division 1, and Group C (IEC Zone I, Group II B) locations. Where intrinsically safety equipment is not available, suitable explosion-proof equipment to suit the Area Classification shall be employed. Junction boxes shall normally be increase safety. Where increase safety equipment is not available, junction boxes shall be provided according to the area classification.

### 8.5. Electromagnetic Interference

Equipment shall meet all electromagnetic compatibility requirements of the IEC 61000-4-2, 61000-4-3, and 61000-4-4 standards.

Each element of the PCS must function without introducing intolerable electromagnetic disturbances to other items or being susceptible to electromagnetic influences from other systems.

Emission limits generally comply with the relevant requirements of BS EN 55022, and Susceptibility performance shall generally comply with the relevant requirements of IEC61000-4. All equipment comprising the PCS shall be designed in such a way as to ensure immunity to interference from VHF and UHF hand portable transceivers operating in the range 150 MHz to 470 MHz with a power output of 1 Watt (RMS) held at 300 mm from any equipment forming part of the PCS.

## 9. SYSTEM DESCRIPTION

### 9.1. Configuration

Configuration of the system and the specifics quantities of hardware will be specified in the specific project documents.

Configuration and programming of the PCS and SGS shall strictly follow the requirements of the P&IDs, control narratives, functional block diagrams, safeguarding narratives, logic diagrams, alarm and trip-setting list and (if available) the cause and effect diagram. Only released for engineering issues shall be used.

### 9.2. PCS Architecture

#### 9.2.1. Automation System

Although NIOEC encourages the use and application of modern technologies in its projects, however such approach to the new findings and technologies must be based on a sound and safe engineering and design practice. As such, taking into account the unsatisfactory performance of fieldbus technology on control loops, especially critical loops and those requiring fast response times, the automation system architecture shall be based on a hybrid of fieldbus technology and the conventional DCS, whereby generally the control loops shall be handled by the DCS and the monitoring loops shall be performed via the fieldbus equipment. The system shall make use of OLE/OPC for interconnectivity of multiple systems from different suppliers, compact packaging with flexible DIN rail mounting, field or rack room mountable control and I/O subsystem.

The system shall be based on an integrated, hierarchical distributed architecture with shared displays such that in combining operator interfaces, process controllers and input/output modules it shall provide an operating integrated system effective at the loop, unit and plant control levels.

Information hierarchy shall be incorporated in fixed, variable and customized format displays. The communication shall be such that any bit of information in any part of the plant, connected to the system, shall be available on any operator station. Each station shall be capable of taking over the function of a failed station.

The PCS shall have the capability for the operator to assume manual control of any or all of the control loops.

The operation of the PCS shall include, but not be limited, to the following:

- Control Configuration.
- Database.
- Hierarchical Displays.
- Historisation.
- Real time and Historical Trending.
- Automatic Diagnostics and Fault Reporting.
- Documentation.

Configuration of the system shall be carried out through Engineering Stations to facilitate on-line system configuration and debugging capability. The Engineering functions shall include system configuration, data base management, graphic display generation, report generation management and utility program access. The functions shall be soft/hard lock protected.

Real time dual redundant LAN and associated communication hardware shall be used to transfer data between various PCS components. TCP/IP shall be provided to link the PCS to the hierarchy of management suite.

#### **9.2.2. Use of Standard Products**

The system shall consist of manufacturer's standard hardware, field proven systems software, and firmware that can be configured to meet the stated requirements. Vendor's standard system operating software shall not be modified to meet any of the Purchaser's requirements.

#### **9.2.3. Software Revision**

All software, exclusive of application software, shall be the most recent revision that is applicable to the system hardware at the time of the hardware freeze date as defined in the contract or purchase order.

Software design shall be such that future revisions or updates of the system operating software will not affect the successful operation of the system.

The system shall allow for upgrading of system operating software on all redundant modules of the system without the necessity of shutting down the process, without losing the operator interface, and without the loss of access to any control function.

