## 3.0 SPARES PHILOSOPHY

3.1 The system including sequence of event recorder, hardwired instruments etc. shall meet the following spare philosophy. This philosophy shall also be applicable for items like barriers, relays, terminals, lamps, push buttons etc.

3.1.1 Mandatory Spares

Vendor shall include following mandatory spares in their scope of supply:

3.1.1.1 Installed Engineering Spares

Installed engineering spares shall be provided in each sub-system for each type of module to enhance the specified system functional requirements by 20%. The basis of offering installed engineering spares shall include:

a) For a system with conventional and / or smart analog input / output, discrete (contact) input / output, 20% spare input / output of each type shall be considered for calculating I/O modules and all other related accessories.

b) For all serial input / outputs to the system, 20% spare serial I/O ports of each type of serial input / output shall be provided.

c) 20% spare accessories like relays, switches, lamps, fuses, circuit breakers, barriers, isolators, terminals etc.

d) The engineering spares shall be wired up to the field cable interface and shall be in ready-to-operate condition when field cable is connected to spare assigned terminals.

e) Spare pairs of the incoming cables shall be terminated on spare terminals in the marshalling / barrier cabinets as applicable.

f) The system shall be fully engineered considering 20% installed engineering spares including processor loading.

3.1.1.2 Spare Space Requirement

In addition to installed engineering spares specified in Clause 3.1.1.1 of this specification, the system shall be provided with following spare space:

a) The cabinets of the of the programmable logic controller system shall have 10% usable spare space for installing additional I/O cards of each type in future and the PLC processor shall have additional 10% capacity to handle these I/O's. In addition, provision shall be kept for internal wiring of the same up to the I/O terminals.

b) Processor system of programmable logic controller shall have capability to execute additional 20% logics.

c) Each operator console shall contain 20% usable spare group and related display capability in addition to as specified in para 3.1.1.1 of this specification.

d) The system shall have capability to extend its historical trending, logging and user's memory by 20% to meet future expansion with/without adding additional memory modules.

e) The communication sub-system shall have sufficient capacity to handle additional data contributed by addition of 20% I/O over and above installed engineering spares.

f) Usable spare space in cabinets to install 10% spare hardwired items like relays, switches, lamps, fuses, circuit breakers, barriers, isolators, terminals etc. in future.

3.1.1.3 Spare Memory Requirement

a) The system shall be provided with a minimum of 40% spare memory capacity, as required for application program and data base to meet specified functional requirements.

b) It shall be possible to extend the memory by at least 20% over and above the actual requirement at a later date.

3.1.1.4 Spare Software Capability

a) Sufficient additional software capacity shall be available in the system to take care of spares requirement as specified in para 3.1.1.1 and 3.1.1.2 of this specification to meet all functional requirements as per para 4.0 of this specification.

b) Unless specifically indicated otherwise, the offered system shall have software licenses to cover all the tag numbers indicated in the Requisition, including installed engineering spares and spare space indicated in clause 3.1.1.1 and 3.1.1.2 of this specification.

3.1.1.5 Predefined Mandatory Spares

a) Mandatory spares shall be ware-house spares and shall be supplied as loose items.

b) Mandatory spare module of 5% or one module of each type, whichever is higher, must be supplied for each type of modules being used excluding modules used in consoles, servers, Personal Computers.

c) For items like, Video Display Units, keyboards, disc drives, network components, hardwired instruments like barriers, lamps, fuses and circuit breakers, complete item limited to 5% or minimum one of each type shall be supplied as predefined mandatory spare. But this shall not include hardware like hard discs, terminals.

3.1.1.6 Consumable Spares

Any paper, ribbon, printer heads, toner and ink required for printers, video copier or any other consumable item shall be supplied along with system required for minimum of six months duration after system acceptance.

3.1.1.7 Commissioning Spares

Unless otherwise specified, vendor shall be responsible to supply all spares which are found necessary to replace failed modules, failed sub-systems, or corrupted / faulty software while performing pre-commissioning and commissioning activities.

3.1.2 Two Years Operational Spares

Two years operational spares shall be as per Clause 1.2.8(a) of this specification and shall be quoted separately.

## 4.0 DESIGN AND CONSTRUCTION

### 4.1 Design Requirements

4.1.1 Programmable logic controller shall be microprocessor based system which shall be used to execute all the process and safety shut-down logic of the plant. When specified, it shall also execute plant interlock logics and sequence operation and analog control. Programmable logic controller shall be an independent unit and shall not depend on any of its functionality on any other system including Distributed Control System.

In case of common engineering database for DCS and PLC, engineering data for DCS and PLC shall be segregated and the data access shall be through respective engineering stations of DCS and PLC only. Such configuration shall meet the SIL3 compliance by third party certifying agency like TUV/ EXIDA etc

Moreover, wherever exchange of safety parameters between the different PLC sub-systems is required for interlock execution, separate communication network shall be provided between these PLC sub-systems. For SIL certified PLCs, this communication network between PLC nodes shall also be SIL certified.

4.1.2 The system shall be of modular construction and expandable in future by adding additional modules which shall be easily accessible for maintenance and repair. The type of modules shall be kept to the minimum possible in order to have interchangeability and low inventory.

4.1.3 **System Availability**

a) The system shall be designed 'fault tolerant' as a minimum by selecting high grade components of proven quality and proper design of system electronics.

Redundancy shall be provided, as a minimum, as per this specification to improve system availability and reliability. Due considerations shall be given to the environmental conditions particularly for field mounted sub-system, if specified in job specifications, during system design.

b) The system shall have a high MTBF value and shall have well proven record of operating in hydrocarbon plants.

c) The system shall be designed with 99.995% or greater availability. The availability shall be defined as follows:

$$\text{Availability} = \frac{\text{Mean time Between Failure (MTBF)}}{\text{MTBF + Mean time to repair (MTTR)}}$$

For the purpose of calculations, consider mean time to repairs as four (4) hours unless the manufacturer recommends higher value for MTTR. It is therefore necessary that:

i) Vendor covers all necessary spare parts in 2 years recommended operational spares which shall be necessary to meet specified MTTR time.

4.1.4 **Operating Environmental Conditions**

4.1.4.1 Environmentally Controlled Location Installation

a) All subsystem of Programmable Logic Controllers located in Control Room, Local Control Room or in Satellite Rack Room shall be able to operate satisfactorily from 15°C to 30°C and 20% to 80% non condensing humidity.

b) In addition to above, all such sub-systems shall also be able to operate satisfactorily in case of air conditioning failure with ambient temperature of 50°C and 90% non-condensing humidity until the system safe operating limits are exceeded. The minimum period of continuous operation in such condition shall be 48 hours at least once in a month without any damage or degradation of system performance. Vendor, therefore, shall provide continuous temperature monitoring for each cabinet housing items / equipments generating heat, such as system cabinets, barrier cabinets, relay cabinets, consoles etc and also provide alarm for operator alert in case the safe operating temperature limits are exceeded. For marshalling cabinets and Power distribution cabinets, temperature monitoring through temperature switches is acceptable.

c) Chemical filters have been provided in the incoming air conditioning air to limit the concentration of contaminants below following limits:

| Contaminants (Corrosive Gases) | Concentration |
|---|---|
| SOx | < 0.01 ppm by volume |
| NOx | < 0.05 ppm by volume |
| $H_2S$ | < 0.003 ppm by volume |
| $Cl_2$ | < 0.001ppm by volume |

All sub-systems and system components shall be suitable for operating continuously in the above mentioned corrosive environments.

4.1.4.2 Outdoor Installations

a) Sub-systems or system components which are installed outdoor shall be suitable to continuously operate at ambient temperature and humidity specified under ambient conditions. The heat generation effect of current carrying for the electronic modules shall also be considered. For this purpose, the system shall be rated for minimum 5 deg C more than the maximum ambient temperature specified. In case the system is not suitable for the above conditions, necessary cooling arrangement shall be provided.

b) Unless otherwise specified, all PLC sub-systems or system components installed outdoor shall have corrosive environmental protection coating meeting the environmental classification class G3 as per ISA-S71.04.

4.1.5 **Transient, Static and EMI / RFI Protection**

4.1.5.1 The system shall be internally protected against system errors and hardware damage resulting from:

a) Electrical transients on power wiring.

b) Electrical transients on signal wiring.

c) Connecting and disconnecting devices or removing or inserting printed circuit boards in the Programmable Logic Controller (PLC).

4.1.5.2 All sub-systems and system components shall be capable of accepting various signal inputs for its direct use while preventing noise errors due to electromagnetic interference (EMI) or radio frequency interference (RFI) including nearby radio stations, hand held two way

radios, solenoids, relays or contactors carrying heavy currents as per levels of Environmental electromagnetic phenomenon defined in IEC-61000-6-2. The system shall have total noise immunity from UHF / VHF radio communication equipments, (RFI) and (EMI) noise generating equipments as per IEC-61000-4.

4.1.5.3 For interplant, inter unit and other system cables routed in the field, the level of surge immunity required for equipment signal ports shall be increased to level 4 as defined in IEC-61000-4-5 and the system shall operate according to performance criterion B as defined in IEC-61000-6-2.

4.1.6 **On-line Replacement**

4.1.6.1 On-line replacement of any module of programmable logic controller shall be possible in such a way that removal and addition of the module shall be possible and safe without de-energising the system. Furthermore, there shall not be any interruption of the system and process upset while replacing a faulty module in case of TMR, QUAD and dual redundant PLCs.

4.1.6.2 Apart from system modules, power supply units shall be replaceable on-line without disrupting the process and without affecting the system redundancies. It shall be possible to hot swap any faulty system module without degrading the system safety or operation or freezing the output status. The switchover to the healthy module shall be bumpless. The swapped module shall take over the function of the failed module without any manual programming.

4.1.7 **Electrical Isolation**

Galvanic or optical isolation shall be provided for all field signals. The isolation levels shall be as follows:

| | | |
|---|---|---|
| Analog I/O channel to system ground | : | 1500V AC |
| Discrete I/O channel to system ground | : | 500V AC |

External isolator shall be provided, if necessary to meet the above.

Isolation shall also be provided between Engineering / operator console/PLC programming terminal and related sub-systems connected to it if there is any possibility of high voltage being transmitted to the sub-systems.

4.1.8 **Design Requirements of Equipments in Hazardous Area**

4.1.8.1 Unless specifically indicated, the field devices are beyond the scope of this specification. However vendor shall be fully responsible for integrating these devices with their system including compiling and maintaining the engineering data base of these devices and incorporating the data base into the Integrated Asset Management System (whenever specified in the requisition).

4.1.8.2 General requirements

a) Unless otherwise specified, all instruments in hazardous area shall be intrinsically safe type. Other concepts shall be used when specified.

b) For conventional instrumentation, entity concept shall be used for selecting proper barriers / isolators.

4.1.9 **Repeat Signals**

4.1.9.1 Unless otherwise specified in the job specifications, following philosophy shall be followed for repeat signals:

a) Whenever repeat signal/ contact outputs are required as per job specifications following philosophy shall be followed:

i) For intrinsically safe input, isolating barrier with dual output shall be utilized.

ii) For Non-intrinsically safe input, isolator with dual output shall be utilized.

ii) For other contact inputs, repeat contact shall be provided using electro- magnetic relays.

4.1.10 **Surge Protection**

4.1.10.1 Surge protection devices (SPD's) shall be provided on the system to limit the surge voltages reaching beyond the safe limits, under normal, abnormal or lightning strike condition. Unless otherwise specified, SPD's shall be provided at least at the following locations:

a) All serial signal cables (UTP / STP / coaxial and not fibre optical) going from or to control system and from one location to another outside the control building at both control system end.

b) All power incoming cable (110V AC, 110V DC, 240V AC, etc), UPS or non UPS, at the power supply distribution cabinet.

