

SCOPE OF WORK AND SERVICES

REQUEST FOR PROPOSAL

FOR

SUPPLY, INSTALLATION AND COMMISSIONING OF

THRUST CHAMBER TEST FACILITY CONTROL SYSTEM

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1 INTRODUCTION

ISRO Propulsion Complex (IPRC) is entrusted with the task of performing flight acceptance testing of cryogenic engine for LVM3 launch vehicle. This testing is carried out at Thrust Chamber Test Facility (TCT).

This RFP defines the scope and basic requirements for realization of PLC (Programmable Logic Controller)/ PAC (Programmable Automation Controller) based Control System (TCS), Emergency Shutdown System (ESS) and Signal Simulator (SS) for Thrust Chamber Engine Test Facility.

2 FEATURES OF TCS, ESS & SS

1. **Control System 1 (TCS):** Hot standby PLC/PAC based system) with full redundancy and SCADA with Client-Server configuration for TCT process and test Control system.
2. **Control System 2 (ESS):** Independent stand-alone PLC based ***Emergency Shutdown System / Safety system*** with SIL-3 standard.
3. **Signal Simulator (SS): Standalone** system for simulating required signal inputs to evaluate TCS and to do testing & evaluation of the instrumentation system.

Salient Features of Control System 1 (TCS)

4. The Control System is designed to control various field control elements (E/P valve, control valve) and **monitor, acquire & store various process parameters** (pressure, temperature, flow & events) during process operation in Manual & Auto mode.
5. Control System is planned with remote Input/output (IO) configuration with full redundancy.
6. TCS and local node will be located in control room. The Local node should be configured in the same network as

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- that of the remote node. Remote IO nodes will be housed in Cable Terminal Room (CTR) located at a distance of 1200 m from control room.
7. All process parameters communicate with control system through main and redundant I/O.
 8. Cycle time is 10 milli seconds including I/O scan, full application program & 64 PID loops execution.
 9. All the Analog and Digital I/O shall be scanned at every cycle time (10ms) and shall be available for control purpose at TCS.
 10. Communication between TCS and Remote Nodes shall be redundant and with cross coupling.
 11. The controller shall transmit the data to nodes for control, real time display, acquisition, online display and offline data analysis.
 12. Execution of time based and parameter based events.
 13. Programming, Graphics development should be as per control philosophy of the facility.
 14. Switch over time from main to redundant system within 2 cycles.
 15. Task based sequence execution for application programs
 - Time based and parameter based events execution at every 10ms task.
 - Auto sequence and abort sequence execution at every 10ms task.
 - Abort logics & Safety Interlocks execution at every 10ms task with high priority.
 - PID loops execution at every 100ms.
 16. Digital Data Acquisition and recording at every 10ms (100 samples/s) for all digital parameters.

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17. Analog Data Acquisition and recording at every 10ms (100 samples/s) for any user-selected 128 parameters and for the remaining parameters at 50/100 ms (user selectable) interval.
18. Digital and Analog parameters data Retrieval & Processing at different sampling rates.
19. Independent network for PLC and Supervisory Control and Data Acquisition (SCADA) level.
20. SCADA based PID operations and provision for PID constants, Set Point (SP) & auto manual changeover entry from SCADA.
21. Client Server configuration for operator station network layer.
22. Data updating in SCADA at less than 500 milli second.
23. OPC connectivity to display the Analog and Digital parameters acquired using multiple data acquisition system/ third party device in SCADA.
24. Modbus interface to interface third party device. Also various parameters of third party system have to be acquired and displayed in SCADA.
25. The modules shall be compact and small in size.
26. The I/Os, operator node quantities of TCS are given in the Table below

Description	Main (Qty)	Redundant(Qty)
Digital Input (DI) Remote	1488	1488
Digital Input (DI) Local	96	96
Digital Output (DO) Remote	1200	1200
Digital Output (DO) local	64	64

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Analog Input (AI) [0-10 V]	320	320
Analog Output (AO) (4-20 mA)	64	64
Pulse input (PI)	8	8
Programming Node	2	
Data processing Node	2	
Data Servers	2	
SCADA Server	2	
SCADA Node/ Operator Station	35	
Colour Printer Duplex	2	
B & W Printer Duplex	2	

Salient Features of Control system-2: Emergency shutdown system (ESS):

- 27. Single stand-alone system
- 28. Cycle time : 10 ms
- 29. Acquisition time : 10 ms for Digital & Analog
- 30. ESS control system is planned to be positioned at Cable Terminal Room (CTR)
- 31. SCADA and programming node at control room.
- 32. ESS Control System shall meet SIL-3 standard
- 33. The Control System is designed to generate outputs for control elements (E/P valve, control valve) in Manual & Auto mode.
- 34. Cycle time is 10 ms including I/O requirements, full application program.
- 35. All the Analog and digital I/O shall be scanned at every cycle time (10ms)

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36. Execution of time and event based for Digital and Analog outputs.
37. Programming, Graphics development should be as per control philosophy of the facility.
38. Digital Data Acquisition and recording at every 10ms (100 samples/s) for all Digital parameters.
39. Analog Data Acquisition and recording at every 10ms (100 samples/s) for all Analog parameters.
40. Digital and Analog parameters data Retrieval & Processing at 10 ms.
41. Client Server configuration for operator station network layer.
42. Data updating in SCADA at less than 500milli second.
43. The modules shall be compact and small in size.
44. Fault tolerance base system is required.
45. The I/Os, operator node quantities of ESS are given in the Table below

Description	Main (Qty)
Digital Input (DI)	56
Digital Output (DO)	88
Analog Output (AO) (4-20 mA)	16
Analog Input (AI)	8
Programming Node	1
Data processing node	1
SCADA node/Operator station	2

Salient Features of Signal Simulator (SS):

The Signal simulator (SS) is used for

46. Validating the automated sequences and abort logics developed in TCS by simulating the required signal inputs. User defined inputs like Ramp, Step and triangular signals and arbitrary/customized test profile need to be generated at specified time interval from GUI for validation purpose.
47. Carrying out the testing and evaluation (T&E) of instrumentation system by simulating the required signal inputs. The signal inputs need to be generated as per lookup tables.
48. SS shall be used to simulate the various types of inputs based on the sensor type (pressure, temperature, speed and flow) and the corresponding signal inputs are as follows.
 - **Pressure** : The source shall be capable of generating DC mV and DC mA
 - **High Temperature [Thermocouple TC]**: The source shall be capable of generating DC mV
 - **Low Temperature [RTD]**: The source shall be capable of generating resistance (ohms).
 - **Speed /Flow [Frequency]**: The source shall be cable of generating TTL pulses up to 5 KHz.
 - **Digital Input Card**: Digital input card is used to receive the sync, abort flags set by the PLC
49. The SS generates the necessary signal inputs for validating the logics for validating TCS and to carry out T&E for measurement chains.

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50. The SS Software shall be capable of incorporating 30 Groups of parameters at a time. In each group, 3 to 4 parameters are populated. In some Groups, mV sources are only active and in some groups/ combinations of sources will be active. The sources required are shown below.

Sl.No.	Type of Sources	Parameters	Total
1	DC Milli Volt (mV)	Pressure : 24	32
		Temperature (TC) : 8	
2	DC Voltage (V)	16 channels	16
3	DC Milli ampere (mA)	Pressure : 32	32
4	Resistance (ohm) (Low range)	Temperature : 8	8
5	Resistance (ohm) (High Range)	Temperature : 8	8
6	Frequency (Hz)	Flow : 3	9
		Speed : 6	
7	Digital Input card	8 channels	8
8	Digital Output card	8 channels	8
10	Matrix switch	As per requirement.	
11	Chassis		
12	Controller		
13	Programming Node	1	
14	Data processing node	1	

Table-1: No of independent sources required.

Total no of pressure channels (mA) = 512 channels. At least 32 mA parameters shall be configurable through matrix switch at single time instant. Switch matrix, shall be appropriately chosen to cater the above requirements. Chassis and Controller shall be chosen so as to meet the requirements of the independent sources as shown in Table-1.

51.The conformance of the performance specifications of the TCS shall be ascertained from the interpreted data from the SS. Also T&E results are to be tabulated in report form and the error is to be computed for validating instrumentation system performance.

52.SS is planned to be positioned at CTR and Programming node at control room.

53.Signal simulator shall be realised in distributed configuration with local and remote I/O node. Remote I/O node to be configured in portable mobile rack & shall be used at CTR for V&V of TCS and at field for T&E. The Network switch for the field shall be permanently positioned. The independent sources for all nodes shall be configurable through PC from CTR or Control Center as shown in Fig3 of Annexure-A1

54.Programming, Graphics development should be as per requirement of the facility.

55.Client Server configuration for operator station network layer.

56.The modules shall be compact and small in size.

2 SCOPE OF RFP

The scope of control system is defined in the following figures given in **Annexure - A1** - System Configuration.

Fig-1 Overall System Configuration.

Fig-2 System configuration for TCT Control system (**TCS**)

Fig-3 System configuration for Signal simulator (**SS**)

Fig-4 System configuration for TCT Emergency shutdown system (**ESS**)

The scope of this **RFP** includes

- a) Detailed Engineering
- b) Procurement of all items related to TCS, ESS & SS realization by vendor.
- c) Integration of hardware & Installation of all required software.
- d) Factory Acceptance Test (FAT)
- e) Training at vendor's site
- f) Shipment of the system to Department site
- g) Installation and commissioning of the system at Department site
- h) Training at Department site
- i) Site Acceptance Test (SAT)
- j) Documentation
- k) Operation and Maintenance (O&M) support
- l) Annual Maintenance Contract (AMC)

2.1 DETAILED ENGINEERING

- a) The detailed engineering shall be done on the basis of finally agreed control philosophy and Input/output List.
- b) The following detailed engineering documents shall be provided for TCS, ESS & SS
 1. Finalized System Architecture and detailed configuration diagram including all subsystems.
 2. The quantity and model/version number of hardware & software.
 3. The specification/detailed catalogue of hardware, system software and other packages proposed.
 4. General assembly drawing and mounting details of control system equipment in suitable industrial standard rack for the integration.
 5. Rack wiring & termination detail.
 6. Networking scheme in cable terminal room & control room as per configuration using suitable network equipment and cables with required drawing.
 7. Power requirement and heat dissipation for all racks, thereby ensuring appropriate cooling of equipments (controller, I/O cards, Servers, Network Switches etc) for continuous operation of 24 hours.
 8. Power distribution schematic.
 9. Site requirement in terms of electrical power and space to the Department.
 10. Finalized FAT & SAT Procedures.
 11. Software Life cycle model followed for software development of TCS, ESS and SS.

- c) Supplier shall provide one copy of detailed engineering document in Hard & Soft form to the purchaser for review and approval.
- d) The soft copy shall be in editable version so as to enable modification in future.
- e) Only the purchaser approved document shall be followed for all further commissioning activities.

2.2 PROCUREMENT OF ALL ITEMS RELATED TO CONTROL SYSTEM REALIZATION BY VENDOR.

- a) All control system materials which are required to meet the control system requirement shall be supplied by the vendor.
- b) The procurement shall be made as per final approved specifications & configuration decided during detailed Engineering.
- c) Detailed specifications & requirement of control system (TCS, ESS & SS) is given in **Annexure-A2**.
- d) The specification of the items which are not covered in the **Aennexure-A2** will be finalized and approved by the purchaser during detailed engineering phase.

2.3 INTEGRATION OF HARDWARE & INSTALLATION OF ALL REQUIRED SOFTWARE

- a) The control system hardware shall be assembled and integrated as per approved detailed engineering documents. The required software shall be loaded.
- b) Any software customization required to meet the specification requirement shall be done in discussion with Department.
- c) The control system as a whole shall be made ready at vendor's site for Factory Acceptance test.

2.4 FACTORY ACCEPTANCE TEST (FAT)

- a) After detailed engineering, custom software generation and loading, the whole system simulation will be subjected to full functional test on simulation basis of all inputs and outputs at vendor's site before shipment.
- b) Therefore, the whole system will be completely assembled, wired and staged for inspection and conducting the simulation test of 100% I/Os as per FAT approved procedure during detailed engineering given in **Annexure – A11**.