Application software shall not require modifications in order to be able to run under new releases of the system operating software. Any new release of system software shall be backward compatible with files created using the previous software releases.

#### **9.2.4. Integrity of PCS**

The PCS shall maintain a high availability figure with a high level of integrity. This shall be achieved by:

- The use of high reliability components,
- The use of hardware redundancy where specified,
- Provision of routine and/or automatic testing and diagnostics,
- Simple fault indication and module replacement repairs.

#### **9.2.5. Reliability of PCS**

The supplied equipment must be designed for the maximum reliability and minimum downtime as required. The system shall have a high degree of tolerance to hardware malfunctions, software and operator miss-keying. Any fault, which develops, shall have its effect localised from that part of the system.

The required reliability shall be achieved through a fault tolerant design, advanced diagnostics and state of the art redundancy schemes.

Automatic switch over between the redundant modules/cards/components shall be incorporated into the system design. Switch over between redundancies shall be transparent to the system; however it shall be reported to the operator stations. Status of data network, node and modules shall be displayed on the station monitors. Failure of either of the networks or associated communication modules shall not interfere with the closed loop control functions.

It shall be possible to replace the malfunctioning redundant parts without system disruption or power off.

#### 9.2.6. Availability of PCS

The availability of the equipment shall be in excess of 99.5 % and shall include all equipment as supplied by the VENDOR. For calculation purposes the equipment supplied by others shall be assumed to have an availability of 99.99%.

The VENDOR shall supply availability calculations based on MIL-HDBK-217 based on a minimum configuration of the following items:

- All controllers associated with process monitoring and control, are operational with no more than a single I/O module failure.
- All control functions available.
- Two VDU and one common functional keyboard operational per operator station.
- At least one printer operational.
- All Engineering and Operator Stations shall be based on specified quantity.

Mean time between failures shall be applied as required to ensure that the entire control cell (excluding field equipment) is a minimum of 99.5% available, based on a MTTR of 4 hours. The MTBF and coefficient of availability rating is inclusive of both hardware and software functions as a system. The PCS supplier shall supply documentation describing the method and identifying the data used in calculating the MTBF and coefficient of availability.

The VENDOR shall detail the MTBF for the total PCS and the method used to achieve the MTTR.

Any module with an MTBF of less than 10,000.0 hours shall be clearly identified by the VENDOR.

#### 9.2.7. PCS Redundancy

The system shall be designed such that all key elements of the system, including CPU, storage devices, communication modules and media, power supplies and other major system elements are provided in automatic dual redundant configurations.

In order to meet the required system availability, redundant and/or fault tolerant technology shall be incorporated.

The following equipment shall be redundant as a minimum:

##### 1) Controllers and associated I/O modules

Complete one to one redundancy is required with full duplication of control modules and I/O modules in closed control loops. It shall also be possible to have redundant control modules that share a single set of I/O. Identical, standard hardware must be used for all redundancy schemes.

Redundant control modules shall simultaneously and synchronously execute a control scheme. The modules shall continuously monitor the health of each other. When the need for a switchover is established by the redundancy software the redundant controller must immediately become active with no software transfer necessary at the time of control transfer to re-establish control. The switchover time from the main to the standby module shall be less than 10 msec. Process control shall continue to be executed in the non-failed unit.

When a module is replaced the new module must automatically initialise, receive the current database from the primary module and pick up in synchronous execution as a secondary module in the redundant relationship. This shall take place without user action for any of the steps.

### 2) Communication Network

The network, including fiber optic cabling shall be dual redundant. On line redundant real time LAN and the redundant associated communication hardware shall have switchover time from the main to the standby of less than 100 msec.

### 3) Power supply

All internal system 24 VDC power supplies shall be dual redundant.

### 4) H1 Cards

The following equipment shall be provided in “mutually backed-up” configuration on an operational group basis.

## 9.2.8. PCS Diagnostics

### a) General

The system shall continuously check itself and report any malfunction, hardware or software, in any part of the system. Clear diagnostic messages and alarming shall be available on the station displays indicating tag address, nature and severity of the defect and time and date.