4.1.10.2 The selection of type and rating of SPD shall be selected such that the introduction of this device shall not change the characteristics or reliability of an application, whether it is for the protection of power system, signal such as analog or communication signal, as applicable. The SPDs shall comply with the requirements of IEC-61643-21.

4.1.11 The system shall be designed fault tolerant and shall utilize high quality components of proven quality. Any single system fault shall not degrade the system safety or functionality or affect operation. The system shall have certified Safety Integrity Level as per IEC-61508 / 61511 as applicable and specified in job specification. Unless otherwise specified, it shall meet the availability requirement specified in Clause 4.1.3 of this specification.

4.1.12 Unless otherwise specified in the requisition, the scan time of programmable controller shall be of the order of 250 milliseconds for SIL certified PLCs. The scan time for standard Non-SIL PLCs shall be of the order of 100 milliseconds. Scan time for a PLC shall be as defined under para 2.16 of this specification. The PLC processor sizing shall be done considering the PLC scan time for the units as mentioned in the requisition. Other activities like diagnostics routines, output / dump of data to peripherals, development of sequence blocks or any other activity which consume processor time shall also be accounted while computing scan time. For SIL certified PLCs, this shall also be in line with SIL certification.

4.1.13 Operation of the PLC shall be completely unaffected by a momentary power loss of the order of 20 milliseconds.

4.1.14 The system shall be programmed in principle as per the logic diagrams.. Owner / Consultant reserve the right to revise or review the logic diagrams even after acceptance of any offer. The programming language of offered PLC shall be as per IEC 61131.

4.1.15 Whenever the requirement of SIL is specified for the PLC, it shall meet the requirements of SIL level specified and shall be certified by an independent body (e.g. TUV/EXIDA) for complying requirements of IEC-61508 / 61511 as specified. For shutdown application requiring SIL certification, PLC shall always meet SIL 3 requirements.

4.1.16 The system shall have extensive set of self diagnostics hardware and software for easy and fast maintenance of PLC. Routine checks should run automatically at frequent intervals for identifying any fault in software or hardware. Diagnostics shall be required at local as well as console level.

4.1.17 Safety barriers shall be provided by the vendor for intrinsically safe input/output circuits wherever specified. In such cases, the system shall be designed intrinsically safe based on entity concept. The barriers shall be certified by a statutory authority like Baseefa, LCIE, CSA, UL, PTB, CIMFR etc., for the use in the area classification as specified elsewhere in the job specifications. The proper selection of the safety barriers shall be the vendor's total responsibility. In case of smart transmitter, the entity parameters of the hand held terminals shall also be considered while selecting proper barriers.

4.1.18 Unless otherwise specified all intrinsically safe barriers shall be 3 port isolating type only providing isolation between;

i) Input and output (non-hazardous to hazardous side of barriers)

ii) Power supply and input

iii) Power supply and output

The minimum isolation level shall be 250V.

4.1.19 **Alarm By-pass Switches**

4.1.19.1 Startup by-pass (SBS) switches for alarms

All SBS's shall be configured in the ESD system (i.e. PLC) and shall be operable from operator console. All such by-pass switches shall be alarmed and shall have audit trail.

4.1.20 All Emergency (ESD) switches shall he hardwired and shall preferably be pull type with red coloured knob. Control room mounted ESD switches shall be installed on hardwired console.

4.1.20.1 The ESD switch contact shall be used in ESD system (PLC etc) for logic implementation and event history.

4.1.20.2 Additionally, wherever specified in the requisition, ESD switches shall also directly trip the final ESD element without any intermediate device. Where multiplication of ESD switch contacts is necessary, fail safe relays shall be utilized.

## 4.2 System Configuration

### 4.2.1 General

a) PLC system configuration shall be as specified in the job specification. For emergency shutdown system application specified with SIL classification, the system configuration shall be TMR or QUAD or DMR as per the job specification and shall be certified by independent agency e.g. TUV/ EXIDA.

b) Regardless of the action feature selected (except for single architecture), the failure of single component shall not result in a failure of correctly executed safety function. The degradation mode for the selected configuration e.g. 4-2-0 or 3-2-0 or 3-2-1-0, etc. shall be documented in SIL certification report.

c) In general, the PLC system shall comprise of various sub-systems as described in the subsequent clauses of 4.2.

4.2.2 **Input/Output subsystem**

4.2.2.1 Each I/O module shall have its own processor. I/O modules configured in redundant configuration, shall have their processors properly synchronised.

4.2.2.2 Unless otherwise specified, system shall accept analog 4 – 20mA inputs and contact inputs. The maximum number of Input/Output per I/O module shall be limited as per the following table.

| Sl. No. | Type of Configuration | Maximum No. of I/Os |
|---|---|---|
| 1 | Single I/O system | 8 |
| 2 | Dual I/O system | 16 |
| 3 | Triple Modular Redundant system (TMR) | 32 |
| 4 | Quadruple Modular redundant System (QUAD) | 16 |

In case of PLC certified for SIL requirements, the maximum number of I/O's shall be governed by the SIL certification applicable for specified SIL level.

4.2.2.3 Each I/O shall be galvanically isolated from external control circuit by suitable means. The minimum isolation level between I/O and logic circuit shall be 1000 volts AC. External isolators/ barriers / relays shall be provided for all inputs and outputs of the PLC.

4.2.2.4 Each I/O shall be protected against the reversal of polarity of the power voltage to I/O.

4.2.2.5 Each input shall be provided with filters to filter out any noise in the input line and contact bouncing noise, as applicable.

4.2.2.6 All the inputs / outputs shall be double ended upto the I/O card i.e. two wires per input / output and not with common return for all inputs/ outputs.

4.2.2.7 The interrogation voltage to the inputs and power supply for 2-wire instruments shall be powered from separate redundant power supply / supplies and shall not be a part of PLC, unless otherwise specified. This power supply shall be supplied at one point and shall be distributed by the vendor.

4.2.2.8 a) Each I/O module channel status shall be represented on the operator console.

b) When specified, input module shall be capable of monitoring the input contacts for any wire open fault and short circuit.

4.2.2.9 Analog Input Module

a) Input module shall be able to accept 4~20 mA DC input from smart transmitters (e.g. 4 – 20mA HART).

b) The module shall have 16 bit A/D resolution accuracy of ±0.25% of full scale over the entire range, unless otherwise specified.

4.2.2.10 Output Contact

a) Output contacts from the PLC shall be potential free dry contacts with contact rating as per para 4.2.2.10 b) of this specification. Vendor must provide arc suppression device for each output contact.

b) The output contact rating shall be as follows:

| Sl. No. | APPLICABLE FOR | VOLTAGE RATING | CURRENT RATING |
|---|---|---|---|
| 1. | All output cards driving solenoid valve and alarm annunciator system unless otherwise specified<br>Category – I | 110 V AC/ DC | 0.5 A |
| | Category - II | 24 V DC | 2 A |
| 2 | All motors/pumps/compressor output cards unless otherwise specified.<br>Category – I | 240 V AC | 5.0 A |
| | Category - II | 220 V DC / 110 V DC | 0.2 A |

c) The category of contacts shall be specified in the Requisition. Each output shall be short circuit proof and protected by fuse. Visual indication of fuse blown must be provided for each module.

d) When specified contact output module shall have monitored output features like wire open and short circuit.

4.2.2.11 Where inputs or outputs have multiple field devices for the same measurement or device, the corresponding inputs / outputs shall be configured in separate I/O modules.

4.2.2.12 Where single input signal is available for QUAD or TMR configuration, inputs shall be multiplied to feed inputs to each input modules / channels.

4.2.2.13 PLC shall be provided with Auto I/O testing facility as a standard diagnostics features. PLCs which do not have auto I/O testing facility, manual testing facility shall be provided to detect any system fault. For manual testing, manual switches shall be provided to bypass each input at a time and its effect on the output shall be monitored.

4.2.3 **Processor System**

4.2.3.1 The processor shall have capability to implement all the control functions required to implement the logic scheme as logic/ladder diagram.

4.2.3.2 The size of the memory shall be sufficient for storage of the program instructions required by the logic schemes and other functional requirements. Offer shall indicate the amount of memory capacity occupied by the actual program and spare capacity available for future program modifications or additions.

4.2.3.3 Memory shall be non-volatile. However in case volatile memory is provided, battery backup shall be provided with a minimum of 3 months lifetime to keep the program storage intact. A battery drain indication shall be provided at least one week before the battery gets drained.

4.2.3.4 Watchdog timer shall be a software device. The healthiness of processors shall be continuously monitored by watchdog timer. Any hardware or software problem in the processor system, which shall include, CPU, memory, power supply, communication interface etc. shall cause the watch dog timer to report processor failure.

4.2.3.5 Wherever dual redundant processor is specified, redundancy shall be provided in such a way that in case of failure of the main processor, the standby shall take over automatically. The changeover shall be bumpless. Redundancy shall be provided for complete processor system including processor, power supply and communication sub system.

4.2.3.6 In case of triple modular redundant system all the three processors shall execute the same instructions/program and check their results and vote to correct any faulty result. The faulty processor diagnostic shall be made available.

4.2.3.7 In case of Quad system, individual processor shall execute the same instructions/ programs and check their results within same CPU module and majority vote to correct any faulty result. The faulty processor diagnostic shall be made available.

4.2.3.8 Failure of a single processor in dual redundant, triple redundant system and two processors in QUAD system shall not affect the system. In case of failure of complete processor system i.e. both processors in case of dual configuration, two or more in case of triple redundant system and more than two in case of QUAD system, outputs shall take failsafe state automatically unless otherwise specified in the data sheets.

4.2.3.9 In case multiprocessor configuration is offered, the processors must be able to communicate with each other over the interconnecting data link. Vendor must ensure that system performance shall not be degraded by any means when such a system is offered.

4.2.3.10 It shall be possible to generate the first out alarm by the PLC in case where a group of parameters are likely to trip a system.

4.2.4 **PLC Console (Engineering / Programming)**

4.2.4.1 The PLC console shall be used for programming, program storing, fault diagnostics and alarm monitoring. Whenever specified, it shall also be possible to use this console for plant operation. The functionality to operate as engineering / programming terminal or operator terminal or both shall be as specified in the job specification.

4.2.4.2 It shall consist of at least one coloured 21" active matrix TFT type LCD display unit with backlit LED and one programming / operating keyboard, mouse and printer. If laptop is specified in the job specifications, the same shall be of 15" TFT type LCD display.

4.2.4.3 PLC console when used for plant operation shall also meet the functional requirements as per clause 4.2.5 of this specification.

4.2.4.4 The keyboard shall be easy to operate with each key clearly identified.

4.2.4.5 All illegal entries shall be rejected by the terminal and shall be identified by warning signal on VDU.

4.2.4.6 Manual forcing of any input or output contact connected to PLC shall be possible from keyboard. Forced functions shall have an associated audit trail.

4.2.4.7 It shall be possible to modify, add or delete the application program on line without affecting the outputs.

4.2.4.8 PLC Console shall display logic and/or ladder diagram indicating power flow and shall show description and status of each contact. It shall also be possible to display process alarms and diagnostic messages as and when they appear. Further it shall also be able to display I/O map in a user defined format.