2.5 SHIPMENT OF THE SYSTEM TO PURCHASER SITE

- a) After completion and acceptance of FAT, the whole control system package shall be shipped to Department site. Import items shall be delivered at C&F Trivandrum. Indigenous item delivery point shall be FOR, Mahendragiri.
- b) The packing cases shall be optimized in order to minimize the transport costs.
- c) A copy of instruction manuals for installation, operation & maintenance shall be included in the cases.
- d) Mobile parts inside the equipment shall be fixed tightly to the structure. Special protection shall be used for fragile goods.
- e) Particularly delicate items shall be further protected from shocks to guarantee perfect stability during transport, by means of foam, rubber or other similar materials.
- f) Closed airtight polythene bags containing silica gel or other moisture absorbents shall be used.

2.6 INSTALLATION & COMMISSIONING AT PURCHASER SITE

This includes following and other activities related to

- a) Positioning of shipped items at cable Terminal room and

control room which are separated by a distance of 1200m.

- b) Identification & verification of all individual components
- c) Installation of control system.
- d) Functional checking of control system.

Positioning

Vendor's responsibility at site shall include the following activities necessary to be performed to complete the job satisfactorily.

- a) Transport of system from site stores to actual location.
- b) The Vendor shall be responsible for lifting, transportation installation and acceptance by Purchaser's representative.
- c) Copies of instructions/manuals in English shall be handed over to the purchaser's Engineer.
- d) Positioning of system rack at site as per control room equipment lay out.
- e) I/O nodes, Control system and operator nodes shall be positioned in Control room and Cable Terminal Room.
- f) Control system equipment shall be located such that it is easy to approach for operation and maintenance.

Identification & verification

- a) Unpacking the system and inspection of the same for damages.
- b) All equipment shall be inspected thoroughly by vendor for completeness and proper functioning. Vendor must initiate the remedial action to replace the faulty equipment or item with intimation to Purchaser.
- c) Each individual component (e.g. input/output modules, switch, etc.) shall be identified by part/model number and serial number. The documentation shall reflect these identification marks and proper labelling shall be ensured.

- d) Racks / enclosures shall be labelled in front and rear for easy identification.
- e) All internal & inter-cabinet wiring shall be ferruled with permanent markers bearing identifications that can be cross referenced with appropriate documentation. Coloured ferrules shall be used with proper coding philosophy. Tag plate shall be provided for the cable no. identification on the top of the related terminal strip in the cabinet. Cross ferruling shall be done.

Installation

- a) Best engineering practices shall be followed to maintain high standard of workmanship & quality in a neat and safe manner.
- b) Installation to be carried out as per approved detailed engineering document.
- c) All equipment, instruments, tools & materials required to carry out the work shall be brought by the Vendor.
- d) Laying and termination of network cables and prefabricated system cables shall be carried out.
- e) Fiber optic cables are under Department scope. The existing terminations at splicing panel can be made use of. However, end terminating slicing panel at control room and CTR (cable terminal room) along with further tapping from panel to racks is under contractor's scope.
- f) Laying and termination of all inter panel earthing cables.
- g) Ensure the correctness of hardware integration.
- h) Ensure the loading of necessary software like system software, application software etc.
- i) The control system shall be powered ON.

Functional checking of control system

- a) Vendor shall be responsible for loop checking which shall include checking of the configuration, network interconnection from node to PLC, I/O module to control system rack termination end and ensuring overall system functioning.
- b) Loop checking shall be carried out to check the functional performance of all elements in the loop and thereby ensuring proper functioning.
- c) Inter system (control system functional check with field devices) panel loop checking shall be carried out along with purchaser.
- d) After completion of all functional tests as per specification, the whole work shall be subjected to final inspection to ensure that start-up trial can be commenced in the presence of Department Engineer. If any defect is noticed, the Vendor shall arrange to rectify the defects noticed.

2.7 SITE ACCEPTANCE TEST (SAT)

After completion of commissioning, SAT will be carried out as per details given in **Annexure –A11**.

2.8 DOCUMENTATION

- a) 3 hard copies and a soft copy of final and as built documentation submission shall be the part of final acceptance and handing over of the system for closing the contract.
- b) Any change resulting from the revision of document shall be undertaken by the vendor without any extra cost.
- c) The soft copy shall be in editable version so as to enable modification in future.

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- d) All project documentation including system instruction manuals shall be in English language.
- e) Each document shall bear the order number, the equipment number and the relevant description as well as the contractor identification code.
- f) The specification and model number of hardware, system software and SCADA packages, Quantity proposed to be supplied.
- g) Wiring and mounting details of control system equipment and Individual rack wiring detail.
- h) Rack wiring diagram for I/O chassis with connector pin details.
- i) Interconnection scheme of control system and its sub system with necessary details and drawing.
- j) Networking scheme in control room as per configuration drawing using suitable network equipment and cables with required drawing.
- k) SAT & FAT Procedures and Training details & Schedule to be provided.
- l) System specification, Service and operational and maintenance manual of all hardware supplied.
- m) Software manual for all control system software, SCADA software, application tools and driver.
- n) Software requirement document, Software design document, complete source code for system and application software.
- o) Factory Inspection and Evaluation reports carried out on the control system.

- p) The entire software document like software requirement document, software design document should be prepared as per IEEE 12207 standards.
- q) As built final detailed configuration diagram including all subsystems to be provided.
- r) All documentation shall be type written or printed & softcopy to be provided.
- s) One set of final detail termination wiring interconnection diagram shall be kept inside each cabinet and equipment.
- t) Contractor shall supply list of brought out items with contractor's Name, Address, Contact persons and required sets of documents as above.

The following documents to be supplied

1. As built version of all documents submitted during detailed engineering.
2. System Architecture & Configuration drawing
3. Electrical power supply distribution diagram
4. Wiring diagram with connector pin details for I/O's.
5. Interconnection diagram including communication links
6. Software Diagnostic details
7. Factory Acceptance Test Procedure, SAT Procedure
8. Software requirement document as per IEEE12207
9. Software design document (Flow Chart, Source code etc.) as per IEEE12207
10. Software Configuration Manual
11. Installation Manual for system Software & SCADA
12. Installation Manual for Hardware
13. Operating Manual for Hardware and Software

14. Maintenance Manual for Hardware and Software
Redundancy Management manual.

2.9 TRAINING

The supplier shall intimate the date of commencement of the training program in advance after the system integration, so that department's engineers shall plan to participate.

- a) The supplier shall provide adequate training to Department Engineers (5 persons), at vendor's site for a minimum period of 7 working days during system integration and software development.
- b) The supplier shall organize the FAT after training, so that the same team shall participate in both FAT & Training program.
- c) The supplier shall provide adequate training to 5 Operational Engineers at Department's site after commissioning of the system for a minimum period of 10 working days to maximum of 15 days.
- d) The training shall be so organized to provide a complete understanding of the functions of the system, overall system concepts and routine operation for maintenance of the system and application software development in control system by themselves. It is essential that the system and other required document shall be available before commencement of training.
- e) The details of training shall include
 - i. Hardware Installation and maintenance
 - ii. System program development
 - iii. System Engineering & Configuration
 - iv. Networking / Communication technique
 - v. Installation of all software packages

- vi. PID programming
- vii. Data base creation & Management
- viii. Application program development in control system
- ix. Error diagnostics & trouble shooting
- x. Any other area on mutually agreed basis

2.10 Operation and Maintenance (O&M) support

After completion of SAT, for maintenance of the system contractor shall provide two service engineers full time at site for a period of 3 years. The engineer shall be capable of handling both hardware as well as software of TCS, ESS and SS systems independently. The person shall be qualified and trained person with previous experience in the same field.

2.11 Annual Maintenance Contract (AMC)

Annual Maintenance Contract (AMC) for a period 3 years including two preventive maintenance per year and any number of breakdowns to be attended within 24 hours. AMC is non-comprehensive and commence after the completion of Operation and maintenance (O&M) support.

ANNEXURE-A1
SYSTEM CONFIGURATION

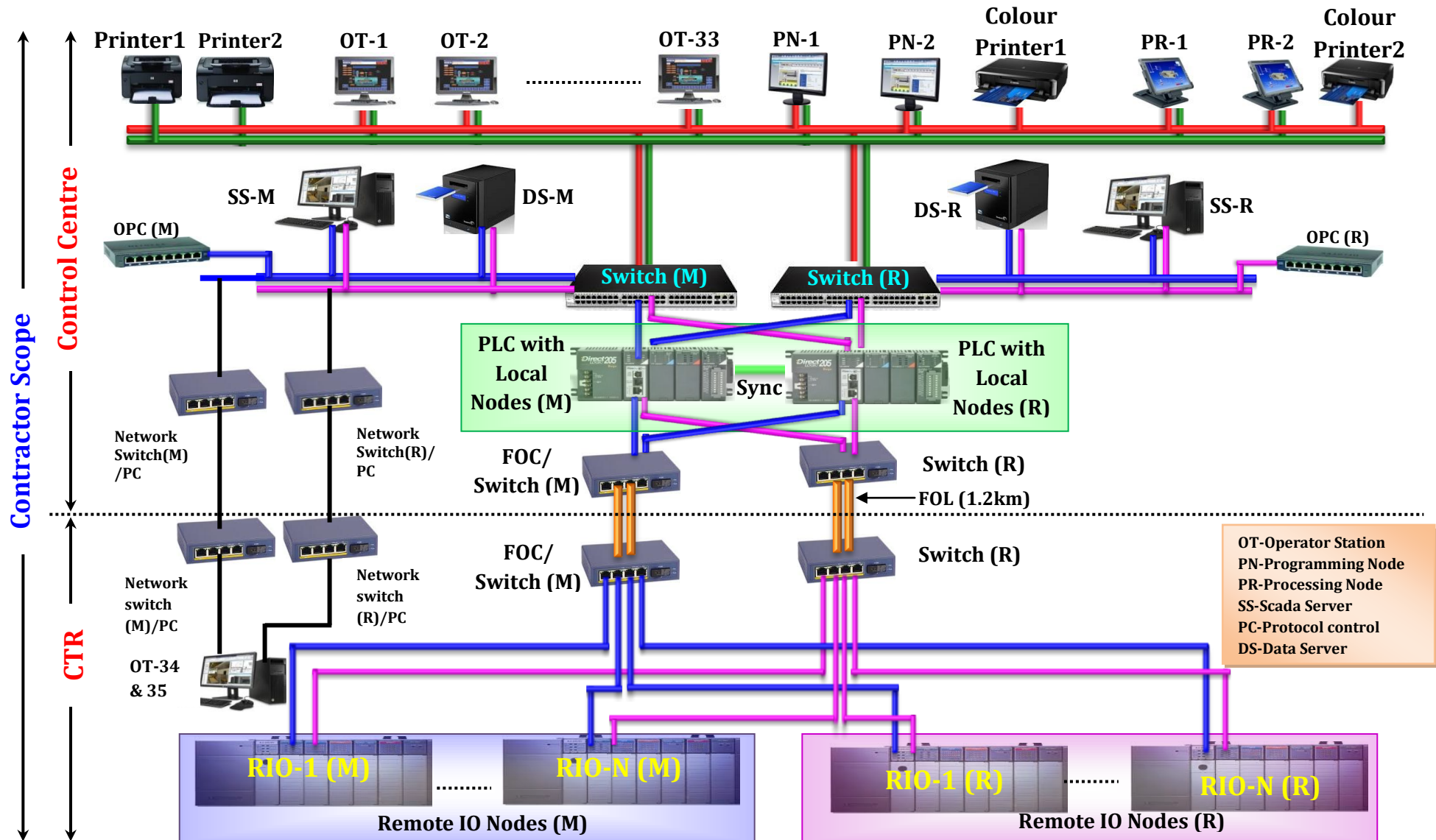
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Note: N in RIO N denotes the number of remote nodes

FIG-2: SYSTEM CONFIGURATION FOR CONTROL SYSTEM-1 (TCS)