All system electronic modules shall have built in status indicators to facilitate rapid fault detection and maintenance work.

The activation of any back up module to maintain the system operation integrity shall be completely transparent to the operator. However diagnostic messages shall be sent to the operators via station displays.

### b) On-line Diagnostics

The system must include comprehensive on-line diagnostics with the following minimum features:

Redundant Control Module processors shall perform calculations in parallel and synchronised manner, so that switching from main processor to backup cause no interruption to analogue or digital output signal and without any data loss.

The built-in diagnostics shall include a mechanism to validate the calculation results of redundant processors before sending the calculation results to field devices. Validation shall incorporate a function to check for any difference in the calculation results of the redundant processors. If such error occurs, the built-in diagnostic function shall determine which calculation was invalid and select the processor output with the correct calculation. Vendor shall clearly describe how his system architecture supports this requirement.

Control Module processors shall utilize Error Correction Code (ECC) on the main memory to reduce errors that may be caused by main memory (RAM).

Real-time network shall utilize CRC and frame length check as minimum precaution for securing real-time data transfer.

System alarms initiated by the self-diagnostics functions must alert the operator at the Operator Station within 3 seconds. System alarms and diagnostic displays must be available for all operator stations.

The on-line diagnostic program shall consist of a malfunctions check program that will alert the operator upon the detection of a fault. This shall be a unique and separate system from plant alarms. The self-diagnostics shall, as a minimum, detect a fault or malfunction in the following:

- Real-time network diagnostics which shall include, as minimum, errors due to wrong address, wrong frame length, and response wait time-over, other side busy, and receive data check sum error, network configuration error, and communication timer error. Real-time LAN shall include error counters
- Power supplies and fans
- All PCS cards (Controllers, Processors, Hardwired analogue and digital I/Os, etc.)
- Printers
- Control Module CPU ROM Sum Check Error
- Control Module algorithm execution error
- Calculation function execution error
- On-line/offline downloads error
- Recovery Message
- Third party system communication error, and link failure
- Redundant Control Module database difference among processors
- Instantaneous AC power supply failure/recovery to the Control Module
- Diagnostics shall cover hardware, software and firmware of the PCS

#### 9.2.9. Scalability of PCS

The PCS shall be modular such that an easy expansion from a small system to a large system can be made. The VENDOR shall describe the future expansion philosophy of the installed system in terms of limits of capability and ease of implementation. The description shall include the expansion aspects of control, man-machine interfaces, system database, applications, operating system, hardware and communications.

#### 9.2.10. PCS System Backup

The entire control software shall be backed up; this includes vendor software, control database, user-built programs, source code, data files, schematics and so forth.

Back up must be possible on commercially available media. To recover from an outage, any component of the system must be able to be re-loaded from bulk memory (hard disks).

All the system-related software including engineering tools, application programs, standard and optional packages that are included in the scope of supply shall be delivered with the system on safely protected flash memory devices magnetic or optical media.

**9.2.11. PCS Battery back-up**

The battery backup shall have a minimum capacity of 72 hours and shall be independent of the PCS UPS system at the UPS downtime. The PCS shall monitor the status of its dc power distribution system in order to alert the operator of the malfunctions.

Power failure to a control module for less than 72 hours shall not require the down load of the control module.

Each Operator stations shall be loaded from its own bulk memory automatically when power is recovered.

**9.2.12. PCS Connectivity**

The PCS shall be able to be connected with upper level computers and networks using Ethernet with TCP/IP protocol.

**9.2.13. PCS Interface with Third Party Subsystems**

Dedicated control and monitoring systems for third party subsystems such as PLCs, Tank Gauging etc., shall be interfaced to the PCS, and will be controlled and monitored by the operators.

Sub-systems shall be interfaced via serial link RS-232/422/485 using MODBUS RTU protocol/ Ethernet Interface/OPC. The vendor shall have interface ports that support serial links/Ethernet link at the Control Module level and shall provide the driver software.