4.2.4.9 It shall be possible to print out the ladder/logic diagram on the dedicated PLC printer. The printer in addition shall also print out:

a) The diagnostic messages as and when generated and diagnostic reports, when called for.

b) Process alarms connected to the programmable logic controller as and when they appear and alarm report whenever initiated. The choice of printing alarms on this printer shall be operator selectable from a key lock / password protected switch on PLC console.

c) The I/O maps showing status of all inputs and corresponding outputs in a user defined format.

4.2.4.10 The PLC console shall be provided with self diagnostics feature which shall display error messages and initiate an audible alarm if the fault is detected. Wherever specified, a potential free contact for diagnostic group alarm shall be provided which shall be connected to the hardwired alarm annunciator system.

4.2.4.11 The system shall be able to identify the failure at least up to the module level including I/O system and redundant processor and report print out.

4.2.5 **PLC Console (Operator)**

4.2.5.1 Where dedicated PLC operator console is specified, it shall be used for operation of plant, fault diagnostics, alarm monitoring and report generation.

4.2.5.2 It shall consist of coloured 21" active matrix TFT type LCD display unit with backlit LED, operator keyboard and printer unless specified otherwise.

4.2.5.3 At least two number cursor control devices shall be provided in addition to keyboard which may include touch screen, mouse, track ball etc.

4.2.5.4 PLC operator console shall have complete graphic capability and shall be able to display process dynamic graphics, overview and group view displays. It shall be possible to operate the plant i.e. start and stop of rotating machinery, opening and closing of valves, PID function etc. from dynamic graphics and group displays available on PLC operator console.

4.2.5.5 It shall be possible to monitor, historise and print out all process alarms, diagnostic alarms and alarm reports.

4.2.5.6 The time stamping of all alarms shall be as per PLC processor time stamping or I/O module stamping.

4.2.5.7 The system shall be able to store and display stored data wherever required. The minimum storage capacity shall be for 30 days at 1 minute sample rate for all the inputs specified, diagnostic alarms, process and first out alarms, manipulation data etc.

4.2.5.8 The system shall be able to generate shiftly, hourly, daily, weekly and monthly reports. The log format shall be furnished during detailed engineering.

4.2.5.9 The system shall be supplied with first out alarm generation capability. The resolution of alarm shall be as per processor cycle time, as a minimum.

4.2.6 **Communication Subsystem**

4.2.6.1 The PLC communication subsystem shall be a digital communication bus that provides a high speed data transfer rapidly and reliably between the processor, I/O sub-system, PLC console and other devices connected in the PLC system.

4.2.6.2 Redundancy in PLC communication subsystem shall be provided as follows unless otherwise specified:

a) For single architecture, the communication subsystem between PLC processor and I/O subsystem shall be single unless otherwise specified. This shall include single communication bus and single interfaces/buffers.

b) For dual I/O configuration, each I/O sub set shall have separate communication interface and bus for connecting to PLC processors.

c) For the triple redundant system, each processor shall have a separate set of PLC communication subsystem.

d) For the Quad systems each I/O subset shall have redundant communication interface and bus for connecting to the redundant CPU modules.

e) The communication subsystem between processor subsystem and PLC console shall be dual redundant, consisting of two separate communication interfaces and two buses, each one configured in redundant mode, unless this is only used as programming aid.

4.2.6.3 In case of redundant PLC communication sub system, on the failure of the active device, the redundant device shall take over automatically without interrupting the system operation. Information about the failed device shall be displayed at local as well as on PLC console. It shall be possible to manually switch over the communication from main bus / device to redundant bus / device without interrupting any system function.

4.2.6.4 The mechanism used by the system for error checks and control shall be transparent to the application information / program. Error checking shall be done on all data transfers by suitable codes.

4.2.6.5 In general, PLC shall provide data in a well established protocol format preferably MODBUS protocol.

Wherever remote I/O is specified in the requisition, it shall be redundant and SIL3 certified (for SIL3 PLCs).Segregation for the remote I/O shall follow the same philosophy of group wise PLC segregation specified in the requisition. Moreover, separate PLC in remote I/O location with peer to peer communication with Host PLC through third party (TUV/ EXIDA etc.) certified SIL3 redundant network is also acceptable for remote I/O requirement. However, separate PLC shall be considered for each of the Remote I/O subsystem within each location.

4.2.7 **System Power Supplies**

4.2.7.1 Unless specified otherwise, the programmable logic controller shall operate on uninterrupted power supply (UPS). However the system shall be capable of operating satisfactorily at the following power supply specifications:

| | |
|---|---|
| Voltage | 110/ 240 V ±10% (as specified in requisition) |
| Frequency | 50 Hz ±3 Hz |
| Harmonic contents | Less than 5% |
| Power interruption | 10 millisecond |

4.2.7.2 The power supply system shall be supplied with dual PLC feeders each capable of handling 100% of the total power supply load requirements. In case of failure of one feeder, redundant feeder shall supply the total load.

4.2.7.3 Each I/O rack shall be provided with redundant power supply system. The power supply for the I/O racks shall be sized to take full load of the I/O racks.

4.2.7.4 The processor rack shall be provided with separate power supply for each processor or redundant power supply module for the processor rack such that failure of one power supply does not affect the system operation.

4.2.8 **Self Diagnostics**

4.2.8.1 The system shall have an extensive set of self diagnostic routines which shall be able to identify all permanent and transient system faults / failures at least up to module level including redundant components and power supplies through detailed VDU displays and report print out.

4.2.8.2 At the local level, failure of a module in any subsystem shall be identified by an individual LED.

4.2.8.3 Diagnostic software shall have the capability to provide information about the failed module/system either in the form of a system configuration display or provide information in the form of a "statement".

4.2.8.4 Self diagnostic software shall have capability to detect faults which make the system permanently close/open in the I/O modules or I/O signal conditioning modules (in case of triple redundant system). This shall be achieved by automatically running the self diagnostic software at cyclic intervals. However, system performance shall not be degraded during the running of this diagnostic software.

4.2.8.5 System for the following functionalities shall be supplied when specified:

a) Long storage historisation

b) Log report generation

c) First out alarm generation

4.2.8.6 System diagnostics shall be capable of identifying, locating and reporting the following faults, as a minimum:

a) Processor fault

b) Communication fault

c) I/O module fault

d) Power supply fault

e) Over temperature monitoring

f) Permanently close / open (stuck on or off) fault

g) Memory fault

h) Signal redundancy fault

Any other additional diagnostic alarm if available as a standard shall also be provided by vendor.

4.2.8.7 Testing software shall be capable of detecting faults in case of normally closed system as well as in normally open system.

4.2.8.8 Feedback must be provided in case of triple redundant system and QUAD system from the output voter system to detect any latest faults of the system in addition to other diagnostic software.

4.2.9 **System Software**

4.2.9.1 The system software shall include all programs for the PLC and PLC console which are required to perform all the PLC functions including communication and self-diagnostics. Whenever PLC is specified for shutdown application with SIL classification, the system shall be designed and engineered in full compliance with the requirement of IEC-61511. Whenever different functional logics are combined within a common PLC, the safety related I/O's of each functionality shall be kept segregated within the system.

4.2.9.2 Logic program shall also be recorded on the external electronic media like DVD which shall be delivered in duplicate together with the system.

4.2.9.3 The PLC programming language for implementation of logic operations shall be based on the following representations:

a) Logic diagrams - Binary logic symbols such as AND, OR, NOT Gates, Timers and Flip-Flops.

b) Ladder diagram - Series / parallel connection of relay contacts.

c) Combination of (a) & (b) above.

4.2.9.4 Diagnostic package and its related equipment and software shall be supplied. A list of additional diagnostic packages available and the packages provided, including the description and capabilities, shall be provided with separate quote, wherever asked.

4.2.9.5 It shall be possible to print out the ladder/logic diagram on a dedicated printer. The printer shall also print out all diagnostic reports. The software package shall enable the owner to modify/add/delete any part of program both on-line as well off-line and for documentation.

4.2.9.6 Software for the generation of various displays including dynamic graphics wherever specified to be provided as per given below:

4.2.9.6.1 It shall be possible to display dynamic graphic of plant on the operator console VDU screens. Graphic displays shall be field configurable only through PLC Console (Programming terminal) with standard / user defined graphic symbols. Dynamic graphic displays of different sections of the plant shall be displayed on different pages.

4.2.9.6.2 The system shall have graphic symbol library as per ISA-5.1 and 5.3. In addition standard industrial symbols like distillation columns, heat exchangers, pumps, compressors, tanks etc. shall also be provided as a standard.

4.2.9.6.3 Graphic displays shall be interactive type through which it shall be possible to control the process. It shall also be possible to send motor start/stop and shutdown valve open/close commands, as specified in job specifications, from this display

4.2.9.6.4 It shall be possible to view the process variable and alarm points and view and change set point value, manipulated variable, controller mode etc. from the graphic display. Also rotating machinery (i.e. compressor / pump) status and valve status shall be displayed on the graphic display with different colours.

4.2.9.6.5 Various colours used in the generation of graphics like colour of the process lines, utility lines, Instrument signal lines and event modifier conditions shall be finalised during detailed engineering. The colours used to identify event modified conditions shall generally be as follows unless otherwise indicated during detailed engineering.

| | | |
|---|---|---|
| Red | : | All points alarm |
| Blue | : | Valve open, pump running. |
| Green | : | Valve closed, pump stopped. |
| Flashing green | : | Shut down valve transition state. |

4.2.9.6.6 It shall be possible to go from any graphic page to related graphic pages or any group view or alarm summary in single key stroke using soft key function.

4.2.9.7 The software for printing alarms, system as well as process, and events on the PLC printer must be provided. All alarms must be printed as and when they appear.

4.2.9.8 Software package for displaying I/O map showing status of inputs and corresponding output providing tag numbers as per logic diagram shall be offered. The I/O map format shall be user definable.

### 4.2.10 Power Supply Distribution

4.2.10.1 All type of power supplies shall be made available at one point. Further distribution of power supply shall be in vendor's scope.

4.2.10.2 In general, all output contacts and solenoids shall be powered with 110V±10% DC/ 24V±10% DC power supply. However, the actual interrogation voltages shall be as per job specifications and logic diagrams.

4.2.10.3 The distribution network for interrogation voltage shall be designed such that a single fault in any branch shall not cause trip of the logic other than where the fault has occurred.

4.2.10.4 Sequential starting of various load centres shall be provided whenever specified.

4.2.10.5 Power distribution network must use bus bars of adequate capacity with DPDT (Double Pole Double Throw) switches and HRC (High Rupture Capacity) fuses in each branch network. Vendor may select circuit breaker if short circuit characteristics do not match the HRC fuse.

4.2.10.6 All cubicles lighting shall be on 240 V, 50 Hz AC normal power supply.

### 4.2.11 PLC System Cabinets

4.2.11.1 All PLC system cabinets shall be completely wired with all modules in place. Inside cabinet wiring shall preferably be done using ribbon type pre-fabricated cables.

4.2.11.2 All the cabinets shall be free standing, enclosed type and shall be designed for bottom entry of cables. Cabinet structure shall be sound and rigid. Cabinet shall be provided with remova IS/IEC ble lifting lugs to permit lifting of the cabinets.

4.2.11.3 Cabinets shall be fabricated from cold rolled steel sheet of minimum 1.5 mm thickness for sides and rear and 2 mm thickness for doors and suitably reinforced to prevent warping and buckling. The rack/ rail mounting plates inside the cabinets shall be of 3 mm thickness. Cabinets shall be thoroughly deburred and all sharp edges shall be grounded smooth after fabrication. Cabinet frame shall be of 9 fold profiled CRCA or of Angle iron frame using minimum section of 50 x 50 x 4 mm angle.