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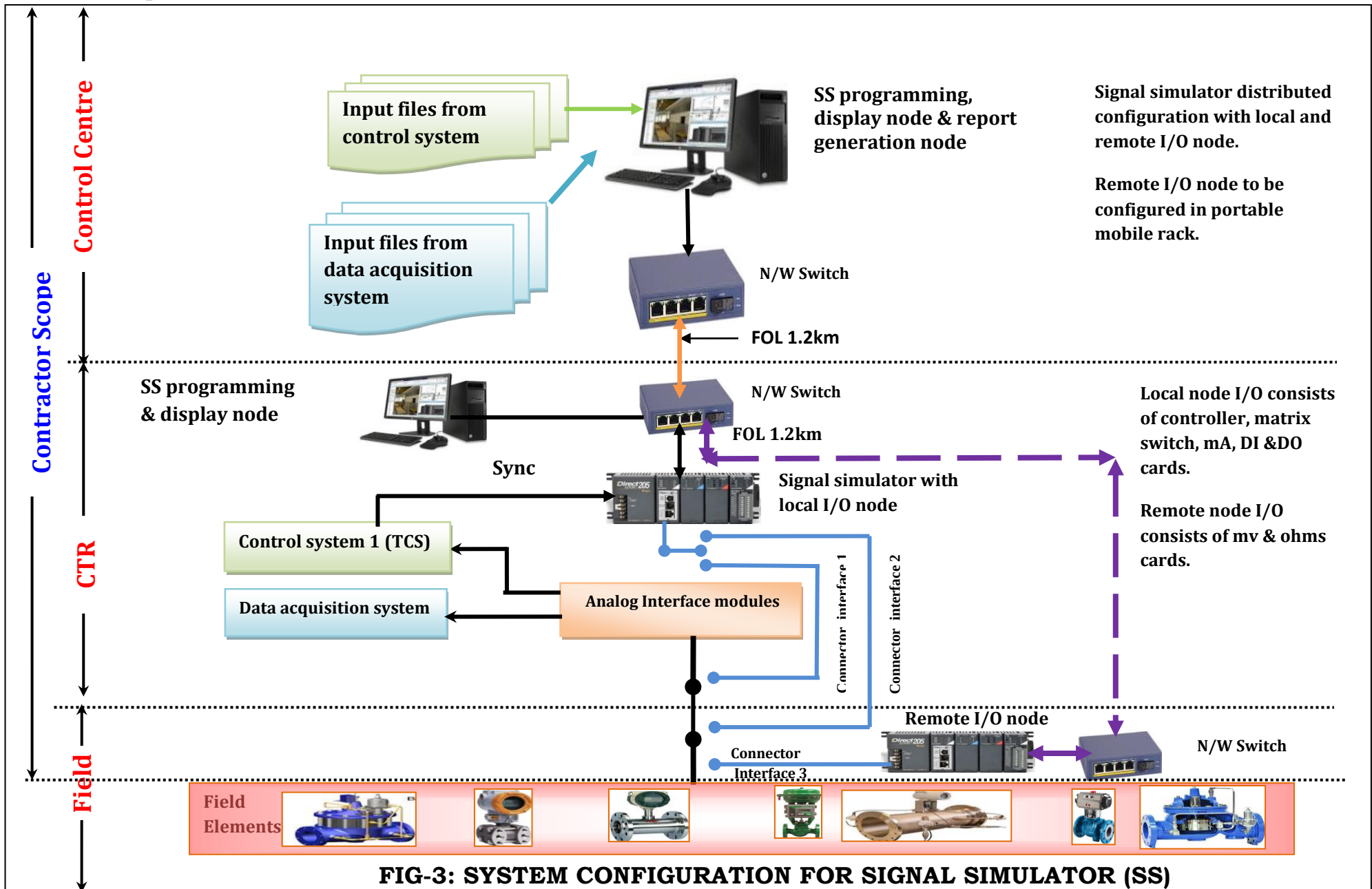


FIG-3: SYSTEM CONFIGURATION FOR SIGNAL SIMULATOR (SS)

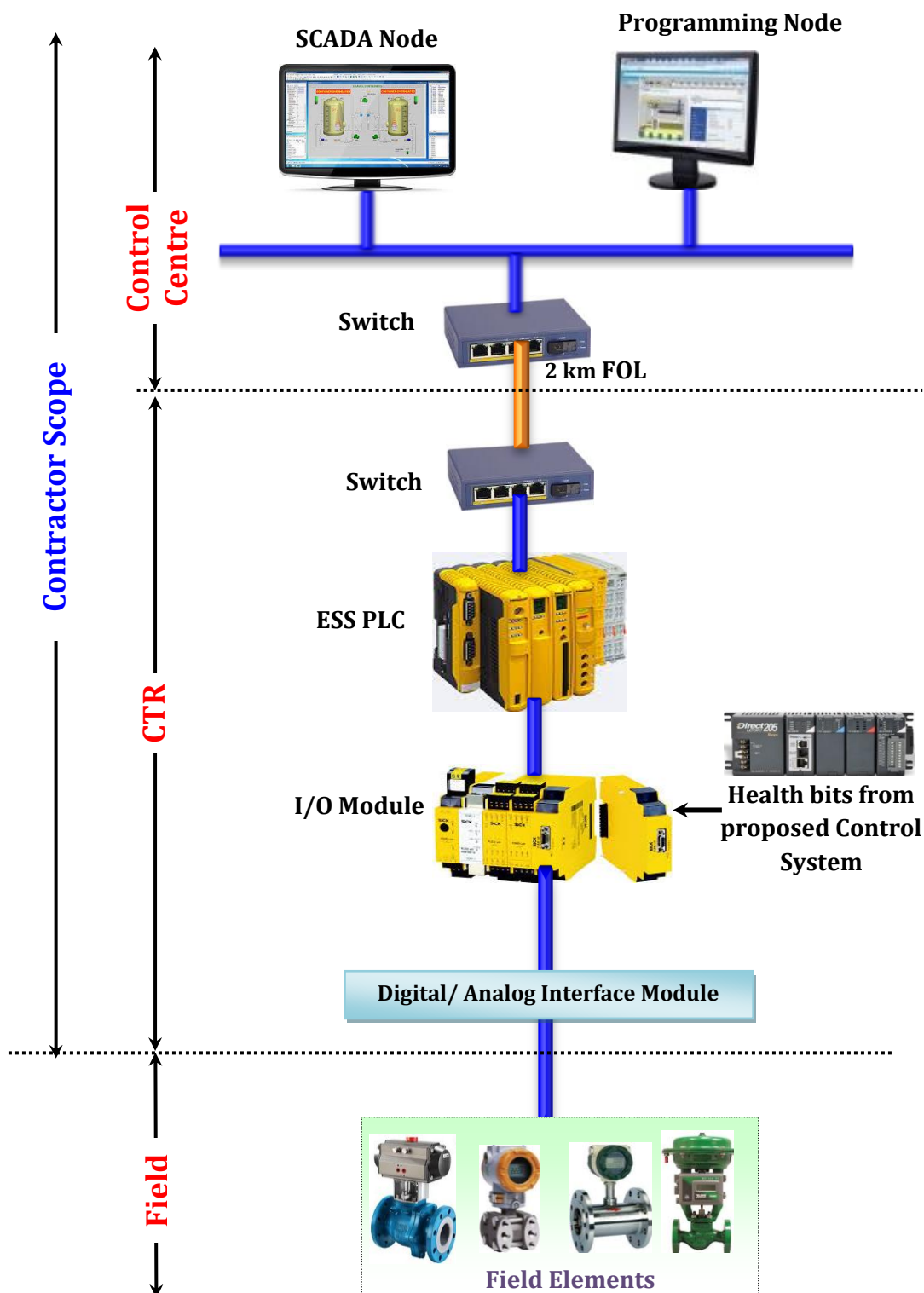


FIG-4: SYSTEM CONFIGURATION FOR ESS CONTROL SYSTEM

ANNEXURE-A2
DETAILED SPECIFICATION & REQUIREMENTS
OF TCS, ESS & SS

1. GENERAL REQUIREMENT FOR TCS, ESS & SS

- a) All hardware & software shall be the **most recent, field proven models / versions** and revision levels marketed by their manufacturers at the time of proposal submission.
- b) User-friendly configuration to facilitate adding extra nodes with Input /Output (I/O) modules.
- c) System shall be capable of expanding to accommodate the additional I/Os nearly 20% for future augmentation. This increase in I/O shall not affect the CPU functioning and cycle time of the system for TCS & ESS. The functionality and performance of SS shall not be affected even after 20% expansion. The rack integration during the realization phase shall be planned accordingly to meet 20% future augmentation.
- d) In case of failure of any module, replacement of the module shall be possible and it shall not lead to change in software or requirement of additional software.
- e) All software should be provided additionally in a separate USB/optical disk to load the software in case of software crash/system failure.
- f) All hardware used shall be modular and expandable. Features such as fault LEDs, healthiness LEDs, status LEDs are necessary.
- g) Processor, Communication module, IO modules shall be compact and small in size.
- h) Software shall be menu driven and easy to use. The PLC and SCADA programming shall be in **Integrated Development environment (IDE)** and changes updated in one place shall be reflected throughout. It shall incorporate on-line tutorials and help functions to assist the user. Software shall be self-

documenting and shall provide cross-reference tables, I/O configuration tables and associated functions.

- i) The party has to offer necessary Antivirus Software for the quoted system.
- j) Hardware & software commonality: All equipment shall be of modular design to facilitate interchangeability of parts and to ensure easy maintenance. The interchangeability shall be applicable to the following
 - i. Processor module
 - ii. Memory module
 - iii. Communication interface module
 - iv. Analog & Digital modules
 - v. Power supply module
 - vi. Any other applicable items
- k) Provision shall be available to modify / develop the software for future requirements and sufficient memory shall be ensured.
- l) The number of types of hardware parts/components used shall be as minimum as possible to eliminate the need for storing large number of spare parts.
- m) All modules and power supply shall be certified for industrial grade usage. The power supply shall be loaded to maximum of 60 percent of its current rating.
- n) For **Signal simulator (SS)**: All cards shall be compatible with the controller and should be synchronised. Signal simulator shall be realised in distributed configuration with local and remote I/O node. Remote I/O node to be configured in portable mobile rack & shall be used at CTR for V&V of TCS and at field for T&E. The Network switch for the field shall be permanently positioned. The independent sources for all

nodes shall be configurable through PC from CTR or Control Centre as shown in Figure 3 of Annexure-A1.

1.1. CONTROL SYSTEM (TCS) REQUIREMENTS & SPECIFICATION

1. The Control System is designed to control, monitor, and measure, acquire and store various field control elements (E/P valve, solenoid valve and control valve), process parameters (pressure, temperature, Flow and speed) during process operation in Manual & Auto modes.
2. For Automatic operation (**auto sequence**) of process elements during various phases of engine testing, the required sequence of operations is to be programmed based on predetermined timings and/or limits of process parameters for parameter based operations.
3. The system shall also execute **abort logics** for safe guarding the process and engines. During engine test operation, the system has to monitor critical facility parameters and abort the test if the majority of parameters in any abort group exceed the limit as part of application program.
4. The system shall also be able to execute a predefined sequence (**abort sequence**) of operation in auto mode in case of abnormalities.
5. The system shall also execute Safety interlocks to provide safe test operation under abnormal conditions with high priority.
6. The system shall be in hot standby configuration with defined failure states and the modules shall be hot swappable.
7. The system architecture is shown in Figure1 of **Annexure-A1**. The details are given below.