The PCS shall perform memory mapping of the sub-system, and achieve seamless integration between the PCS database and sub-system.

**9.2.14. PCS Spare Capacity**

The spare capacity shall allow on site development and modification without major changes to the hardware, software and system configuration.

No more than 70% of the available memory and 70% of the available storage disc shall be utilised during normal PCS operation.

Each system shall be supplied with 10% spare for all elements of the system configuration, including graphics, history, reports, and trends. Fitted and wired spare of 10% for each I/O type and control capability in the base system shall be installed as a minimum. The base system is defined as the quantity of hardware and software needed to meet the project requirements.

Communication networks within the automation system shall include a minimum of ten percent (10%) fitted and wired spare hardware and unused node addresses. System expansion requirements shall be in accordance with the project procurement documents which shall be 30% as minimum. System expansion shall be achievable without shutting down the regulatory controllers not directly involved with the expansion.

The communication network shall utilize automatic network self-addressing technology (plug-and-play), which automatically assigns unique new controller addressing when a new device is connected to the control network.

**9.2.15. PCS Performance and Sizing****a) General**

The control response period shall be used as the measure of PCS performance. The control system can perform proportional, integral, derivative (PID) control using any combination of hardware and software. Functions (e.g. signal selectors, summers, calculation blocks, etc.) associated with controllers shall not increase the control response period.

In case of licensed process units, the maximum allowable control response period shall basically follow the process licensors operational requirements. However following figures are the minimum requirements if no special requirements are specified by the licensors.

| Process Category                                                                                                                                                                                                                                                                                                                                                                                                                                              | Maximum control response period (msec) |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------|
| Flow, PRESSURE, DIFFERENTIAL PRESSURE                                                                                                                                                                                                                                                                                                                                                                                                                         | 300                                    |
| Temperature                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 1000                                   |
| Level                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 1000                                   |
| Designated Fast Process Control Loops                                                                                                                                                                                                                                                                                                                                                                                                                         | 150                                    |
| All Others (Analysis, Density, pH, Etc)                                                                                                                                                                                                                                                                                                                                                                                                                       | 1000                                   |
| <p>* Shorter control response periods may be required for certain control services (e.g. compressor anti-surge, reactor temperature, etc.). Multi-variable advanced process control may be implemented with longer control response periods.</p> <p>In general, the shorter the control response period, the better the control performance. Control response periods longer than those listed above may degrade performance and affect unit operability.</p> |                                        |

**NOTE:** The criteria shown in the above table are typical requirements, if there are no requirements on such special requirement where applicable. The maximum allowable control response period shall basically follow to the process licensors operational requirements.

**b) PID Equation Form**

The PID controller equation should be of the form in which the derivative action is only based on the change in process variable. Those forms of the PID equation in which the derivative action is based on the change in error (and derivative is used) cause the controller output to spike when the operator changes the set point.

**c) Controller Set Point Tracking**

Controller set point should track their respective process variables while in manual mode. For cascade loops, the output of each primary controller should track the set point of its respective secondary controller when the secondary controller is not in cascade mode. All primary controllers should also revert to manual mode when their associated secondary controllers are not in cascade mode. This allows the controller output tracking to take

effect, thereby facilitating bumpless transfer when cascade is re-established. Proper configuration of tracking allows operators to change the mode of any controller from manual to automatic or from local automatic to cascade without causing a process disturbance.

#### **d) Controller Central Processing Unit Capacity**

The control system Central Processing Unit(s) (CPU) shall include sufficient capacity to permit 50% of the slowest controllers at 1000 ms to be changed to 300 ms. Changes to the execution/acquisition rate may be required during process unit operation.

This requirement is in addition to other provision for spare capacity in the control system. The system shall have a standard feature to give the user the freedom to select some control and sequencing functions to be executed at system's fastest execution rates.

#### **e) Indicator Performance**

Indicator data acquisition rate shall be used as a measure of performance. Indicator data acquisition rate is defined as the total time the control system takes to read the process data from the input processor and conditions it for visual display.