4.2.11.4 Cabinet painting procedure shall include blast cleaning, grinding, chemical cleaning, surface finishing by suitable filler and two coats of high grade lacquer with wet blasting wherever required. Two coats of paint in the panel colour shall be provided for non-glossy high satin finish. Final coat shall be given after assembly at site. Colour of the panels shall be as per Requisition.

4.2.11.5 Each cabinet shall be maximum 2100 mm high (excluding 100 mm channel base), 800 mm wide and 800 mm deep, in general. Construction shall be modular preferably to accommodate 19" standard racks. All cabinets shall be of same height.

4.2.11.6 Cabinets shall be equipped with front and rear access doors. Doors shall be equipped with lockable handles and concealed hinges with pull pins for easy door removal.

4.2.11.7 In order to effectively remove dissipated heat from the cabinets, ventilation fans along with vent louvers backed by wire fly screen shall be provided as required. Ventilation fans shall be provided in all cabinets where the temperature rise with all doors closed and all internal and external loads energised shall exceed 10° C above the ambient temperature. A temperature element (resistance temperature detector or semiconductor type sensor) shall be provided in each System cabinets and temperature switch as a minimum in each marshalling/ PDB cabinet for temperature measurement. Ventilation fans shall be provided in dual configuration, as a minimum.

Each fan shall have a separate dedicated assembly and shall be replaceable on-line without shutting down any equipment/ cabinet/ console in part or in complete.

Ventilation fan assembly shall operate at 240V AC power supply. Each fan shall have its own dedicated circuit breaker.

Each ventilation fan shall be fitted with a protection type finger guard. Whenever, the numbers of cabinets are compacted (supplied in mechanical joined conditions), each cabinet shall be provided with separate ventilation fan assembly.

The maximum noise level with all fans operating and cubicle doors open shall not exceed 85dBA.

Following signals and alarms shall be provided separately as follows:

i) Fan failure alarm for each system cabinet in PLC

ii) Temperature indication of each system cabinet in PLC.

iii) A common high temperature and fan failure alarm in the PLC for each marshalling / PDB cabinets for a group of maximum 10 cabinets as per the requisition.

4.2.11.8 Internal illumination shall be provided for cabinets to ensure proper illumination level of 250 lux for performing maintenance activities.

Lamps shall be provided in each cabinet which shall be activated individually by door operated switches. The lamps shall activate when door is opened and deactivate when the door is closed. The door lock switches selected shall have undergone life cycle cyclic test of at least 1000000 operations and test certificate for the same shall be provided from the manufacturer. A manual over-ride switch shall be provided inside the cabinet which shall keep the lamp deactivated even when the door is open. Cabinets housing memories, which are likely to be affected by fluorescent light, shall have incandescent lamps.

The cabinet lighting shall operate on 240V AC Non-UPS power supply.

4.2.11.9 Equipment within the cabinet shall be laid out in an accessible and logically segregated manner. Cable glands shall be provided and supplied by vendor for incoming and outgoing cables to prevent excessive stress on the individual terminals. All metal parts of the cabinet shall be electrically continuous and shall be provided with a common grounding lug.

4.2.12 **Control Panel /Hardwired Console**

4.2.12.1 Control panels, if required, shall be non-graphic self supporting, free standing cubicle with back doors made up of sectional steel panels. Each section shall be maximum 2100 mm high, 1200 mm wide and 1000 mm deep and shall be mounted on 100 mm high channel base. Care shall be taken to ensure that the face of the panel is truly flat and smooth.

4.2.12.2 Panels / hardwired console shall be fabricated from 3.0 mm thick cold rolled steel sheet. Angle iron frame shall use a minimum section of 50x50x4mm angle.

4.2.12.3 Front of panel/console instrument nameplates shall be black laminated plastic with white core. Nameplate shall be provided on the rear of the panel also for each instrument.

4.2.12.4 Document pocket / wallet shall be provided on the inner side of front and rear doors of each cabinet and on the inner side of the door of each panel. Similar arrangement shall also be made on the inner side of doors of console.

4.2.13 **Wiring Requirements**

4.2.13.1 All wiring shall conform to API RP 552- Transmission Systems. Different signal level cables shall be routed with separation distances as recommended by this code.

4.2.13.2 All wiring inside racks, cabinets, and back of the panels shall be housed in covered, non-flammable plastic raceways arranged to permit easy assembly to various instruments for maintenance, adjustments, repair and removal.

4.2.13.3 All wiring in the raceways shall be properly clamped. All incoming cable and outgoing cables shall be terminated by vendor at marshalling rack. Total wiring cross-sectional area shall not exceed 50% of the raceway cross sectional area.

4.2.13.4 Separate wiring raceways shall be used for power supply wiring, DC and low level signal wiring, and intrinsically safe wiring. Parallel runs of AC and DC wiring closer than 300mm shall be avoided.

4.2.13.5 Vendor can alternately offer prefabricated cables for interconnection between different cabinets and panels.

4.2.13.6 Wire termination shall be done using self insulating crimping lugs. More than two wires shall not be terminated on one side of single terminal. The use of shorting links for looping shall be avoided.

4.2.13.7 Terminal housing shall be strictly sized with considerations for accessibility and maintenance. Minimum distance required between various components is listed below. These distances are clear distances and are excluding the width of the raceways or any other component / item mentioned herein. Following clearances should be considered:

a) Distance between terminal strip and side of the cabinet parallel to the strip, up to 50 terminals, shall be minimum 50 mm.

b) Distance between terminal strip and, top and bottom of the cabinet shall be minimum 75 mm.

c) Distance between two adjacent terminal strips shall be minimum 100 mm.

d) Additional distance for each additional 25 terminals shall be minimum 25 mm.

e) Distance between cable gland plate and the bottom of the strip shall be minimum 300 mm.

4.2.13.8 All terminal / terminal blocks shall be DIN Rail mounted type and shall be easily removable. The size of the terminal blocks / terminals of different types shall be consistent and identical. All terminal blocks shall be mounted on suitable anodised metallic or plastic stand-off.

4.2.13.9 No splicing is allowed in between wire/ cable straight run.

4.2.13.10 Terminal strips shall be arranged group-wise for incoming and outgoing cables separately. Terminal blocks for intrinsically safe wiring shall be separate. 20% spare terminals shall be provided, as a minimum, preferably in each terminal strip. Terminals shall be suitable for wires up to 2.5 sq. mm base solid or stranded conductor in general. For power cables, higher size terminals shall be used.

4.2.13.11 Cabinet and rack layout shall be made considering proper accessibility and maintenance.

## 4.3 Earthing

4.3.1 All system equipment such as marshalling cabinets, system cabinets and other powered equipment shall be provided with following type of grounding system:

a) Protective Earth / Electrical Earth

b) System earth / signal earth

Both system earth and safety earth shall be totally separate from protective earth.

### 4.3.2 Protective Earth / Electrical Earth

a) Earth metallic enclosure / cabinet / console etc. shall be provided with electrical earth lug, as a minimum.

b) Unless recommended otherwise by vendor, all earthing lugs of metallic equipment indicated in Clause 4.3.2(a) above shall be connected individually to electrical protective earthing system bus-bar / earthing station using a maximum of 10 sq mm solid copper conductor PVC insulated wires.

c) Where multiple cabinets are multiplexed together, earth looping with permanent shorting link cables shall be acceptable. Earthing connection wires as indicated in Clause No.4.3.2(b) above shall be used for connecting multiplexed cabinets to protective earth station / bus-bar.

4.3.3 **System Earth**

a) System earth shall be totally noise free dedicated earthing system and shall be fully isolated from electrical protective earth. This earth must be very high integrity system and shall be used to ground zero volt references and signal cable grounds.

b) System earth shall be less than one (1) ohm grounding system or as per vendor's recommendation with its own dedicated earth pits. The earth pits shall be suitably located outside the control room and away from any heavy noise plant equipment.

The earth pit design shall be as per IS-3043 code of practice for earthing. A minimum of two (2) number of earth pits, in redundant configuration, shall be provided in each Control room / SRR / Remote IO cabinet location for System earth. In case number of pits required to meet system earth resistance are more than one (1) number, the number of system earth pits shall be two times the actual number of pits required to meet the redundancy requirement specified above. All these system earth pits shall be securely connected with each other to form a one homogeneous system earth grid.

c) Each marshalling / system cabinet etc. shall be provided with system earth bus-bar which shall be insulated from the metallic body frame. This bus-bar shall be used to earth also signal zero volt references and signal cable screens. Terminals used for termination of spare conductor pairs / cores of multi-pair signal / control cables shall be connected to system earth bus-bar. Shorting links shall be used for spare terminal looping.

d) System bus-bars in the multiplexed cabinets can be joined together by permanent shorting links. System bus-bars of other cabinets can also be connected together provided they are permanently joined using 35 sq. mm stranded copper conductor cable.

c) The redundant System earth pits at each location shall be connected to the Electrical protective earthing system through suitable surge isolation and protection device for lightning equipotential bonding. These lightning surge isolation and protection devices shall comply to the requirements of IEC 62561-3.

4.4 **Interface with DCS**

The PLC shall be required to be interfaced to the Distributed Control System bus whenever specified. A suitable interface shall be offered in order to achieve the following functions:

a) Display of all input points under alarm/first out alarm connected to PLC or generated by PLC, continuous indication for analog signal on the main DCS operator console.

b) Generate shutdown reports on the logging printer of Distributed Control system.

c) To receive certain operational commands from the operator console for the operation of certain output devices connected to PLC

d) To display diagnostic message of PLC.

In general, PLC shall provide data in a well established MODBUS protocol format.

The interface shall be dual redundant unless otherwise specified.

The speed of data transfer shall be such that any change in I/O which is to be updated on the operator console shall not exceed 3 second from the time event to update on the operator console screen considering one second standard update rate in DCS operator console.

**4.5 Sequence of Event (SOE) Function Requirement**

Sequence of Event, whenever specified, for analog and digital inputs shall be generated and time stamped in PLC. The maximum resolution between two events shall not exceed specified PLC scan time unless specified otherwise. A separate SOE PC with colour 21" active matrix TFT type LCD display unit with backlit LED and printer shall be provided for PLC sub-system unless specified otherwise.

The following signals or changes of state shall also be logged as part of the Sequence of Event functionality:

For each hard wired analog input:

- Shutdown / trip alarm
- Input Measurement diagnostic status (e.g. input out of range)
- Maintenance override status (wherever provided)
- Input force status.

For each hard wired digital input:

- Shutdown / trip alarm
- Input status (e.g., line breakage)
- Maintenance override status (wherever provided)
- Input force status.

## 5.0 TESTING, INSTALLATION, COMMISSIONING AND ACCEPTANCE

### 5.1 General

5.1.1 This specification defines the basic guidelines to vendor for factory testing and acceptance, installation, commissioning and field acceptance of the complete PLC system. On the basis of this specification, vendor shall submit their own detailed testing, installation, commissioning and acceptance procedure. For hardware, the procedure shall include test name, purpose of test, test equipment / set up, definition of input, test procedure, results expected and acceptance criteria. Similarly for software, it shall include test name, details of the method, list of tests, sequence of execution, results expected and acceptance criteria. For PLC system with SIL 3 requirement, certificate for hardware & software (Like TUV/ EXIDA) shall be verified.

5.1.2 The testing and acceptance of the system shall be carried out on the approved testing procedures and criteria based on this specification and vendor's standard testing requirements and procedures.

### 5.2 Factory Acceptance Tests (FAT)

5.2.1 Vendor shall test and demonstrate the functional integrity of the system hardware and software. No material or equipment shall be transported until all required tests are successfully completed and certified "Ready for Shipment" by the owner/consultant.