Processor/ Controller specification:

8. Processor shall be suitable for hot standby configuration
9. The CPU shall contain the program memory at RAM level, and Application program in EEPROM/Flash EPROM for program memory.
10. Power back up shall be provided for memory storage programs.
11. Contractor has to certify system response time, type of memories, backup, percentage of loading and idle cycle time etc.
12. The processor shall have real time clock with battery backup. Time synchronization between all nodes is essential.
13. System shall have the provision to interface IRIG-B time and display in UTC format.
14. All the timers should be generated by the control system with a selectable value of 1ms, 10ms, 20ms, 50 ms, 100ms, 500ms, 1s and 5s.
15. System cycle time shall be fixed 10 ± 1 ms (including full application program, 64 PID loops)
16. The system shall include all necessary modules for bulk memory and removable storage media.
17. **Detail break up of cycle time to be provided along with offer (as per Annexure-B).**
18. CPU shall be high performance latest version with necessary parallel processors having standard control unit and arithmetic logic unit (certified for Industrial Control applications and able to handle complex algorithms).
19. The CPU shall confirm to the following among other details.
 - i. In built floating point processor.
 - ii. Crystal controlled real time clock with battery backup better than 10 ms uncertainty over a period of 1 hour

and it should be stable for 72 hours with an accuracy of ± 1 second.

- iii. Deterministic and Real Time Operating system
- iv. Multitasking capability with more than 8 periodic tasks
- v. Power fail / auto reset
- vi. Watch dog timer protection
- vii. Industrial grade Isolated power supplies(Two independent power supplies in 'OR'ed configuration for controller and similar set independently for I/O modules)
- viii. Communication interface
 - Built in or separate 100/1000 Mbps or better Ethernet/proprietary modules to communicate from PLC to I/O node with 2 independent ports through high speed switches.
 - Built in or separate 100/1000 Mbps or better Ethernet module to communicate from PLC to high speed switches with 2 independent ports for SCADA /work stations.
 - Compatible with Profibus / Foundation field bus / Profinet, Ethernet IP, EtherCAT, Modbus TCP/IP and OPC UA.
- ix. Capability to handle priority interrupts
- x. Software / Hardware timers : 1ms, 10 ms, 20 ms, 50 ms, 100 ms, 500ms, 1s and 5s.
- xi. Programming: Ladder Diagram (LD), Functional Block Diagram (FBD), Structured Text (ST), Instruction List (IL), Sequential Functional Chart (SFC) - IEC 61131-3 Compatible. High level language with object oriented programming shall be available.

- xii. System should be supportable for unlimited Tags & flags along with labelling provision.

20. CPU STATUS INDICATORS

The CPU shall continuously monitor its own status and error conditions indicated by means of status LEDs fitted on the CPU itself. All the CPU diagnostic alarm shall be reported on the SCADA/HMI.

LED indications shall be provided for the following:

- i. Processor status
- ii. I/O status
- iii. Backup battery status
- iv. Power supply status
- v. Communication Fault status

21. MEMORY

The CPU memory shall be onboard and shall conform to the following

- i. RAM memory with battery backup. The capability shall be such that it should be sufficient for configuration of all data base and control strategies for the current I/O quantities plus 30% for future expansion requirement. Requirement of spare memory capacity can be decided / finalised on approval of Purchaser.
- ii. RAM, ROM, Flash memory, Data memory, program memory and other memory shall be in line with 10 ms cycle time requirement and shall be planned for continuous usage of 24 hours.
- iii. Even though the hardware details of the control module is specified here, Contractor can recommend/offer a better & latest CPU and other hardware to meet this

system requirement. The suitability will be reviewed by Purchaser.

iv. The controller shall be 24V DC powered.

Input/ Output modules specification & requirements:

22. Interface to the process shall be through Controller via I/O modules for both main and redundant systems.
23. The Analog input (AI), Digital input (DI), Analog output (AO), Digital output (DO) and Pulse input (PI) modules are interfaced with Department supplied field elements like sensors/ EP valve / control valve via signal conditioner/ isolated barriers / relays.
24. The field element output will be wired to I/O modules of both main and redundant systems.
25. All I/O modules shall be rack mounted in an enclosure, which is proximal or integral with the associated control module.
26. All I/O boards shall be slot independent.
27. All I/O modules shall be hot swappable.
28. Output cards shall be short circuit protected.
29. Input cards shall be reverse polarity protected.
30. All the I/O terminations shall be wired to connectors in the system cabinet.
31. Each I/O module shall contain status display LEDs on the front panel of the module itself.
32. Dummy modules to be provided for unused slots.
33. Operating environment: Operating Temperature: 15-50 Deg C
Humidity: 5-95 %, non-condensing
34. **Analog input module specification**
 - a) Analog input cards shall be provided to accept 4-20 mA/ 0-20 mA, ± 10 VDC as per the requirement. Each Analog input shall have preferably independent A/D converter to

enhance data conversion speed. The cards shall have hardware/ software low pass filters on all channels.

- b) No. of channels : ≥ 4 per module.
- c) Input Signal : 4-20 mA/ 0-20 mA, $\pm 10/0-10$ VDC
- d) Resolution for 0-10V : ≥ 16 bit
- e) Filter type : Low pass (Hardware/ Software)
- f) Filter Bandwidth : 10 to 30 Hz (selectable)
- g) Input Impedance:
 - i. ≥ 1 M ohms for voltage input
 - ii. ≤ 500 ohms for current input
- h) Overall Accuracy@ STP : $\leq \pm 0.1$ % for Voltage input
 $\leq \pm 0.2$ % for Current input
- i) Conversion time for all channels in a module : < 10 ms
- j) Electrical Isolation : ≥ 250 V
- k) Reverse polarity protection: To be provided
- l) Channel health monitoring and diagnostics: required for
each channel
- m) IO redundancy : required/programmable

35. Analog output module specification

- a) No. outputs : ≥ 4 per module
- b) Output Signal : 4-20 mA
- c) Resolution : ≥ 16 bits
- d) Conversion time for each channel : < 10 ms
- e) Overall Accuracy @STP : $\leq \pm 0.20$ %
- f) Load resistance for current : $\geq 500 \Omega$
- g) Electrical Isolation : ≥ 250 V
- h) Short Circuit Protection : To be Provided

i) Channel health monitoring and diagnostics: required for
 each channel

j) IO redundancy : required/programmable

36. Digital Input module specification

a) No. of inputs : ≥ 16 per module.

b) Input voltage(Nominal) : 24 V DC

c) Switching Threshold

i. Low : $< 10V$

ii. High : $> 12V$

d) Input Resistance : $\geq 2\text{ K}\Omega$

e) Switching Delay : $\leq 2\text{ ms}$

f) Electrical Isolation : $\geq 250\text{ V}$

g) LED Indication :To be provided for
 individual channel in module

h) Reverse polarity protection : To be provided

i) Channel health monitoring and diagnostics: required for
 each channel

j) IO redundancy : required/programmable

37. Digital Output module specification

a) No. of Outputs : ≥ 16 per module

b) Type : Transistor

c) Output Voltage : 24 V DC (nominal)

d) ON/OFF Switching Delay : $\leq 2\text{ ms}$

e) Continuous Current Per Output : $\geq 0.1\text{ A}$

f) Electrical Isolation : $\geq 250\text{ V}$

g) LED Indication : To be provided for individual channel in
 module

h) Channel health monitoring and diagnostics: required for each channel

i) IO redundancy : required/programmable

38. Pulse Input module specification

a) Number of Channel Input : ≥ 2 per module

b) Input Voltage : 24 V DC

c) Input Current at 24 V DC : ≤ 10 mA

d) Input frequency : 10 Hz to 100 KHz

e) Counter Resolution : ≥ 16 bits

f) Input Resistance : ≥ 2 K Ω

g) Measurement Technique : Period measurement

h) Electrical Isolation : ≥ 250 V

i) Channel health monitoring and diagnostics: required for each channel

j) IO redundancy : required/programmable

39. A high speed network connecting all the components of the Control system and other third party devices to perform real time information transfer between various components. The specification of switches is given **Annexure-A2**.

Servers

40. Necessary Servers or storage devices shall be provided for data acquisition, storage and retrieval for main and redundant system independently to meet the 50 samples/ sec data acquisition rate. Digital Data Acquisition and recording every 10ms (100 samples/s) for all digital parameters.

41. Analog Data Acquisition and recording for user-selected 128 parameters every 10ms (100 samples/s) and for the remaining parameters at 50/100ms (user selectable) interval.

42. The controller shall transmit the data to data server through

Ethernet for online display, storage and offline data analysis.

43. The Data server shall have sufficient storage capacity to store all the data for 48 hours continuous mode acquisition. Servers shall be loaded with latest version of Windows/ LINUX (preferable) Operating Systems with necessary Drivers and Software for Centralised Acquisition, monitoring and data reporting.

44. All the Analog and Digital I/O shall be scanned at every cycle time (10 ms) and shall be available for control purpose at PLC.

45. The specification of Server is given in **Annexure-A2**.

REDUNDANCY ASPECTS:

46. Redundancy is to be provided at all levels such as processor, power supply, communication controller, I/O modules, Networks, server, SCADA etc. to have hot standby operation.

47. Detailed FMECA study for overall system configuration, subsystem and modules shall be done.

48. In case of failure of the main system, the redundant system shall take over the following control operations.

Reading of input data, execution of user defined program, output setting, on-line diagnostics, housekeeping and handling communication.

49. The system shall be smart & fault tolerant, it shall have the capability to diagnose any fault or error conditions whether temporary or stable and take appropriate decision to change over to redundant system in real time, while the process is under control. The system must function reliably even in case of a single fault on hardware, firmware or software, and a warning advice shall be provided in diagnostic SCADA screen.

50. In case of any failure in the main system, the main controller shall bumpless transfer the control to the redundant controller without loss or interjection of data within two-cycle time (20 ms) to maintain program and I/O continuity.

51. During normal operation, the Main system shall scan the input signals (from both main & redundant I/Os), execute the user application program, generate output signals (for both Main and Redundant system) and store the data from main and redundant RIOs. As long as main controller is alive, the redundant controller shall have no control in execution of the programs and decision is based solely on the main controller. The redundant controller shall execute the same program but generate no output signal.
52. **Controller:** The main and redundant CPUs are to be connected through high speed communication link and Controller shall be configured in hot-standby configuration. In case of main controller failure, system shall switchover to standby controller and status of the IO modules shall be maintained.
53. **Power:** Main and redundant controller, IOs shall be powered from dual redundant power supplies. The maximum load rating of the power supply shall be limited to 60%. Separate power supply shall be used for main and redundant systems.
54. **Communication link:** Communication Topology shall be dual bus with cross-linking/dual ring. The main and redundant controller shall communicate to the IOs in the CTR through main and redundant fibre optic links. The IO network shall be cross-coupled and at any instant communication link failure shall be tolerated. Two independent communication ports shall be available in I/O nodes of each system for IO communication. SCADA and Data server shall be communicated through redundant links and in case of one communication link failure, the server shall continue to work normally without any data loss. All the operator stations shall also have redundant links and in case of one link failure switch over shall be within 5 second. Two independent communication ports shall be available in each system for

SCADA communication.

55. **Analog Input module:** Main system module shall be used for control when both main and redundant channels are healthy. In case of main channel / module failure, redundant channel data shall be used for control. Health check of individual channel based on user/pre-defined voltage/current level. Health check of individual channel based on short circuit conditions and open circuit conditions shall be possible. These health check bits shall be used by user program in further control logics. ***Analog input modules shall be equally distributed in at least four remote nodes.***
56. **Digital Input module:** Main system module shall be used for control when both channels are healthy. In case of main channel / module failure, redundant channel data shall be used for control.
57. **Digital Output module:** Single valve operation requires generation of 4 digital outputs, 2 in main and 2 in redundant for redundancy purpose. Two Digital outputs of each system are used for driving one field element with AND-OR logic. These outputs shall be organised such that one output shall be connected in one node and second output in another successive node so that in case of failure of one node/module/channel does not affect the performance of output. In case of failure of processor, all digital outputs shall remain in fail safe (OFF/de-energised) state.
58. **Analog Output module:** Main and redundant system shall share the current output when both systems are healthy. In case of failure of main or redundant channel / module, the total current shall be generated by the healthy channel without any time delay. PID loops shall support IO redundancy. AO channel wise redundancy to be provided preferably through software. The healthy channel information shall be displayed in SCADA screen. The Switchover

indication shall be reflected in Diagnostic screen of SCADA.