For initial system sizing and configuration, an acquisition rate of 2 seconds shall be used. Where indicated data is used in control scheme, the acquisition rate shall follow the controller execution rate listed elsewhere in this Specification.

#### **f) Scanning**

The PCS shall scan all data-points at least once every second. All calculated points associated with a scanned data-point shall be computed at that data-points scan rate. No pulses shall be lost to totalisers between scans.

#### **g) Alarm/Event Handling**

All alarms and events shall be guaranteed to be displayed and printed at the relevant control room within 2 seconds of occurring at the field equipment. Alarm/event acceptance shall be complete within 1 second of acceptance action by the operator.

The PCS shall be capable of handling up to 100 alarm and events per second without affecting alarm event or display handling.

Each PCS control equipment shall be capable of buffering one event per data-point up to a maximum of 100 per equipment when all changes cannot be transmitted completely or a communications failure occurs to the control room operator stations.

#### **h) Displays**

Call up time to bring full display with all information of a standard operation display shall be within two seconds. All dynamic data including historical trends embedded in graphic displays shall be presented on the monitor within the call up time.

All operational displays and customised graphics shall have a data refresh rate of 1 second and all other facilities shall have an initiation response time within 2 seconds of the request being made i.e. reports and logs.

#### **i) PCS System Boot Up After Power Failure**

All nodes on the real-time network shall boot up from self-contained database without dependence on other nodes.

Control Modules shall detect power failure/recovery and perform immediate power fail/recover processing and set the control algorithm status to certain defined conditions.

All Control Modules and nodes connected on the real time process LAN network shall boot up automatically upon power source recovery. Each Control Module or node on the network shall have its own database stored inside it, which will enable it to boot up independently without loading the database from other nodes or servers on the network.

Operator stations and historisation platform shall boot up automatically to the level where all its functions are in operation. User log in and password shall not be required during the boot up process. Boot up shall take place automatically upon switching on the power source.

**j) PCS Loading**

The equipment shall be designed so that under full load conditions, the loading of Processing shall be less than 80%, and that of the Memory shall fall below 70%.

Network load in normal operating condition shall not exceed 50%. This load shall be calculated based on the conditions of "No alarm status" and "All operator displays are continuously updated at one-second cycle with 50 dynamic data per display" occurring simultaneously.

**k) PCS Performance Guarantee**

The performance figures shall be maintained by the PCS at all times independent of system loading. The VENDOR shall provide typical and guaranteed figures for the system offered and the equipment shall be guaranteed for satisfactory performance at all operating conditions specified by the PURCHASER.

### **9.3. System Cabinets Mechanical and Electrical Design**

#### **9.3.1. Mechanical Design**

- Internal layout of cabinets shall be designed to provide unimpeded access to all electronic modules, power distribution switches, fuses, LAN Connection cables, terminals and field cable termination areas.
- Internal framework shall be designed to provide rigid and secure mountings for module racks, power distribution and field cable termination areas.
- Framework shall be braced as required to resist vibration movement.
- Cabinet assembly shall utilise nuts and bolts of adequate size and strength to suit the application. Self tapping screws and pop rivets shall not be used.
- Individual cabinet sections shall match accurately with those adjacent in terms of location holes, overall dimensions and finish.
- Neoprene rubber seals shall be used to seat all doors and side panels.
- Each cabinet shall be designed as free standing units with side walls.
- Cabinets shall be constructed in sections for transportation. Each cabinet section shall be provided with removable, lifting eyes for handling. Group lifts shall employ lifting frames.
- Cabinets shall be plinth mounted. Plinths shall be drilled for mounting by M12 (minimum) bolts. Plinths shall be removable for installation.
- Access shall be by means of 135 degree hinged doors to each cabinet at front and back.
- Cable entries shall be via the bottom of the cabinets from an under floor void. Cables shall be adequately clamped and supported to minimise strain on connectors, associated termination's and equipment.