5.2.2 The purchaser reserves the right to be involved and satisfy himself at each and every stage of inspection. The purchaser shall be free to request any specific test on any equipment




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considered necessary by him although not listed in this specification, as a part of approval of factory testing procedure. The cost of performing all tests shall be borne by the vendor.

5.2.3 Vendor to note that acceptance of any equipment or the exemption of inspection or testing shall in no way absolve the vendor of the responsibility for delivering the equipment meeting all the requirements specified in Requisition.

5.2.4 It shall be vendor's responsibility to modify and/or replace any hardware and modify the software if the specified functions are not completely achieved satisfactorily during testing and factory acceptance.

5.2.5 Schedule of FAT shall be included in the Vendor's proposal.

5.2.6 Vendor shall not replace any system component/module/sub-system unless it is failed. A log of all failed components/modules in a sub- system shall be maintained which shall give description of the failed component/module, effect of failure on the sub-system, cause of failure and number of hours of operation before it failed. If malfunction of a component/module in a sub-system repeats, the test shall terminate and vendor shall replace the faulty component/module. Thereafter the test shall commence all over again. If even after this replacement, the sub-system fails to meet the requirements, vendor shall replace the full sub-system by the one meeting the requirements and the system shall be tested all over again. If a sub-system fails during the test, which is not repaired and made operational within four hours of active repair time after the failure, the test shall be suspended and restarted all over again only after the vendor has replaced the device in the acceptable operation.

5.2.7 Testing and FAT shall be carried out in two phases. The minimum requirements for testing during these two phases shall be as follows:

5.2.7.1 Under the first phase, vendor shall perform tests at his works to ensure that all components function in accordance with the specification for each type of test. A test report shall be submitted for purchaser review within one week of completion of this test. Phase II testing (witness inspection) shall start only after this.

All sub-systems shall undergo a minimum of 30 days (720 hours) burn-in period and this can include FAT duration. Should there be a failure noted during FAT, this duration shall be extended. It may include any such time for which the system has been kept powered on even for system generation and Phase-I testing.

Following tests shall be performed by the vendor and reports shall be forwarded to purchaser:

a) Quality control test which shall be carried out to assure quality of all components and modules in accordance with vendor's quality control and assurance procedures.

b) System pre-test which shall be physical check of all modules, racks, cabinets etc.

c) System power-up test which shall test functionally all hardware and software. This shall include testing of redundancy, System performance on power supply variations, application software testing and system diagnostic verification.

5.2.7.2 The second phase of testing shall systematically, fully and functionally test all hardware and software in the presence of purchaser representatives. All subsystems shall be interconnected to simulate, as close as possible, the total integrated system. Following minimum tests shall be carried out:-

a) Visual and mechanical testing, which shall be carried out in principle to assure correct, proper, good and neat workmanship by the vendor This testing shall include dimensional verification, Layout verification as per approved GA drawings, Verification of Sheet thickness / Quality of painting (outer and inner) / Nameplates, identifiers and tag plates / Adherence to ferruling philosophy / Dressing of wires / prefabricated cables and clearances / Locks and handles as a minimum.

b) Verification of Bill of Material. The Bill of material verification shall include both hardware and software.

c) Functional testing:

This shall include the simulation of each input and output to verify proper system response. The testing as a minimum shall include:

i) Complete system configuration loading.

ii) Demonstration of all PLC system builder functions including addition/deletion of an input/output, addition/ deletion of a rung or an element in a rung, generation of dynamic graphics and other views, report generation etc.

iii) 100% checking of logics configured in the PLC by connecting switch/lamp at input/output, by simulating inputs and verifying outputs preferably using simulator, other related functions like forcing, first out shall also be verified.

iv) Checking of scan time. Scan time verification shall be carried out during Factory Acceptance Test based on the specified requirements considering discrete input by given step change and Step input or slow ramp input (typical frequency of 4 cycles / second) with amplitude corresponding to 16mA (4mA to 20mA or vice versa) for all conventional analog and smart (HART) inputs from a signal generator. The scan time values so observed shall be within 90% confidence level.
The inputs to the system shall be:

- Step input i.e. 0 or 1 for all contact inputs. Step input can be generated by wiring back a digital output configured for the purpose.
- Step input or ramp input for all analog inputs. However, for PLC, the scan time check with analog inputs shall only be for record purposes.

v) Checking of all PLC console displays, keyboard and touch-screen operation (wherever specified), printer/hard copier functions etc.

vi) System redundancy checks including correct changeover of the back-up unit in case of failure of main unit.

vii) System diagnostic checking for all subsystems on local level as well as on console, including checking of the testing software for I/O modules/signal conditioning modules, when specified.

viii) Checking of output status on processor failure.

ix) Checking of first-out alarm generation.

x) Simulation of power failure and system restart auto boot-up of system configuration and program after power restoration.

5.2.8 Vendor shall notify the purchaser at least three (3) weeks prior to factory acceptance test. In the event that representative arrives and the system is not ready for testing, vendor shall be liable for back charges for any extra time and expenses incurred.

**5.3 Installation, Testing and Commissioning**

5.3.1 Vendor shall offer the services of an installation team which would install the equipment in the control room, lay the interconnecting cables inside control room, check-out, test and commission the system.

All technical personnel assigned to the site by the vendor shall be fully conversant with the supplied system and software package, and shall have both hardware and software capability to bring the system on line quickly and efficiently with a minimum of interference with other concurrent construction and commissioning activities.

5.3.2 Vendor's responsibility at site shall include all activities necessary to be performed to complete the job as per Requisition including:

a) Receipt of hardware/software and checking for completeness of supplies.
b) Installation of the system including for free supply equipment, if any.
c) Field cable termination and inter-cabinet cabling and termination.
d) Check out equipment installation.
e) Checking of interconnections, hardware and software configuration, overall system functioning etc.
f) Loop checking.
g) Field tests.
h) Commissioning and on-line debugging of the system.
i) Involvement during plant commissioning and performance of final acceptance test.
j) Co ordination for integration with DCS / other third party system.

5.3.3 **Field Inspection**

5.3.3.1 All equipments shall be inspected thoroughly by vendor after its receipt at site for completeness and proper functioning. Vendor must initiate the remedial action, in case unsatisfactory operation of any item is observed, with intimation to Engineer-in-charge.

5.3.3.2 Vendor must document all observations including details of any malfunction observed. Items/ equipments requiring total replacement must document the reasons for the same.

5.3.4 **Loop Checking**

5.3.4.1 Loop checking shall be carried out by vendor including checking the interconnections, configuration and overall system functioning.

5.3.4.2 Vendor's scope of work as a part of system installation and loop checking shall include termination of field cables in the control room, checking of interconnection between instrument/equipment, glanding, ferruling/tagging of interconnecting cables in control room, ferruling of field cables in control room and performing overall loop performance check.

5.3.4.3 Vendor shall coordinate with the field contractor for smooth and proper loop checking. Any discrepancy found during checking shall be brought to the notice of the Engineer-in-Charge. Complete loop checking shall be performed in his/her or his/her authorised representative's presence.

5.3.4.4 The input signals shall be simulated by disconnecting/connecting the field wires for all field switches connected to PLC. All field transmitters connected to control room shall be loop checked at 0%, 50% & 100% of full scale (for both increasing and decreasing signals). Wherever receiver cards are used, the set point shall be generated by giving the input signal to receiver card. All outputs shall be checked in field, either for actual operation of solenoid valve or actual pick-up of electrical contactor for rotary equipments. Shutdown schemes shall be checked for proper functioning, configuration and actuation.

5.3.4.5 After loop checking is completed, vendor shall connect back any terminals and connections removed for loop checking.

**5.4 System Acceptance**

5.4.1 The owner shall provisionally takeover the system from vendor after System acceptance test. System acceptance test shall be started only after the satisfactory performance of loop checking and verification of all loop checking records by Engineer-in-charge.

5.4.2 The system acceptance test shall be carried out in the presence of owner's representative and Engineer-in-charge or his authorised representative. The tests carried out in System acceptance test shall be fully recorded and duly signed by all representatives participating in the System Acceptance Testing.

5.4.3 Vendor shall carry out the following functional tests, as a part of system acceptance test, as a minimum:-

a) Hardware verification as per final Bill of Material.
b) Visual and mechanical check-up for proper workmanship, identification, ferruling, nameplates etc.
c) System configuration as per approved configuration diagram.
d) Demonstration of all system function, display and diagnostics.
e) Checking of correct change-over of redundant devices.
f) Checking of various peripheral devices like printers and printing of all reports.
g) Complete checking of logic system, loading of user's program and checkout of results.
h) Checking of proper functioning of all disc drives, alarm summary, alarm history etc.
i) Proper information transfer on the information network by verifying system displays and printout.

**5.5 Final Acceptance Test**

The owner will take over the system from the vendor after the final acceptance test, which is defined as successful uninterrupted operation of the integrated system for three weeks. Vendor's personnel shall be present during the test. Any malfunctioning of the system components shall be replaced / repaired as required. Once the system failure is detected, the acceptance test shall start all over again from the beginning. The warranty period commences from the day owner takes over the system.

## 6.0 GENERAL REQUIREMENTS

6.1 Vendor shall comply fully with the general requirements of PLC system including logistic support services, documentation, warranty, maintenance contract and shipping instructions.

**Post Warranty Maintenance Contract**

Vendor shall quote separately for post warranty maintenance contract after warranty period for five years for the complete system as per commercial terms and condition of the requisition and the type (i.e. comprehensive or non-comprehensive) of post warranty maintenance shall be as specified in job specification. The personnel deployed during post-warranty maintenance shall have thorough knowledge of the system and at least two years of experience on the maintenance of similar system. Any other conditions of contract required by vendor shall be explained in the offer.

## 7.0 SHIPPING

7.1 All the materials used for packing, wrapping, sealers, moisture resistant barriers and corrosion preventers shall be of recognised brands and shall conform to the best standards in the areas for the articles which are packed.

7.2 Workmanship shall be in accordance with best commercial practices and requirements of applicable specification. There shall be no defects, imperfections or omissions which would tend to impair the protection offered by the package as a whole.

7.3 The packing shall be suitable for storing in tropicalised climate, the ambient conditions, being specified in job specifications.

7.4 Shipment shall be thoroughly checked for completeness before final packing and shipment. Vendor shall be responsible for any delay in installation or commissioning schedule because of incomplete supply of equipments.

## 8.0 REJECTION

8.1 Vendor shall make his offer in detail with respect to every item of the purchaser's specifications. Any offer not conforming to this shall be summarily rejected.

## 1.0 GENERAL

### 1.1 Scope

1.1.1 This specification together with the attachments covers the design and engineering of instruments, control systems, accessories and materials, along with special test equipments, where the supply is part of a package being supplied by vendor. This specification is general and all instruments/systems included may not be required for the proposed package. The scope shall be as defined in the scope of supply of Instrumentation.

1.1.2 The detailed scope of work, specific job requirements, exclusions, deviations, additions etc. if any, will be indicated in Scope of Supply of Instrumentation and Job Specification of Instrumentation included in the material requisition.

1.1.3 This specification provides only the qualitative specifications of commonly used instruments. Specifications of Instruments not covered in this specification shall be submitted by vendor for review by Purchaser.

1.1.4 Vendor shall be fully responsible for design, material selection, sizing and selection of the proper instruments for their system. The compliance to this specification does not absolve the vendor of the responsibility towards contractual obligations with regards to completeness, proper selection, satisfactory operation and easy maintenance of the unit.