59. **Pulse Input Module:** Main system module shall be used for control when both main and redundant channels are healthy. In case of main channel / module failure, redundant channel data shall be used for control. Health check of individual channel based on user/pre-defined frequency level. Health check of individual channel based on short circuit conditions and open circuit conditions shall be possible. These health check bits shall be used by user program in further control logics.
60. All I/O nodes shall be configured with processor to meet the scan time.
61. The servers shall be in hot standby configuration with automatic switch over. Both the servers need to be synchronised on a dedicated dual network. Sufficient network ports shall be provided. Data from main system and redundant system shall be logged and available at normal conditions at respective servers. System shall be capable to monitor both the main and redundant data and also to store & retrieve.
62. Switchover automatically from Main Server to Redundant Server in a bumpless transfer mode such that the changeover is transparent to both operator stations and the controllers.
63. Switch over of SCADA network from main link to redundant link in case of link failure shall be automatic and the changeover shall be transparent to operator station users. Switch over times shall be less than 5s
64. The health status of processor, nodes, communication links, server, SCADA system shall be available in the diagnostic screen.
65. When main and redundant systems are healthy, provision should be available in SCADA main mimic to monitor

redundant controller data (if assigned in main mimic).In case, of particular channel failure, the redundant data of such channel shall be automatically switched over in main mimic.

66. Independent rack to be provided for main system and redundant system. Main and redundant switches and servers shall be positioned in respective main & redundant system racks.

67. Console switches are hardwired switches used for authorization, manual abort and manual hold and are connected to the DI card of local RIO node of TCS. The process/ simulation switches are also connected to the DI card of the local RIO node. The specifications and the quantity is given in **Annexure-A2**

PLC Programming

68. **Programming / Engineering Node:** This shall be a high performance workstation type computer capable of programming and configuring any Control system device.

69. The programming language shall be powerful, intelligent and user friendly for every stage of work and up to operation for planning, designing logics, online / offline testing, maintenance.

70. Standard PLC programming languages like Ladder Diagram (LD), Functional Block Diagram (FBD), Structured Text (ST), Instruction List (IL), Sequential Functional Chart (SFC), high-level language with object oriented programming (OOPS) shall be available.

71. The PLC programming software shall be user friendly, menu driven and easily programmable.

72. Control system shall be able to perform logic functions, and advanced control strategies.

73. Control system contractor shall provide the system software and associated equipment and interface tools required.

74. System software for writing application shall run on licensed latest version OS preferably Linux OS.
75. Application program shall be written in a logical fashion to simplify maintenance and trouble shooting. Logic for a specified requirement shall be grouped together. Identical process elements controlled in a similar manner shall have similar logic structures except for tag numbers. I/O modules shall be grouped in a logical fashion.
76. The software shall be easily loaded from CD/USB media. The software used shall be able to quickly acquire data through Ethernet using built-in instrument drivers or in-built instrument I/O libraries.
77. Forcing/simulating of the Analog and Digital outputs shall also be a standard feature. However, such details shall be logged and available for review. Disabling/Enabling the forcing condition on individual channel basis as well as all channel basis shall be possible.
78. Uploading a new program shall be fast enough. Flexibility shall be available for online modification of the program for minor changes/ modification and shall not affect the process / run mode condition.
79. PLC shall have the provision for on line and off line programming with Software lock.
80. The programs and logic diagrams implemented in the system shall be available in printed form.
81. I/O channels shall be accessed with defined Tag names as per user requirement
82. Provision for secured backup of developed programs.
83. Software license shall be provided for all software and shall not be hardware / machine specific. Hardware / system upgrade and augmentation of additional client nodes shall not call for new license / renewal of license. All licenses shall be

valid throughout the service life of the supplied system.

84. Validation tools to identify version changes in software codes. Provision shall be provided to identify the change in program / code for different versions. Compare provision shall be available to identify/compare two different version programs.
85. Version control of software shall be maintained.
86. Supply of source code for above mentioned operations with details for modification during future requirement.

APPLICATION SOFTWARE

87. The contractor shall develop and demonstrate PLC software as per details given below. The software design document, source code, validation and verification procedures shall be provided by the contractor.

Auto Sequence:

88. The auto sequence is used for operating field control elements in auto mode. The time and parameters based sequence shall be developed in TCS & ESS using PLC programming language. The programming shall have the flexibility to change the variables (time, Analog & Digital) through separate Input data files. The events should be synchronised with software timer.
89. Input files shall be created in CSV format, that data shall be read by PLC, and program shall be executed.
90. Separate Data Base files to be incorporated for Analog & Digital constants/details for Processing & Display.
91. Sample chronology of operation for Auto sequence is given in Annexure-A6.
92. Sample I/P file for auto sequence is given in Annexure – A7.
93. Maximum no. of auto sequence modules to be developed :**50**

Nos

Interlock and Auto Abort:

94. The interlock and abort logics shall be developed using PLC software. Various parameters to be compared as per the logics (1/2 or 2/2, or 2/3 or 4/4) provided for the set limit and a set of time based abort sequence to be executed. For automation modules m/n logics (where n = total no of parameters and m = sufficient number of parameters satisfying the conditions) shall be implemented for clearing the checkpoints during chilling and filling. The program shall have the flexibility to change the variables (time, Analog & Digital) through separate data table to execute abort sequence. The logging of Interlock enable/disable status, setting and generation of Alarm limit, execution of interlock shall be provided for offline analysis.
95. Various types of interlock like latch, reset, retain, restore to be developed with various conditions (1/2 or 2/2, or 2/3 or 4/4).
96. The program shall have the flexibility to enable/disable a particular interlock/abort group.
97. A Sample Interlock and Auto Abort format is attached in **Annexure-A8** of this document.
98. Maximum no of abort group to be developed :30 Nos
99. Maximum no of interlock to be developed :100 Nos
100. Program shall have the flexibility to change the logics, parameters, limits, validity time through separate data table/ input files.
101. Sample input file for abort logics is given in **Annexure-A9**

Data Logging & Reporting

102. Data logging and reporting software shall have capability to store all events, operator actions, process alarms with their description, occurrence time and priorities.
103. Provision to process and print out / plot the Analog and digital data through network using work station.

104. The data acquired are to be accessible offline and can be visualised. Software shall be capable of data gathering, data reduction and reporting.
105. Offline processing software to retrieve, print and plot the data in engineering unit/raw data.
106. All Digital and Analog Parameters shall be acquired by the system. All the reports shall be available in portable document format and Microsoft word/Excel format.
107. Provision to start /stop the acquisition system without affecting the functioning of the control system and monitoring of the data on the operator station.
108. Database with channel and Identification Tag names, Sensor constants for engineering unit conversion, sensor range shall be prepared and loaded in servers.
109. Data retrieval software shall allow the operator to edit, replace values or insert new values in records. Altered values in the database shall be tagged for reference purpose.
110. System shall have provision to acquire and retrieve the data at different sampling rates (10 ms, 20 ms, 50 ms, 100 ms, 1 sec, 5 sec etc.) for Analog and digital parameters.
111. The data reporting software for Analog parameter should take 4th order curve fitting sensor constants for engineering unit calculation in on line display, offline print out and trend.
112. Data reporting software for processing of all Analog and digital parameters shall be developed and loaded with reference to countdown time based on reference / sync signal for printing and plotting in offline.
113. Perform input signal smoothing, averaging etc. as required.
114. Alarm limit checking for various types of alarms such as deviation alarm, absolute alarm etc.
115. The system shall have sufficient memory to store the data

continuously for 48 hours.

116. Data reporting software shall process continuously for the maximum duration of 48 Hours data with 10ms sampling rate.
117. The data reporting software for plotting Analog & digital parameters separately and with the option to mix up Analog & digital parameters shall be developed and loaded.
118. A new data file shall be created with unique data and configuration file name without any data loss for every restart or the total size exceeds 1GB.
119. Data acquired for continuous 1 hour shall be retrieved within 5 minutes.
120. The data reporting software for plotting Analog & digital I/Os in CS shall be developed and loaded with reference to count down time based on reference/sync signal for printing and plotting in off-line using SCADA.
121. The backup of raw data shall be taken in CD/DVD.
122. The raw data shall be split into multiple files of 700MB size for CD backup.
123. A Sample Analog data reporting format is attached in **Annexure-A3** of this document.
124. A Sample Trend Graph format is attached in **Annexure-A4** of this document.
125. A Sample Digital data reporting format is attached in **Annexure-A5** of this document.
126. Provision to retrieve or display the data in raw count/ Engineering units.
127. Main and redundant data shall be independently logged and retrieved.
128. Trend graph, digital report and Analog report shall be stored and printed.
129. Parameter shall be differentiated in trend with different

colour and symbols.

130.A4 size B&W Duplex Network Laser printer and A4 size colour network Laser printer shall be provided.

Online display

131.The on-line monitoring and acquisition software shall have Security login, Audit trail, Concurrent Graphical Engineering, Multi screening operator station, On-Line and Historical trending.

132.The system should provide real time parameter display, trend display and Bar chart with colour change for alarm condition (based on lower and upper limits) for all parameters and variable time windows.

133.Multiple usage of same parameter for alarm condition (based on different lower and upper limits) at variable time windows shall be possible.

134.The display pages shall be organised in such a way that the system shall allow the operator to recall pages of the plant relevant to units or areas.

135.The Operator Station shall have facility for monitoring and operating each interlock group through soft key / key board/ mouse. There shall be facility for accessing interlock logic groups in one key stroke which shall be freely configurable.

136.The system shall have the facility for redirecting of alarms to alarm summary, pop-up windows, files, displays and printers. Online documentation shall be available for operation, maintenance and configuration.

137.Historical reports of the operational activities and alarm summary to be provided.

DATA REPORTING

138.Data shall be acquired and stored in independent raw files.

139.Data reporting software shall have provision to select the

following during online and offline processing of data and trend.

140.Parameters

- Time
- Axis scale
- Sampling time
- Prediction band
- Time Offset correction
- Zoom
- Grid and Markers

141.Data reporting software shall have provision to provide Analog and digital report for any parameters in any interval.

142.Trending shall be online and offline and maximum of 5 parameters shall be possible.

143.Report generation selection shall be through database file and online.

144.Offline data processing shall be possible without affecting the process/controller.

145.Data shall be stored in multiple files and provision shall be provided to process the previous file except the current file.

Man-Machine Interface/SCADA Node& Software:

146. MMI shall be of PC based workstation with LED type screen supporting high-resolution graphics capable of displaying Control system information, process information and other sub-systems connected to the same.

147. The process filed elements and their interconnection shall be represented pictorially as mimic diagrams.

148. There shall be **MMI / SCADA / Mimic node** for control & monitoring of the process elements and **Engineering Station** for program development.

149. Run level licensed Software shall be provided to all the workstations. All work stations shall be loaded with licensed Windows/ Linux based latest Operating system, SCADA for Mimic development, Data reporting software and required Driver Software.
150. Licensed Software for development shall be provided to the engineering stations.
151. Contractor shall clearly specify the configuration tools that will be used in each operator stations/workstations.
152. All work stations shall provide continuous display for 100 hours.

Programming environment

153. The development environment should provide concurrent development of the SCADA project by multiple programmers and finally merge the project for overall functionally before generating the run time version and real time architecture.
154. The development package should provide necessary tools to test the individual tasks that are generated at the SCADA package.
155. The development package should provide facility to maintain version management of the total software being developed.
156. Developing environment shall be with high-end graphical tools to develop necessary mimics as per the requirements. Developing environment shall have provision to import images, grouping, dragging, resizing, editing of objects.
157. The development package should consist of a full-fledged online help system in English with provision for context sensitive help.
158. The graphic building utility with full-animated graphics

should provide necessary support to import custom photographs as background images. The package should support user configuration for animation of the graphics objects in Runtime Environment.

159. Online debugging of SCADA packages under development should be possible. This should cause minimal disturbance to the runtime system.
160. SCADA system should be supportable for unlimited Tags & flags. All the I/O points shall be accessed by assigning Tags.
161. All the objects created for animation of EP valves, control valves, Analog parameters can be accessed by TAG names.
162. Provision shall be made in the software such that the scheme created for an object can be used by any object by only changing the Tag names i.e. I/O channels.
163. Provision shall be made in the S/W such that same function can be used by multiple objects and only parameters to be changed.
164. System should provide real time Trend display and Bar chart with alarm conditions of critical parameters to be displayed by visual indication (e.g. colour change) and audio signal.
165. Provision to select different mimic pages with soft key menu.
166. Provision should exist for developing user triggered pop-up messages and alerts with customizable command on the popup messages. These popup messages and closing the messages by either operator action event or program triggered variables should exist.
167. Program developed/ modified in the SCADA server shall be synchronized to all client nodes.

Security level

168. Minimum 4 levels of security logins shall be provided for user, administrator, programmer and observer (monitor) with password protection.
169. Authorised operator shall be able to monitor field devices & send commands using standard faceplate command window. Group displays, logs, trends etc. shall be accessed by menu selection.

SCADA Functions

170. The controller shall transmit the data to SCADA server through Ethernet for online display, storage and offline data analysis. The server shares the same to mimic for control, real time display through Ethernet LAN. SCADA network and PLC network shall be independent.
171. Data updating in SCADA shall be less than 500 milli second.
172. Operator can select any mimic of interest & issue ON/OFF, Analog commands to field element using optical mouse with double click in pop-up for confirmation of output. Additionally soft authorizations shall be provided for critical channels.
173. Interlock Enable/Disable features along with associated E/P and control valves shall be differentiated for ease of console operator through SCADA.
174. PID loops are required for operating control valves and 4-20 mA shall be generated by Analog output card by issuing command through SCADA with 100 ms sampling. The clipping provision of commands shall be available from SCADA if required.
175. SCADA node shall also support offline data processing.

176. The system shall have smart comprehensive diagnostic features at all levels like Processor, I/O module, power supply, communication module, network, Server, Ethernet switch, SCADA and the status shall be monitored and stored in SCADA diagnostic screen.
177. Error information shall be time stamped and logged for offline analysis.
178. SCADA mimic page for online error diagnosis and logging of various subsystems like processor, communication interfaces, network, Server, local and remote I/O nodes.
179. Network Diagnostics software shall be provided to monitor the Network Traffic.
180. Generating alarm contacts for audio visual alarm, event logging etc. shall be possible in SCADA. User defined alarms and events should be configurable for their properties and messages. All alarms and event should be immediately logged in a database time tagged with the countdown time. The alarm/event Database access for online/offline viewing and extracting data should be provided. Necessary tools for customization of the event/alarm reports should be provided.
181. SCADA software shall have the provision to receive and transmit the data from third party device. The received Analog and digital parameters shall be displayed in SCADA mimic for monitoring. These Analog and digital data will be acquired using another data acquisition system and transmitted to SCADA system through standard protocols such as TCP/IP, UDP.
182. OPC connectivity shall be available in SCADA system for interfacing of data. Using OPC interface, Analog and digital data acquired from external multiple data acquisition systems shall be received and updated in the SCADA Mimic for monitoring with a refresh rate less than 500 milli second.

Unlimited Tags shall be interfaced through OPC. Logging of this OPC data shall be done. OPC server software shall be provided in SCADA server.

183. Modbus interface is required to interface third party device. Also various parameters of third party system have to be acquired and displayed in SCADA.

SCADA based PID loop

184. PLC /SCADA based PID loops are used to operate the control valve for controlling flow, pressure, level etc.
185. Parameters to be controlled are given as feedback signal to PLC based control system. Control valve has to be operated either in manual or auto mode through SCADA. PID loops to be executed with a sampling time of 100ms.
186. Proportional (P), Integral (I) and Derivative (D) constants are programmed through SCADA.
187. In manual mode, the percentage opening / closing of control valve is varied through operator station using SCADA.
188. In Auto mode, the percentage opening / closing of control valve is controlled by comparing the feedback signal with set point value and output (4-20mA) to be generated based on Proportional (P), Integral (I) and Derivative (D) constants set. The set point value can be varied through SCADA from operator station.
189. The provision for changing the process variable (PV) feedback signal for the control valve without affecting the functionality shall be available.
190. The PID loops shall have auto tuning feature and provision to enter manually the PID constants.
191. PID auto tuning software shall be provided.
192. Program to be developed to accept the percentage opening value for the control valve through keyboard/virtual keypad with confirmation.

193. The PID loop software shall have the provision to control the control valve by step input, ramp input or trigger input.
194. PID loop standard libraries shall be available for control purpose such as Ratio control, Cascade Control etc.
195. PID loops shall support Analog IO redundancy.
196. PID loop algorithm and its code shall be provided.

Mimic requirements

197. Program development and animation of mimic diagrams required for the project is under the scope of contractor. The requirement details will be provided by Department.
198. ON/OFF command of field control elements shall be issued through optical mouse in the work station with a conformation in the popup and CS command and field valve status shall be animated with colour change by reading digital data. The tag names and parameter description shall be displayed through tooltip. The colour scheme will be provided by Department.
199. Percentage opening value for control valve shall be entered through keyboard/virtual keyboard in the workstation and opening feedback (% value) of control valve to be displayed in mimic.
200. All the required Analog parameters shall be animated in the mimics with the provision to visualise the sensor voltage/count or Engineering value in real time display. The raw counts shall be converted into engineering units as per the sensor constants. The conversion factor/constants shall be accessed from separate database file and can be modified whenever required.
201. Animation shall be done based on the Analog input parameters and colour of the object shall be varied according to the input values.
202. Animation shall be done to represent the low & high

limits by colour scheme/popup/alarms.

203. Downloading of mimic pages to all work stations from any work station through network.

204. A Sample Mimic page is attached in **Annexure–A10** of this document.

205. Maximum number of mimics to be developed: **70 Nos**

**1.2. EMERGENCY SHUTDOWN SYSTEM (ESS)
REQUIREMENTS & SPECIFICATION**

1. The Emergency Shutdown System/Safety PLC is an independent stand-alone system.
2. ESS system shall have two or multiple processors in the single system for decision making. Processor internal architecture shall be with 1oo2 (1 out of 2) or better to identify failures and take appropriate action using voting. All the IO modules shall have 1oo2 internal architecture and voting logic for decision making.
3. All components shall be Fail Safe (Configurable).
4. Cycle time shall be 10 ms with full application program & data acquisition.
5. ESS / Safety PLC design shall be with inbuilt internal redundancy in processor, input / output circuits.
6. ESS PLC shall have redundant microprocessors, Flash and RAM and that shall be continuously monitored by a watchdog circuit and by a synchronous detection circuit.
7. ESS system shall have input/output circuits with built-in diagnostics. Every input circuit shall be associated with an internal output circuit for exercising the input circuitry safety.
8. ESS system shall have redundancy to maintain operation even when components fail.
9. All the components of Control system should be SIL-3 certified.
10. It should meet IEC-61511/IEC-61508 standards. SIL 3 certification in accordance with IEC EN-61508/ IEC 62061, IEC 61131-2, certified by TUV Rheinland-Germany, HSE-UK

11. Network connectivity between control room and cable terminal room shall be provided.
12. Remote operations shall be possible from control room for manual operation of valves using SCADA mimics.
13. SCADA shall support maximum of 512 tags (excluding diagnostics/ system flags).
14. SCADA update time shall be less than 500 milliseconds.
15. Remote health monitoring of PLC and I/Os shall be possible from control room.
16. PLC programming shall be in accordance with IEC 61508-3
17. Application program shall be developed to execute time based automatic emergency stop sequence as per the user requirement.
18. ESS system shall be positioned in CTR and remotely accessed or monitored in Control room through Ethernet.
19. System shall be Fault tolerant and fail safe system.
20. The health bits of both Main and Redundant (TCS) control system will be provided as input and has to be monitored by ESS.
21. In case of both main and redundant TCS failure, a predetermined sequence has to be executed by ESS to Open / close the E/P valves and control valves.
22. ESS shall be independent of TCS.
23. ESS shall be of SIL-3 certified Hardware.
24. Remote programming and downloading from control room.
25. Diagnostic features shall be available in the monitoring node.
26. Manual command generation shall be possible from Mimic to operate the valves.

27. Program shall be developed for time based auto sequence of valves.

28. Data shall be acquired to monitor and retrieve the events at every 10ms interval.

29. PLC Processor

- a) CPU : Inbuilt
- b) Internal program storage : Required
(Compact Flash/SSD)
- c) Programming languages : As per IEC-61508-3
- d) User Memory : 2 MB
- e) RAM(ECC Type) : 128 MB
- f) Memory : Memory shall be available to meet the IO configuration & application program.
- g) Cycle Time Requirement : 10ms
- h) Ethernet ports : 100 Mbps
- i) Supply voltage : +18 to +30V DC
- j) Communication : Ethernet/ IP
- k) I/O Handling Capacity : 200
- l) Clock : Hardware clock
- m) Data Storage : Compact Flash/SSD of 32GB or above
- n) Interrupts/diagnostics/ status information : Yes
- o) Certification : SIL-3

- p) Backup of the project : Internal on Compact Flash/SSD
- q) Access protection : Required for write, read access
- r) EMC/ Vibration : As per international standard

30. Digital input card for ESS

- a) Number of inputs : ≥ 4 channel per module
- b) Nominal Input : 24 V voltage
- c) Electrical Isolation : $\geq 250V$
- d) Reverse polarity : To be Provided. Protection
- e) Status indication : Required for individual channel
- f) Reaction Time : < 10 ms
- g) Certification : SIL-3
- h) Fail Safe : (Low or high) Configurable Condition
- i) Failure Indication : Yes, provision for remote detection

31. Digital output card for ESS

- a) Number of Outputs : ≥ 2 per module
- b) Current per output : $\geq 0.1A$
- c) Electrical Isolation : ≥ 250 V
- d) Operating Voltage : 24V DC nominal
- e) Status Indication : LED for individual channel

- f) Reaction Time : < 10 ms
- g) Certification : SIL-3
- h) Fail Safe Condition : (Low or high) Configurable
- i) Failure Indication : Yes, provision for remote detection

32. Analog output card for ESS

- a) Number of channels : ≥ 2 channel per module
- b) Output current : 4-20 mA
- c) Current resolution : ≥ 12 bit
- d) Accuracy : $\leq \pm 0.50 \%$
- e) Conversion Time : < 10 ms
- f) Electrical Isolation : ≥ 250 V
- g) Certification : SIL-2 or higher

33. Analog input card for ESS

- a) Number of inputs : ≥ 2 channel per module
- b) Input Signal : 0 -10 V
- c) Resolution : ≥ 16 bit
- d) Accuracy : $\leq \pm 0.30 \%$
- e) Conversion Time : < 10 ms
- f) Electrical Isolation : ≥ 250 V
- g) Certification : SIL-3

1.3. SIGNAL SIMULATOR (SS) REQUIREMENTS & SPECIFICATION

1. The Signal simulator (SS) is used for validating the automated sequences and abort logics developed in TCS by simulating the required signal inputs. User defined inputs like Ramp, Step and triangular signals and arbitrary/customized test profile need to be generated at specified time interval from GUI for validation purpose.
2. Carrying out the testing and evaluation (T&E) of instrumentation system by simulating the required signal inputs. The signal inputs need to be generated based on as per lookup tables as per **ANNEXURE-A12**.
3. SS shall be used to simulate the various types of inputs based on the sensor type (pressure, temperature, speed and flow) and the corresponding signal inputs are as follows.
 - **Pressure** : The source shall be capable of generating DC mV and DC mA
 - **High Temperature [Thermocouple TC]**: The source shall be capable of generating DC mV
 - **Low Temperature [RTD]**: The source shall be cable of generating resistance.
 - **Speed /Flow [Frequency]**: The source shall be cable of generating TTL pulses up to 5 KHz
4. The SS generates the necessary signal inputs for validating the logics for validating TCS and to carry out the Test & Evaluation (T&E) of measurement chains.
5. The conformance of the performance specifications of

the TCS shall be ascertained from the interpreted data from the SS. Also, T&E results are to be tabulated in report form and the error is to be computed for validating instrumentation system performance.