1.1.5 All items, as offered, shall be field proven and should have completed trouble free satisfactory operation for a period of minimum 6 months on the bid due date in the similar application with the process conditions similar to those as specified in the purchaser's data sheets. Items with proto-type design or items not meeting provenness criteria specified above shall not be offered

1.1.6 In the event of any conflict between this specifications, data sheets, related standards, codes etc., the vendor shall refer the matter to the purchaser for clarification and only after obtaining the same should proceed with the manufacturing/engineering of the item in question. DCS/ PLC is not included in this specification. Vendor shall refer specifications attached separately in case DCS/ PLC is included in scope of supply.

### 1.2 Bids

1.2.1 Vendor shall provide the following information along with their offer:

a) Compliance to Complete Material Requisition/Tender.

b) Utility requirements including Power consumption and Instrument air supply consumption. The offer shall indicate the power requirement for Uninterrupted Power Supply (UPS), Non-UPS and DC power clearly indicating the locations for each.

c) Estimated heat load for the equipment located in control room.

d) Control room size and layout (Tentative)

1.2.2 Vendor shall clearly define the operational philosophy proposed, which shall be in line with requirements specified in the job specification. Vendor shall also clearly indicate the provision of control panels and control systems required for the package along with offer.

1.2.3 Documents like Instrument list and typical specifications and any other details if submitted by vendor in their bid, shall not be reviewed and shall be retained for records only. All such details shall be submitted by vendor only after the finalisation of P&ID (Piping and Instrument Diagram) during detail engineering. No implication shall be admissible on the

basis of these documents and vendor shall be responsible for completeness and correctness of the same with respect to Purchase Requisition/Tender.

1.2.4 Vendor's offer, catalogues, drawings, instrument manuals etc. shall be in English.

1.2.5 In addition to mandatory spares, commissioning and consumables indicated elsewhere in this specification, Vendor shall also quote recommended spares for 2 years normal operation for the complete instrument and control system for the offered package.

**1.3 Applicable National/International Standards:**

1.3.1 Design and terminology shall comply, as a minimum, with the latest edition of following codes, standard practices and publications, unless otherwise specified:

AGA American Gas Association, Gas Measurement Committee
- Report No.3 Orifice Metering of Natural Gas and Other Related Hydrocarbon Fluids – Concentric, Square-Edged Orifice Meters
- Report No.7 - Measurement of Natural Gas by Turbine Meter

AG181 Foundation Fieldbus System Engineering Guidelines

ASME American Society of Mechanical Engineers.
- B 1.20.1 Pipe Threads.
- B 16.5 Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24 Metric/Inch Standard
- B 16.47-B Large diameter Steel Flanges: NPS 26 Through NPS 60 Metric/Inch Standard
- B 16.20 Ring Joint Gaskets and Grooves for Steel Pipe Flanges.

ANSI/FCI American National Standards Institute/Fluid Controls Institute
- 70.2 Control valve seat leakage classification.

API American Petroleum Institute
- RP 520 Sizing, Selection and Installation of Pressure Relieving System in Refineries.
  - Part-I - Sizing and Selection
  - Part-II - Installation
- RP 521 Guide for Pressure Relieving and Depressurising Systems.
- RP 526 Flanged Steel Safety Relief Valves.
- RP 527 Seat Tightness of Pressure Relief Valves.
- MPMS Manual of Petroleum Measurement Standards.
- RP 551 Process Measurement Instrumentation.
  - Part 1 - Process Control and Instrumentation.
- RP 552 Transmission Systems
- RP 554 Process Instrumentation and Control
- RP 555 Process Analysers
- S 2000 Venting Atmospheric and low pressure storage tank.
- S 670 Machinery Protection Systems

ASME American Society of Mechanical Engineers.
- ASME Boiler and Pressure Vessel Code (BPVC), Section VIII, Division 1: Rules for Construction of Pressure Vessels.

PTC 19.3 TW :2010 & ERATA 2012
- THERMOWELLS Performance Test

MFC-3M Measurement of Fluid Flow in Pipes using Orifice, Nozzle and Venturi

| | | |
|---|---|---|
| | MFC-14M | Measurement of Fluid Flow in Pipes using Small Bore Precision Orifice Meters |
| ASTM | American Society for Tests and Materials | |
| BS | British Standards | |
| | EN 50288-7 | Multi Element Metallic Cables used in Analogue and Digital Communication and Control – Part-7 : Sectional specification for Instrumentation and Control cables |
| EN 10204 | Inspection Document for Metallic Products | |
| IBR | Indian Boiler Regulations. | |
| IEC | International Electrotechnical Commission. | |
| | 60079 | Electrical Apparatus for Explosive Gas atmosphere. |
| | 60085 | Electrical Insulation – Thermal Evaluation and Designation |
| | 60332 | Tests on electric and optical fibre cables under fire conditions - Part 1-1: Test for vertical flame propagation for a single insulated wire or cable - Apparatus Parts and Sections |
| | 60529 | Classification of degree of protection provided by enclosures. |
| | 60534-2 | Industrial Process Control Valves-Flow capacity. |
| | 60584-2 | Thermocouples – Tolerances |
| | 60751 | Industrial Platinum Resistance Thermometer and Platinum Resistance Sensors |
| | 61285 | Industrial Process Control Safety of Analyser Houses |
| | 61000-4 | Electromagnetic compatibility for Industrial Process measurement and Control equipment |
| | 61158 | Foundation Fieldbus Specifications |
| | 61804-3 | Functional blocks for process control – part 3 Electronic Device Description Language (EDDL) |
| IS | Indian Standard | |
| | 5 | Colours for ready mixed paints. |
| | 319 | Specification for free cutting Brass bars, rods and sections |
| | 1239 | Mild steel tubes, tubulars and other wrought steel fittings |
| | 1271 | Specification of Thermal Evaluation and Classification of Electrical Insulation |
| | 1554 | PVC insulated (heavy duty) electric cables-working Part I voltage upto and including 1100V |
| | 2074 | Ready mixed paints, air drying, red oxide- zinc chrome. |
| | 3624 | Specification for pressure and vacuum gauges |
| | 5831 | PVC insulation and sheath of electric cables |
| | 7358 | Specifications for Thermocouples |
| | 8784 | Thermocouple compensating cables |
| ISA | International Society of Automation | |
| | S-5.2 | Binary logic diagrams for process operations. |
| | S 7.0.01 | Quality standard for Instrument Air |
| | S-75.xx | Standards related to Control Valves |
| ISO 5167 | Measurement of fluid flow by means of orifice plates, nozzles and venturi tubes inserted in circular cross-section conduits | |
| ITK | Interoperability Test Kit (latest version) | |

| | |
|---|---|
| NACE | National Association of Corrosion Engineers |
| NEC | National Electric Code |
| NEMA | National Electrical Manufacturer's Association |
| NFPA-496 | National Fire Protection Association - Purged and pressurised enclosures for electrical equipment |
| OSHA | Occupational Safety and Health Authorit. |
| SAMA | Scientific Apparatus Maker's Association |

**1.4 Drawing and Data**

1.4.1 Detailed drawings, data and catalogues required from the vendor shall be as per Vendor Data Requirement attached elsewhere in the Material Requisition / Tender.

1.4.2 The minimum requirements expected from the various documents listed in Vendor Data Requirement shall be as follows:

1.4.2.1 **Document Control Index (DCI)**

This document lists out all drawings and documents prepared and/or submitted by vendor to purchaser after placement of order through vendor portal. Following information shall be available in this document:

a) Name and number of each drawing and document listed.

b) Expected and Actual date of submission to purchaser.

c) Review category of the documents

1.4.2.2 **Instrument Index**

Instrument Index lists out all instruments appearing on the P&ID without any exception. It is a basic instrument document which is necessary for the smooth execution of a job and is also a reference document after the completion of job. Instrument Index shall be prepared in EIL Format. In case, any other format is used, it must contain all information as listed in this format as a minimum.

1.4.2.3 **Sub Vendor List (for Instruments and Accessories)**

This document shall list out all instrument items and accessories including control system along with the name of the sub-vendors from whom vendor is likely to procure these items. Instrument Sub-vendor shall meet the enlistment conditions of EIL approval at the time of placing the order on sub-vendor for the Project Approved Vendor List. The EIL approval conditions are available with the Sub-Vendors. Vendor shall follow the approval requirement.

For Instruments / items not covered in the vendor list, Vendor shall get approval from purchaser/ owner for the vendors proposed, prior to the placement of order. In such cases the sub-vendors suggested shall be manufacturer of repute and it shall meet the provenness criteria specified in this document.

1.4.2.4 **Instrument Sizing Calculations**

Instrument sizing calculations provide information regarding sizing (as per standards specified else-where in this document), type, selection and other related information.

Following sizing calculations shall be applicable, in general, duly approved by the authority indicated in Vendor's Standard Quality Plan;

a) Control valve including noise and velocity.

b) Pressure relief valves/pilot operated pressure relief valves/rupture disc/breather valve/flame arrester.

c) Flow element including orifice plates, averaging pitot tubes, venturi, flow nozzle etc.

d) Utility consumption calculation including power supply (UPS/Non UPS), Instrument air, steam for tracing, cooling water, nitrogen etc.

e) Cable sizing calculations for power cables.

f) Intrinsically safe loop calculation for proper selection of cables considering various entity parameters.

g) Segment loading calculations.

h) Thermowell wake frequency calculations as pe ASME PTC 19.3 TW-2010

1.4.2.5 **Utility Requirements**

This document lists out the following information regarding utilities required by the vendor;

a) List of utilities required i.e. Power (UPS, Non UPS), Instrument air, Cooling water, steam for tracing, Nitrogen etc.

b) Location and estimated/actual requirement at each location. The requirement shall be listed as minimum/normal/maximum.

c) Incase of AC power, the In-rush current with duration and power factor shall also be indicated for each location.

d) In case of cooling requirement of any instrument/equipment, vendor shall provide the detail of pressure/flow requirement with location.

1.4.2.6 **Nozzle Elevation for Level Instruments**

Nozzle elevation for level Instruments represent the nozzle elevation, nozzle sizes and rating, requirement of stand-pipes, type of level instrument etc. for all the vessels, columns, exchangers and tanks.

1.4.2.7 **Purchase Requisition (PR)**

Purchase Requisition shall contain following information as a minimum but updated in line with the finally accepted offer of the successful vendor including:-

a) Instrument specifications including detailed instrument data sheet and special requirements, if any

b) Testing and Inspection requirements

c) Vendor data requirements

d) Other related documents like Standard Specifications, Quality Assurance requirements etc.

1.4.2.8 **Functional Schematics**

Functional Schematics details out the functionality of all the loops shown on the P&ID including their correlation. The schematic shows all the hardware necessary to configure a loop including their physical location, their interconnection and important software blocks as applicable to make a loop complete. Similar loops may be combined under the same functional schematic.

1.4.2.9 **Logic Diagrams**

Logic diagram is a logic representation of process interlock and shutdown system and details out the functionality, in a schematic form, as either process cause and effect table shown on the P&ID or in a separate write-up. The schematic shall be prepared based on ISA S5.2 – A Binary Logic Diagrams for Process Operations and shall show the physical location of Input/output devices, their interconnection with functional blocks, bench status of all electrical devices etc. The schematic shall also be supplemented with operational requirements like startup and process bypasses, reset and shut down push buttons, selector switches, status lamp etc.

1.4.2.10 **Segment Drawing**

The FF segment drawing provides the complete segment design details indicating all the devices of a segment, the Tag names, device control/monitoring functional requirements, spur length, FF Junction box barriers connectivity, termination details, location of JB etc.

1.4.2.11 **Instrument Loop drawings**

Each loop shall have a separate Instrument Loop drawing which shall show each component from field device to final receiver including physical location; initiating device, its terminal number; junction box with its terminal number; cable number with pair number/polarity; receiver instrument terminals/cabinet terminals; system functional blocks of loop in simplified manner (without configuration details).

1.4.2.12 **Control Room Layout**

Control room layout drawing shall show the location of control panels, system cabinets, marshalling racks and other auxiliary cabinets, consoles with monitors, hard wired consoles, printers, non-system panels/cabinets including panels/cabinets for packages, LEL panel, fire alarms panels or any other equipment required to be installed in control room. The layout shall be prepared on control room architectural drawing and shall also show layout of equipment in engineering room/computer room etc.

1.4.2.13 **Panel Front Arrangement**

This drawing shall show the arrangement of panel mounted instruments like indicating instruments, alarm annunicator, indicating lamps, push buttons/switches etc. including their approximate sizes and their mounting locations.

1.4.2.14 **Configuration Diagram**

This drawing is a graphical representation of all major hardwares required in a configurable control system which are necessary to meet all the expected functional requirements.

1.4.2.15 **Dynamic Graphic Display Drawings**

These drawings provide a graphic representation of P&ID's arranged in a sequence which when displayed on the HMI, shall provide easy and logical operational views.

1.4.2.16 **Input/ Output Assignment**

This document indicates the physical assignment of various I/O modules and their respective channels to various physical inputs and outputs.

1.4.2.17 **Instrument Duct/ Tray/ Trench Layout**

Instrument duct/tray trench drawing shows the routing of main instrument duct/tray trench in the unit/plant. The drawing shall be prepared on plot-plan/ Equipment layout and shall show the size, cross-section at various locations, general notes, symbols, reference drawings and the control room entry.

1.4.2.18 **Instrument Location Plans**

Instrument Location Plans shall show the location of instruments, location of tapping points, location of local panels, junction boxes, main cable trenches, instrument air distribution scheme etc. These drawings are prepared on equipment layout drawings in 1:50 or 1:100 scale depending on density of instruments.

1.4.2.19 **Instrument Cable Schedule**

The instrument cable schedule shall show all instrument and power cables required for complete instrumentation. The document shall show tag number, cable number, type, length and size of cables, type of junction box, identity of local panel, control room panel/cabinet location etc. The document shall also show the size of terminals considered for power junction boxes and the dimensions of cable considered by the contractor.

The cable schedule document shall include all single & multi pair cables indicating terminations of instruments, field junction boxes and respective termination in satellite rack room cabinets. The instrument cable schedule shall be prepared on EIL format.

1.4.2.20 **3D Modelling:**

Whenever 3D modeling is included in package vendor's scope, it shall include the following instrumentation items as a minimum:

a. Instrument Cable Duct.
b. Analyser shelter/ cabinet.
c. Local Control Panels.
d. Prefabricated Hook-ups
e. Gas Detectors
f. CCTV
g. Instrument Junction Boxes
h. Instrument Stanchions and Canopy

## 2.0 DESIGN PHILOSOPHY

2.1 Instrumentation shall be complete in every respect in accordance with latest approved P&IDs for the safe, efficient and easy operation, start up and shut down of the plant.

2.2 All instruments and equipments shall be suitable for use in a hot, humid and tropical industrial climate in which corrosive gases and/or chemicals may be present. As a minimum, all instruments and enclosures in field shall be metallic construction, dust proof and weatherproof to IP-65 as per IS/IEC-60529 and secure against the ingress of fumes, dampness, insects and vermin. All external surfaces shall be suitably treated to provide protection against corrosive plant atmosphere.

2.3 The design of electronic instruments shall be in compliance with the electromagnetic compatibility requirements as per IEC 61000-4 'Electromagnetic compatibility for Industrial Process measurement and Control equipment.

**2.4 Instrument Requirements for Classified Area:**

a) Certified Intrinsically Safe (IS) equipment as per IEC-60079-11 shall be used, in general, in hazardous area, for conventional loops.

b) Field instruments in fieldbus loops shall be designed and certified as per the hazardous area protection specified in Job Specification.

c) In case intrinsically safe equipment is not available, flameproof enclosures as per IEC-60079-01 may be considered.

d) Junction boxes, cable glands and accessories required for flameproof instruments shall also be certified flameproof.

e) All non flameproof panels and cabinets installed in classified area shall be purged as per requirements specified in NFPA-496, as a minimum.

f) Other type of protection specified in IEC-60079 shall not be used.

**2.5 Statutory Approvals**

a) Contractor shall be responsible for obtaining all statutory approvals, as applicable, for all instruments and control systems.

b) In addition, equipments/instruments/systems located in the hazardous area shall be certified by the local statutory authorities for their use in the area of their installation. In general following certification shall be given:

i) For all intrinsically safe/ FISCO/FINICO/ explosion proof/flameproof equipments/ instruments/systems or equipments with any other type of protection allowable as per this package which are manufactured abroad and certified by any statutory authority like Laboratorie Central Des Industries Electriques (LCIE), British Approval Service for Electrical Equipment in Flammable Atmospheres (Baseefa), Canadian Standards Association (CSA), Factory Mutual(FM), Underwriters laboratories(UL) etc. for compliance to ATEX directives or other equivalent standards. All these equipments/ instruments/systems shall additionally have the approval of Petroleum and Explosives Safety Organisation (PESO)/ Chief Controller of Explosives (CCE), Nagpur, if installed in INDIA and the same is mandatory.

ii) For all flame proof equipments manufactured locally (indigenously), the testing shall be carried out by any of the approved test house like Central Institute of Mining & Fuel research (CIMFR)/ Electronics Regional Testing Laboratory (ERTL) etc. The equipment shall in addition bear the valid approval from Petroleum and Explosives Safety Organisation (PESO)/ Chief Controller of Explosives (CCE), Nagpur and a valid BIS license.

iii) For all intrinsically safe equipment manufactured locally (indigenously), the testing shall be carried out by any of the approved test house like Central Institute of Mining & Fuel research(CIMFR)/ Electronics Regional Testing Laboratory(ERTL) etc. The equipment shall in addition bear the valid approval from Petroleum and Explosives Safety Organisation (PESO)/ Chief Controller of Explosives (CCE), Nagpur.

c) Approvals other than above shall neither be offered nor will these be acceptable.

**2.6** Following units of measurement shall be applicable, unless indicated specifically otherwise:

| | | | |
|---|---|---|---|
| Flow | Liquid | : | $m^3/h$ |
| | Steam | : | kg/h |

| | | | |
|---|---|---|---|
| | Gas & Vapour | : | $Nm^3/h$ |
| Pressure/Vacuum | Gauge | : | $kg/cm^2g$ |
| | | : | mm of H2O |
| | Vacuum | : | $kg/cm^2$ |
| | | : | mm of H2O |
| Temperature | | : | °C |
| Level | | : | % |
| Analysis | | : | % |
| | | : | ppm |
| Conductivity | | : | micro siemens |
| Viscosity | | : | mPa.s (cP) |

**2.7** Local control loops shall be avoided. In case these are unavoidable, these shall be electronic field mounted manual loading station only.

**2.8** Ranges for instruments shall be selected in general, such that in normal process operation the indication is between 35% to 65% of the range i.e. middle 30% of the full working range.

**2.9** Field mounted direct actuated Flow and Temperature switches shall not be used. Instead, transmitters shall be used along with flow element/temperature element. Process switches shall not be considered unless its use is unavoidable and the same shall be subject to purchaser's approval. In case switch has been considered, same shall be provided with sealed micro switch contacts rated for the specified application. Also contacts shall be SPDT type unless otherwise specified. Contacts used in intrinsically safe applications shall be suitable for the application.

**2.10 Intrinsically Safe System Requirements (for Non Fieldbus Instruments)**

Following points must be considered while designing an intrinsically safe system;

a) All intrinsic safety barriers shall be active type isolating barriers only, with three port isolation.

b) Barriers must be selected based on entity concept. Cable parameters shall also be considered while matching entity parameters.

c) Each instrument in the hazardous area and the intrinsic safe barrier shall be certified for intrinsic safety by any statutory authority.

d) Each input and output in a loop shall have separate barrier. No barrier shall be shared between two loops or input/outputs.

e) Any device required to be connected to any intrinsically safe loop in the hazardous side permanently or temporarily shall also be certified intrinsically safe.

f) Configuration tools whenever required for any intrinsically safe item, which forms part of the intrinsically safe item, shall also be certified intrinsically safe.

**2.11 Power Supplies and their Distribution**

a) Power supply shall be made available at the following voltage levels, unless otherwise specified:

- For Instruments, Control Systems, Analyzers — 240V AC/110V AC

| | | |
|---|---|---|
| ° | Solenoid Valves, Relays, lamps | 24V DC/110V DC ±10%/ 240 AC/ 110 V AC UPS |
| ° | Input interrogation voltage | 24V DC/110V DC ±10% |
| ° | Panel/cabinets lighting | 240V AC Non-UPS ± 10% |

In case 24 V DC is required for Input interrogation, relays and lamps, any other vendor supplied instruments/ electronics), same shall be considered by the vendor using dual redundant power packs (110 V AC to 24 V DC converter). 24 V DC feeders shall not be provided by Purchaser unless indicated specifically in the job specifications.

b) All instruments, control systems (PLC and DCS) and analyser system shall be able to operate at the following UPS specification:

| | | |
|---|---|---|
| Voltage level | : | 240V AC/110V AC ± 10% |
| Frequency | : | 50 Hz ±3 Hz |
| Switch over time | : | 5 milli seconds. |

c) Power feeders shall be supplied to the vendor at only one location. All further distribution within the package shall be taken care of by the vendor. Number and size of power feeders shall be informed during detail engineering. Vendor shall provide adequate number and size of terminals and cable glands required.

d) Instrument power circuits shall be individually protected and isolated from fault with the help of fuses and DPST switches. Power supply to the individual instrument shall be disconnected with the help of DPST switch and protected with the help of fuses. Miniature circuit breakers (MCB's) may be selected in place of switch fuse unit in case protection is provided for overload protection.

**2.12 Alarm Philosophy**

a) Alarms shall be provided to give audible and visual warning of any process and machine malfunction in the package.

b) All trips shall have a pre-trip warning alarm in addition to alarm at the trip condition.

c) Package alarms including pre-trip warning alarms and trip alarms (shutdown alarms) shall be annunciated on the local panel as per approved P&ID.

d) Rotating equipments shall have the status indication provided on the local panel as per approved P&ID.

e) 'Fail-safe' type with normally closed alarm contacts shall be used.

2.13 All line or equipment mounted instruments like control valves, pressure relief valves, thermo-wells, orifice flanges, level instruments etc., installed on pipes and vessels under IBR shall be certified by IBR or their authorized representative.

2.14 Location of process connections shall be from the side or from the top of the process equipment but not from the bottom. This requirement is applicable to both pipes and vessels. The location of lower side connection for level measurement when necessary shall be extended inside the equipment with the approval of purchaser to prevent plugging due to dirt or other suspended solids. In addition, the connections shall be short, vertical or horizontal and without any pockets.

2.15 Material of construction of instruments shall be as per the material selection chart, attached as Annexure I of this specification, as a minimum. However vendor is responsible to ensure that the selected material is consistent with temperature, pressure, corrosion conditions and other process requirements.