6. Signal simulator shall be realised in distributed configuration with local and remote I/O node. Local node consists of controller, matrix switch DI, DO and mA sources. The mA sources shall be preferably HART configurable. Remote I/O node to be configured in portable mobile rack & shall be used at CTR for V&V of TCS and at field for T&E. Remote Node consists of mv & ohm sources. The Network switch for the field shall be permanently positioned. The independent sources for all nodes shall be configurable through PC from CTR or Control Center as shown in Figure 3 of Annexure-A1.
7. SS shall be positioned in CTR and remotely accessed or monitored in Control room through Ethernet. Network connectivity between control room and cable terminal room shall be provided. Remote programming and downloading from control room.
8. Programming, Graphics development should be as per requirement of the facility.
9. The hardware modules shall be field proven and with latest launch date of product
10. The modules shall be compact and small in size.
11. **Abort sequence:** The shutdown sequence to safeguard the test facility and test article in case of the deviation or abnormal behaviour in the process against the required specifications.

12. **Auto Abort and Sequence validation:** The automated sequence designed in the TCS consists of test steps based on the chronology of events to achieve the test requirements. In case of abnormality in the process, various pressures, temperature, flow and speed parameters are monitored by the TCS and subsequently the abort sequence is issued based on the conditions. Such parameters are called as abort parameters. Tentative number of groups and the abort parameters within each group is given in **ANNEXURE-A12**.
13. The SS Software shall be capable of incorporating 30 Groups of abort parameters at a time. In each group, 3 to 4 parameters are populated.
14. Matrix Switch: The Matrix switch is used to interface the selected source (mA) to the selected measurement channel. The input of the switch shall be configurable through Row addressing and output of the switch shall be configurable through the column addressing so that any source shall be connected to the any one or two measurement channels. The switch shall be of reed relay with 512 cross points. At least 32 mA parameters shall be configurable through matrix switch at single time instant. Switch matrix shall be appropriately chosen to cater the above requirements.
15. **Operation and Working:** The SS shall generate appropriate signals at the specified time intervals based on the Input test case. Before starting the validation process, all the systems (TCS, SS and ESS) will be in normal mode.

16.Auto sequence validation (TCS): The process of auto sequence validation in TCS shall be initiated by receiving the start command from TCS. For Synchronization purpose, TCS will issue the 'Time Sync' (Digital Output) to SS, ESS and Data Acquisition System (DAS). The 'Time Sync' signal shall be recorded in SS and ESS with reference to the time. The time at which the 'Time sync' exceeds 2.5 V is taken as reference time (Tref). Simultaneously on receiving 'Time Sync' the TCS will execute its automated sequence and the SS will give the mV /mA /Frequency / Resistance output for the selected group of parameters at the appropriate time set in the GUI. The mV /mA / Hz will be calculated from the first/ fourth order constants of the transducers. The resistance value is taken by interpolating the calibration constants of the RTD (Resistance Vs Temperature) to the nearest value of the desired engineering output. The inputs required for the abort channels shall be fed from high accuracy sources through the matrix switch. The matrix switch shall be configurable through the GUI. The parameters which are not participating in the validation process shall be kept at nominal value. The generated input signal so fed from high accuracy source passes through Transformer isolated barrier (TIB) and signal conditioner (SC) and reaches TCS Analog input.

17. The input source value can be ramped from the initial value to the final value depending upon the incremental slope (bar/sec, K/sec, Liters/sec and Revolution per sec) as per the input test case.

Similarly, the source value will be brought down to the desired levels depending upon the decremented slope and the time of activation of each source will be recorded for generating the report. The Abort signal (Digital output) received from the TCS during the course of simulation for abort groups is recorded in the SS. The source signal levels and the time of activation of each source will be recorded. The SS system will have to receive the time stamped Analog Input stream of data from TCS with data samples of 0.01 sec (cycle time of TCS) in offline mode at the end of each validation. The received data from the TCS will be amalgamated to recorded data of the SS for generating the report and further assessment.

18. **Abort Group validation:** The Logic of the selected group shall be validated for all possible combinations. If the logic specified is defined as “m/n “in the GUI where n is the No of sources and ‘m’ is the Number of parameters shall go out of bound [abort]. $[2n - 1]$ combinations of input sources within each group shall be generated and validated.
19. In the case of TCS ‘reset’, The Automatic test system shall set volt/mA/ Frequency / resistance to the nominal value of the each parameter as per GUI.
20. **Result of each validation:** The ‘Time Sync’ Tref recorded by SS is taken as reference. Similarly the DATA from the TCS, a time reference is taken when the ‘Time Sync’ exceeds 2.5 V and designated as Tref TCS. The data recorded at the SS and the TCS data are matched using Tref and TrefTCS. A new file shall be created from the SS data and TCS data (Analog

input parameters) will be generated at end of each test case.

- 21. Testing and evaluation (T&E) of instrumentation system:** The process of test and evaluation of instrumentation shall be initiated by receiving 'Time Sync' (Digital Output) to SS and Data Acquisition System (DAS). The signal inputs need to be generated based on as per lookup tables for pressure transmitter (mA), pressure transducer (mV), Speed (Hz), flow (Hz), thermocouple (mV) and RTD in ohms as per **ANNEXURE-A12**. The generated signals from SS shall be fed to measurement channels based on the realized Switching matrix and the data shall be recorded in SS and DAS. The data recorded at the SS and the DAS data are matched using sync signal. The SS system will have to receive the time stamped Analog Input stream of data from TCS with data samples of 0.01 sec in offline mode at the end of T&E. The received data from the DAS will be amalgamated to recorded data of the SS for generating the report and further assessment. A Sample report format is attached in **Annexure-A12** of this document.
- 22. Report Generation:** The contractor shall automate the T&E report generation based on the signal inputs pressure transmitter (mA), pressure transducer (mV), Speed (Hz), flow (Hz), thermocouple (mV) and RTD in ohms as per the format attached in **Annexure-A12**.
- 23.** All the modules, necessary interface connectors and required software of the functioning of the signal simulator (SS) is under the Contractor scope.

24. DC (mV) Source: The DC (mV) milli Volt source is used to generate voltage levels required for simulating pressure and Temperature (TC) measurement channels. As the pressure transducer output and the temperature sensor (TC) output do not exceed 100 mV, the milli volt card will have to generate $\pm 50/\pm 100$ mV. The milli Volt signal generated as per the transducer calibration constants will be fed in to the P&F make Transformer Isolated Barrier. The Input Impedance of the TIB is 20 Meg Ohm. As the SS is going to be used for evaluating the 16 bit Analog input card of the TCS, the resolution of the card must be sufficient to distinguish smallest incremental voltage.

- Signal Output Range : $\pm 50/\pm 100$ mVDC (selectable)
- Number of channels : ≥ 4 per module.
- Voltage Resolution : $\leq 5 \mu\text{V}$
- Accuracy : $\leq 0.15\%$
- Output resistance : ≤ 5 ohms
- Settling time : < 5 milli second

25. DC(V) Voltage Source: The DC (V) Volt source is used to generate voltage levels directly to the Analog input card of TCS.

- Signal Output Range : ± 10 V DC
- Number of channels : ≥ 4 per module.
- Voltage Resolution : $\leq 2\text{mV}$
- Accuracy : $\leq 0.1\%$
- Output resistance : ≤ 5 ohms
- Settling time : < 5 milli second

26. DC(mA) Milli Ampere Source: The Milli Ampere Source is used to generate milli ampere required for simulating pressure transmitter channels. The input resistance of Transformer isolated barrier is ≤ 100 Ohms and output resistance is 250 Ohms.

- Signal Output Range : 4-20 mA
- Number of channels : ≥ 4 per module.
- Resolution : 16 bit
- Accuracy : $\leq 0.2\%$ FSR
- Load resistance : min 500 Ω (drivable)

27. Resistance (Ohm) Low range Source: The resistance source is used to simulate the 4 wire RTD. The resistance source is excited as the source which is used to connect to the signal conditioner through Zener Barriers. The current excitation (2 mA) of the resistive load (RTD/Resistance) is provided by signal conditioner. The load current will not exceed 2 mA because the RTDs are going to be used to measure the low temperature in which the high current excitation is prohibited due to self-heating error.

- Signal Output Range : 0.5 Ω to 100 Ω
- Number of wires : 4 wire RTD
- Accuracy : $\leq \pm 0.1\%$ or better
- Resolution : 0.05 Ω
- Settling time : < 5 millisecond
- Number of channels : ≥ 2 per module.

28. Resistance (Ohm) High range Source: The resistance source is used to simulate the 4 wire RTD. The resistance source is excited as the source which

is used to connect to the signal conditioner through Zener Barriers. The current excitation (2 mA) of the resistive load (RTD/Resistance) is provided by signal conditioner. The load current will not exceed 2 mA because the RTDs are going to be used to measure the low temperature in which the high current excitation is prohibited due to self-heating error.

- Signal Output Range : 100 Ω to 1 k Ω
- Number of wires : 4 wire RTD
- Accuracy : $\pm 0.2\%$ or better
- Resolution : 0.125 Ω
- Settling time : < 5 millisecond
- Number of channels : ≥ 2 per module.

29. Frequency (Hz) Source: The frequency source is used to simulate the Flow and Speed measurement channels. The output frequency of the turbine flow meter is 300 Hz (Nominal) and 700 Hz (20 lps, FSO). The output frequency of the speed sensor is 1666 Hz (Nominal) and 2500 Hz (for 45,000 rpm FSO).

- Signal Output Range : 1 Hz to 5 KHz
- Accuracy : $\pm 1\text{Hz}$ or better
- Counter resolution : ≥ 32 bits
- Voltage level : TTL or 24 V open CC
- Number of channels : ≥ 2 per module.

30. Digital Input Card: Digital input card is used to receive the sync, abort flags set by the PLC. As the amplitude of Digital output of PLC is $\pm 24\text{V}$, the digital input card with 24VDC is selected.

- No. of Digital Inputs : ≥ 4 per module

- Digital Input Voltage : 24 VDC
- Input resistance : $\geq 2 \text{ K}\Omega$
- LED Indication : To be provided for
individual channel in module

31. Digital Output Card: Digital output card is used to handshaking TCS & to Synchronise other systems. As the amplitude of the Digital output of PLC is $\pm 24\text{V}$, the digital input card with 24VDC is selected.

- No. of Digital Outputs : ≥ 4 per module
- Output Voltage : 24 VDC
- Current per output : $\geq 0.1 \text{ mA}$
- LED Indication : To be provided for
individual channel in module

32. Matrix Switch: The Matrix switch is used to interface the selected source (mA) to the selected measurement channel. The input of the switch shall be configurable through Row addressing and output of the switch shall be configurable through the column addressing so that any source shall be connected to the any one or two measurement channels. The switch shall be of reed relay with 512 cross points

- Maximum Switching current : 0.5 A per channel
- Maximum Switching power : 10 Watts per channel
- DC path Resistance : $< 1 \Omega$
- Resistance of Open channel : $> 1 \text{ G}\Omega$
- Bandwidth for two wire configuration: $> 100 \text{ Hz}$
- Cross Talk : -90 dB @ 10 KHz
- Isolation : 90 dB @ 10 KHz

- Relay operate time : < 300 us
- Relay release time : < 300 us

33. Controller & Chassis: The controller shall have PC either in slot 0 or standalone PC. The controller shall have adequate number of slots to incorporate the Digital to Analog output cards for generating mV, mA, ohms and Hz. For each signal source (mA / mA / ohms / Hz) with adequate number of channels per card shall be required. The empty slots shall be left for future expansion. The controller shall be LXI based system.