## 2.16 Field Transmitters

2.16.1 SMART Field Transmitters:

2.16.1.1 The field transmitters in all conventional loops shall be smart type only unless specified otherwise. Field transmitters for flow, pressure, temperature, differential pressure and level applications shall be yoke mounted type unless specified otherwise. Meter electronics used for flow measurement etc. shall include all the associated items like pre-amplifier, converter, transmitter, integrator, integral output meter etc.

2.16.1.2 Field transmitter shall be intrinsically safe and meter electronics shall be intrinsically safe, in general. In case, intrinsically safe is not available from the approved vendor list enclosed with this MR/tender, flameproof enclosure is acceptable. In case sensor/ pick up coil is intrinsically safe, suitable barrier shall be provided and installed in flameproof enclosure.

2.16.1.3 These transmitters shall be 2 wire systems having 4 - 20 mA DC output with superimposed digital signal having simultaneous analog and digital communication with HART communication protocol, unless otherwise specified.

2.16.1.4 The transmitter shall be microprocessor based and it shall incorporate a non-volatile memory which shall store complete configuration data of transmitter and sensor characterization. All necessary signal conversions, including conversion to produce output with the required protocol shall be carried out in the transmitter electronics. The configuration data of the instruments shall be stored in a non-volatile memory such that this remains unchanged because of power fluctuations or power off condition. In case vendor standard instrument has battery backed RAM, vendor to ensure that battery drain alarm is provided as diagnostic maintenance message.

2.16.1.5 Transmitter shall also run complete diagnostic subroutines and shall provide diagnostic alarm messages for sensor as well as transmitter healthiness. In the event of detection failure, the output shall be driven to a predefined value, which shall be field configurable.

2.16.1.6 Universal hand held configurator / terminal for the configuration and maintenance of instruments with HART output shall be provided for all HART based smart instruments.

2.16.2 Fieldbus Field Transmitter and devices:

2.16.2.1 Fieldbus transmitters/ devices shall be provided, if specified, in fieldbus loops.

2.16.2.2 Field bus based transmitter/ devices shall meet the following requirements;

a) All instruments must satisfy the requirements of the fieldbus registration laboratory with applicable checkmark like foundation field bus, profibus etc as specified in Job Specification.

b) All instruments shall be polarity in-sensitive. Also transmitter shall be LAS capability. Line plugging detection facility shall be provided, whenever specified in data sheet.

c) All instruments shall have Analog Input (AI) block and Proportional, Integration and Differential (PID) control block, as a minimum.

d) All instruments must be interoperable and shall have valid interoperability test clearance like ITK latest version for foundation field bus or equivalent for profibus PA, as applicable.

e) The field bus instruments shall support peer to peer communication with two wire communication and bus powered supply.

f) All instruments shall support EDDL or FDT/DTM requirements.

g) Internal software shall be configured by the vendor including the following information such as serial number, Device Tag (Tag Number) and Process description

h) All instruments shall be capable of supporting incremental Device descriptor (DD) for extra functionality and /or software revisions in device memory.

i) Soft copy of the Device Descriptor (DD) files for configuring the FF device parameters and common file format (CFF) files for integrating the device into the system shall be provided by the bidder for offline configuration by System vendor immediately after despatch.

j) Fieldbus based field indicator shall be able to indicate all signals available in the fieldbus segment, selectively.

2.16.2.3 The fieldbus / devices provided shall be able to communicate with latest universal fieldbus communicator.

2.16.3 Accuracy of transmitters (Pressure & Differential pressure), smart as well as fieldbus based shall be as follows:

| Type of Transmitter | Range of Transmitter | Accuracy for the rangeability of 1:10 |
|---|---|---|
| Direct | 760 mm WC and above | Equal to or better than ±0.075% |
| Direct | Less than 760 mm WC | Equal to or better than ±0.15% |
| Diaphragm seal | 500 mm WC and above | Equal to or better than ±0.25% |
| Diaphragm seal | Less than 500 mm WC | Equal to or better than ±0.5% |

The accuracy is defined as the combined effect of repeatability, linearity and hysteresis.

2.16.4 Transmitter shall update the output at least 8 times a second unless otherwise specified.

Unless specified otherwise in purchaser's specification, transmitter response time shall be as follows:

a) For transmitter range of 760 mm WC and above, the response time shall be equal to or better than 500 milliseconds.

b) For transmitter range below 760mm WC, the response shall be equal to or better than 1 second.

The response time of the transmitter shall be considered as the sum of dead time and 63.2% step response time of the transmitter.

2.16.5 Unless specified otherwise, the over-range/static pressure protection of the transmitter shall be as follows;

| **Range of Transmitter** | **Over range/ static pressure <N1>** | |
|---|---|---|
| | **Pressure Transmitter (kg/cm²)** | **Differential Pressure Transmitter (kg/cm²)** |
| 0 < ® < 250 mm WC | 20 | 20 |
| 250 < ® < 1000 mm WC | 45 | 52 |
| 1000 < ® < 5000 mm WC | 45 | 70 |

| | | |
|---|---|---|
| 5000 < ® < 10000 mm WC | 45 | 160 |
| 1 < ® < 10 kg/cm² | 52 | 160 |
| 10 < ® < 100 kg/cm² | 160 | 210 |
| > 100 kg/cm² | 210 | 210 |

<N1> However if the Over range/ static pressure value specified above is less than the maximum/ design pressure of service conditions, offered instrument shall be suitable for the maximum/ design pressure.

2.16.6 Diaphragm seal DP transmitters in flow measurement with a DP of less than 250 mmWC shall be avoided and alternate type of flow meters shall be provided for such cases suitable to the process condition.

2.16.7 All transmitters shall have vent and drain facility and the same shall be provided with metallic plugs. All the cable entries shall also be provided with metallic plugs.

**2.17 Instrument Connections**

2.17.1 The connections of instruments installed on vessels, tanks, standpipes and piping shall be as per following EIL Standards.

a) 7-52-0001 Instrument Connections on Vessels and tanks.

b) 7-52-0002 Instrument connection on Piping.

2.17.2 Pneumatic instrument connections for signal and air supply shall be 1/4" NPT (F).

2.17.3 Electrical cable entry connection shall be 1/2" NPT (F)/ 3/4"NPT (F) as per the cable size. Suitable cable gland shall be used.

2.17.4 End connections shall meet the following, unless, otherwise specified:

a) Threaded end connection shall be NPT as per ASME B1.20.1.

b) Flanged end connection shall be as per ASME B16.5 or ASME B16.47B or AWWA C207 Cl D as per related Piping Specification.

c) When Flanges are Raised Face (RF) type, the face finish shall be as per ASME B 16.5 and shall be as follows:

125 AARH : 125 to 250 microinch AARH

63 AARH : 32 to 63 micro inch AARH

d) Grooves of ring type joint flanges shall be octagonal as per ASME B 16.20 and groove finish shall be as follows:

63 AARH : 32 to 63 micro inch AARH

**2.18 Instrument Air Supply**

2.18.1 Air supply at pressure specified elsewhere shall be made available to the vendor at the battery limit for distribution to the instruments.

2.18.2 Pneumatic Instruments shall operate on air supply of 1.4 kg/cm²g and shall have transmission and output signal of 0.2 to 1.0 kg/cm²g.

2.18.3 Instrument air quality shall be as per ISA- S 7.0.01and free from corrosive, hazardous and toxic contaminants.

**2.19 Interface with Main Control Room**

2.19.1 Wherever applicable, instrument junction boxes shall be provided as interface between purchaser and vendor. Marshalling details between purchaser-vendor cabling shall be shown with corresponding junction box termination number allocated against appropriate purchaser's/vendor's instrument tag number in the format provided by purchaser.

2.19.2 Direct signals from package/package skid

All signals from package skid/battery limit to purchaser's control room shall be terminated in the junctions boxes located at the battery limit. Separate junction boxes shall be used for the following type of signals:

- Fieldbus based Signals
- Intrinsically Safe Analog Inputs/Outputs (4-20mA)
- Non -intrinsically Safe Analog Inputs/Outputs (4-20mA)
- Intrinsically Safe Thermocouple Inputs
- Intrinsically Safe RTD Inputs
- Intrinsically Safe contact Inputs
- Non-Intrinsically Safe contact Inputs
- Intrinsically safe contact Outputs
- Non-Intrinsically Safe contact Outputs

DCS and PLC signals shall be further segregated and shall in no case be mixed up.

2.19.3 Repeat Signals from Package Local Panel

a) Where signals as indicated in Clause 2.19.2 is less in number and do not justify separate junction boxes, all such signals may be routed via local control panel.

b) All such signals shall be terminated on separate terminal strips in the local control panel. The terminal strips shall be segregated as per Clause 2.19.2.

c) Intrinsically safe barriers for all such signals, wherever required, shall be provided.

The above shall only be considered with prior approval from purchaser.

**3.0 SPARES PHILOSOPHY**

**3.1 Mandatory Spares**

Unless specified otherwise, the following mandatory spares shall be provided by vendor.

3.1.1 **Predefined Mandatory Spares**

Mandatory spares shall be ware-house spares and shall be supplied as loose items.

3.1.1.1 Higher of 10% or minimum one of each type (range, type, material and rating ) of complete instruments for commonly used instruments such as transmitter, gauges, temperature elements, switches, probes.

3.1.1.2 For Control valve one set of packing and bonnet gasket with tag, one set of stem seal o-ring for each actuator and piston o-ring additionally for each piston actuated valve, line bolting (set of studs and nut) and set of gasket with each tag no.

3.1.2 **Commissioning Spares**

Vendor shall be responsible to supply all spares which are found necessary to replace while performing pre-commissioning and commissioning activities and this includes system oriented items (hardware / software).

3.1.3 **Consumable spares**

Vendor shall supply consumable spares for six months of normal operation.

3.1.4 **Engineering Spares**

3.1.4.1 For Control system, installed spare module of higher of 10% or minimum one of input/output modules (including termination panels, if applicable) to enhance the system functional requirements of control system.

3.1.4.2 For Hardwired console / Local control panel:

a) A minimum of 20% spare windows with alarm modules shall be provided in alarm annunciator.

b) A minimum of 20% spare status lamps / switches / pushbuttons / terminals or one no of each type, whichever is higher, shall be provided.

c) For pneumatic panels, 10% spare instrument air header branch lines and 15% spare bulkheads and tapping points shall be provided in each panel.

d) Control panels shall have additional spare-space as per clause 4.2.8 of this specification.

**3.2 Spares for 2 years normal operation**

Vendor shall supply a list of recommended spare parts for each instrument and system required for two (2) years of normal operation. These spares shall be quoted separately.

## 4.0 GENERAL SPECIFICATION OF INSTRUMENTS

### 4.1 Panel Board Instruments

4.1.1 Alarm Annunciator shall either be solid state type or microprocessor based programmable type with plug in modules and integral power supply. Window display shall be back lighted incandescent lamps or cluster LED type integral power supply. For window display with back lighted incandescent lamps two numbers of incandescent lamps of minimum 5 watt each shall be provided for each window. For cluster type LED display, the number of LED's in the cluster matrix windows shall be sufficient to provide illumination level of at least 150 lumens. The circuit shall be designed in such a way that removal/failure of one lamp or LED from a window/ cluster shall not hamper functioning of that particular window/display. The annunciator lamps shall be replaceable from the front of the enclosure panel. In general, dedicated alarm logic module shall be used for each alarm input. However, when micro processor based alarm Annunciator is offered failure of one microprocessor shall not affect more than four alarm windows.

Intrinsically safe annunciator circuit, when used, shall have power supply unit in a safe area. Annunciator alarm sequence shall be as per F3A of ISA.