- The controller shall have externally connected peripherals like 24" LCD display, wireless key board, wireless mouse, DVD writer, A4 size laser printer and a speaker. For Portability, either the system should be mounted in a standard 19" half rack of approximately 20 U Height, with heavy duty castor wheels or standalone instrument system.
- The system should be capable of operation at standard 230 VAC, 50 Hz with industrial grade power supply.
- Humidity: 5 % to 95 % non-condensing
- Operating Temperature: 15 °C to +50 °C
- Monitoring Functions : Chassis voltage level monitoring, Power supply monitoring/control, Cooling fans monitoring/control, Chassis temperature monitoring
- Status LEDs : Chassis temperature, power supply voltage and fan monitoring
- Remote Interface : Monitor port on rear panel

- Airflow : Front & bottom panel intake, rear exhaust and ensure adequate cooling
- The controller shall be synchronized with the TCS timings through the digital output from the TCS in order to have the time stampings at the appropriate time (Start time).
- All proposed cards shall be compatible with the controller and should be synchronised.

34. Software/Programming: The contractor shall develop and demonstrate SS software as per details given below. The software design document, source code, validation and verification procedures shall be provided by the contractor.

- The Software shall indicate the synchronized time of TCS as a logged event from the digital data from the TCS.
- The number of groups and selection of parameters for a group shall be user defined and configurable through GUI.
- The parameters other than in a group in the particular window time shall be in nominal value.
- The time window for each parameter shall be user defined and configurable through software.
- The software shall define the real world sensor data characteristics and program data generation in terms of full scale output, offset definition, time frame.
- Software shall have provision of holding the timer in case of hold received from TCS and the timer

should resume from the same instant after the release of Hold.

- The number of parameters in a group is variable [Number of rows, Vertical Scalability] and selected by the user.
- The time lines are also variable [Number of columns, Horizontal scalability] and selected by the user
- The GUI shall take the following user input like Tag Name, Measurement Range, First and Fourth order curve fitted constants of the transducer A0, A1, A2, A3 and A4, Calibration points of the Transducer (20points), Desired Engineering output at the specified time, Time at which the desired engineering output is to be activated, Time at which the desired engineering output is to be deactivated, Incremental slope (Desired engineering output/Difference in time) of the desired engineering output at the time of activation, Decrement slope (Desired engineering output/Difference in time) of the desired engineering output at the time of deactivation.
- Generation of arbitrary/customized signals and standard signals like Ramp, step and triangular signals through GUI.
- The software shall be Windows OS / Linux, device drivers for all add-on cards and licensed copy of programming software. Development of the GUI interface, look up table, input file generation for various test cases and report generation shall be

done using high level languages and source code shall be handover to department after the competition of the project. The Source code should have provision for any modifications and updating in future.

- o All the developed software documentation shall be in line with IEEE 12207

1.4 OPERATION STATION/SCADA NODE SPECIFICATION

Sleek operator stations with CPU, HDD, RAM, DVD, Monitor, Graphics, Keyboard, Mouse and Network interface cards with the following specification

- | | |
|--------------|--|
| a) Processor | Intel Core i7 12700 (or Higher), @ 3.6 GHz, 6 MB cache (or Higher) |
| b) Chipset | Intel Q670 or higher Chipset or Equivalent/Higher |
| c) Memory | 16 GB @ 1600 MHz DDR4 RAM with 32 GB Expandability |
| d) Hard Disk | 1 TB Hard Disk 5400 RPM or higher + 512 GB M.2 NvMe SSD |
| e) DVD Combo | DVD Super Multi Drive (R/W) internal |
| f) Video | Integrated Graphics Media Accelerator x 4500 support up to 2GB video memory through DVM, support DirectX10 |
| g) Audio | Intel High Definition Audio |
| h) NIC | Four ports (Integrated 100/1000 Mbps dual Network Integrated Card |

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Scope of work and services

Annexure: A

	(NIC) (2 ports) & Additional 2 ports 100/1000 NIC on PCI/PCI Express Slot
i) Monitor	24" LED Full HD IPS Digital colour Monitor having 1920x1080 native resolution with Digital Input & Aspect Ratio 16:9 & built-in speaker
j) Keyboard	Multimedia keyboard with USB 2.0 Interface
k) Mouse	2-Button optical scroll mouse with USB Interface with Mouse Pad
l) Peripheral Interface	6 USB interface ports (at least 2 USB with 3.0. Two front & 4 USB ports wired at the rear preferred), minimum 1PCI slot, PCI Express x1, 1PCI Express x16 Slots & One serial port
m) Others	Fan for CPU Cooling
n) Operating System	Preloaded with Linux/ Genuine Microsoft Windows 11 Professional with license & recovery media or higher
o) Software	Required drive software for Mother Board/Chipset Driver in CD, NIC & DVD writer
p) Certificati on	Windows 11/ Linux certification
q) Security	System level security with CD disabling & high surge protection

- | | |
|--------------------------------|--|
| r) Regulatory Certification on | Ecology, Energy, Ergonomics, Emissions(ROHS, Energy Star and FCC Class B ERTL certified) |
| s) Input power supply | 50Hz, 230V AC with Indian Standard Plug Tops |
| t) Colour | Chassis :Black ,Front :Black |
| u) Antivirus | To be provided(Years to be defined) |

1.5 DATA SERVER / SCADA SERVER SYSTEM SPECIFICATION

- | | |
|--------------------|--|
| a) Processor | 2 X Intel @ 2.4 GHz, 35.75MB Cache memory or higher |
| b) Memory | 64 GB (4 x 16 GB) ECC DDR4 2933 MHz RAM or higher |
| c) Raid Controller | 1GB SAS3 (12Gbps) H/W Controller Supports RAID 6 |
| d) Hard drives | 3 x 4TB SATA 7.2K RPM 3.5" Hot Swap HDD + 1 x 480GB Data Centre Grade 2.5" Hot Swap SSD |
| e) Removable media | Slim DVD-RW internal. |
| f) Expansion slots | 2 slots or more after configuring the requirements |
| g) Graphics | Integrated Graphics controller. |
| h) Network | 5 x 10/100/1000 Ethernet. (If additional card is employed it should be dual Ethernet card only) |

- | | |
|-----------------------------|---|
| i) I / O ports & Connectors | 4 USB (at least 3 USB with 3.0.) |
| j) Input device | USB keyboard and mouse along with pad |
| k) Power supply | 2 x hot plug power supply (230 V @ 50Hz) unit |
| l) Power | 230V @ 50Hz, Indian power cords to be supplied |
| m) Form factor | Rack-Server depth should not exceed 780 mm |
| n) Fan | Five or more hot-plug fans |
| o) Software | System management software to monitor the system health at local console and over network |
| p) Monitor | 24" LED Wide Monitor having 1920x1080 native resolution with Digital Input & Aspect Ratio 16:9 & built-in speaker |
| q) Keyboard | Multimedia keyboard with USB Interface |
| r) Operating System | Windows 11/ Linux |

1.6 PRINTER

A) A4 size B&W Duplex Network Laser printer

- Type : LaserJet Black & White
- Resolution : Upto 600 X 600 X 2dpi

- Print Speed : Upto 26 ppm
- RAM Size : 128MB
- Processor : 750 MHz
- Type : Automatic two sided printing
- Media Capacity: 250 Sheets
- Connectivity : Hi-Speed USB 2.0 & built-in 10/100 Base-TX Ethernet, WiFi802.11b/g/n

B) A4 size colour network Laser printer

- Resolution : 600 X 600 dpi (Black)
: Upto 600 dpi (Colour)
- Print Speed : Upto 21ppm
- Processor : 60 MHz
- RAM : 128 MB
- Media Capacity: 300 sheets
- Connectivity : Hi-Speed USB 2.0 & built-in 10/100 Base-TX Ethernet, WiFi 802.11b/g/n

1.7 INDUSTRIAL ETHERNET SWITCH

The controller shall communicate with I/Os and mimic/display/processing stations on Ethernet network to meet the required cycle time in PLC and updating time in work station.

- The industrial grade Ethernet bus shall operate at 100/1000 Mbps.
- The architecture shall be switched LAN.
- The communication over this shall not load I/O bus.

- Work stations are to be connected via Ethernet links and Ethernet switch and shall communicate on TCP/IP.
- a) Type : Layer 2/3 Manageable switch
- b) Switching capacity : 16 Gbps or better
- c) L2 features : SNMP/ RMON/BOOTP/Telnet/Web Network management protocols Port trunking 802.3 Ethernet, 802.3u Fast Ethernet, 802.1d spanning tree, 802.1 W Rapid spanning tree, 802.1P Priority tags, 802.1q VLANs, 802.1ac VLAN Tagging, 802.1 ad Link Aggregation control, 802.3x Flow controls, 802.1X MAC Based Network Access control, IPv6 support
- d) Console port : Yes
- e) MAC address table : 8K or better
- f) Fan less design : Yes
- g) Housing : IP 30
- h) Number of copper ports : 16
RF45
- i) Number of SFP port(uplink) : 2 or more

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Scope of work and services

Annexure: A

- j) Management Interface : Telnet, CLI/Console, HTTP, SNMPv1/v2/v3, SSH
- k) Security : IEEE 802.1 x Port-based/ MAC based control, Port security, DHCP snooping, SSH, Dynamic Arp inspection, Access Control List, RADIUS, TACACS + Broadcast/ Multicast / Unicast storm control
- l) Port Management and configuration : Port disable/enable, Auto negotiation 10/100/1000 Mbps full and half duplex mode selection
- m) Quality of service : Ingress policing, Rate – Limit, Egress Queuing/ shaping, Auto QoS
- n) VLAN : 802.1Q support, upto 255 VLAN
- o) Enclosure : IP30 Aluminium Metal case
- p) Installation : DIN Rail mountable
- q) Power supply : 24 VDC , Redundant 24V DC power input and relay output for fault indications
- r) LED Indicators : Link/ Activity for RJ45 and Fibre ports, Redundant Power 1 & 2
- s) Operating temperature : 0 to 75 deg C
- t) Operating humidity : 10 – 95% non condensing
- u) Certification : CE, FCC Class A

1.8 ETHERNET CABLES

- a) Category : CAT6
- b) Type : Stranded and Shielded (100MHz)
- c) Wire Gauge : 24 AWG
- d) Wiring standard : T568B
- e) Cable impedance : 100 Ω
- f) Operating temperature : -10°C to 60°C
- g) Connector : Moulded connector shield (metal shield housing) as per EIA/TIA 568B with gold contacts more than 50 and twist protection, 2 x RJ45.
- h) Boot: Moulded Gray Boot with pressing clip around each connector, shielded with RJ45 connector, with integrated moulded pressing clip for pressing the RJ45 connector clip.

1.9 CONSOLE SWITCHES (Hardwired)

Console switches are hardwired switches used for authorization, manual abort and manual hold and are connected to the DI card of local RIO node of TCS. The process/ simulation switches are also connected to the DI card of the local RIO node. The wiring details be finalised during detailed engineering.

The following switches along with accessories are essential for realization and are tabulated below.

S.NO	Switch Type	Quantity
1.	Pushbutton actuator, flush mounting, LED, switching element and transparent cover. lens colour :	15

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Scope of work and services

Annexure: A

	Plastic blue	
2	Pushbutton actuator, flush mounting, LED, switching element and transparent cover. lens colour : Plastic Green	15
3	Pushbutton actuator, flush mounting, LED, switching element and transparent cover. lens colour : Plastic Red	15
4	Pushbutton actuator, flush mounting, LED, switching element and transparent cover. lens colour : Plastic yellow	15
5	Stop pushbutton actuator, flush mounting, and switching element. Front ring : Aluminum natural Twist to unlock clockwise Mushroom head cap :Plastic RED	5
6	Key lock switch actuator 2 positions, flush mounting and switching element.	25
7	Indicator, flush mounting lens colour : Plastic yellow	15
8	Indicator, flush mounting lens colour : Plastic Green	15
9	Indicator, flush mounting lens colour : Plastic red	25
10	Indicator, flush mounting lens colour : Plastic blue	15

- a) Front protection: IP 65
- b) Switched action: Maintained action (MA)
- c) Mounting cut-out: 30.5 mm dia
- d) **Switching Element:** Switch rating 250VAC 6AContacts: 2 NO, Contact material: Au-Ag = Gold-Silver, Switching system: SA = Snap-action switching element and screw terminal.
- e) **Transparent cover:** Hinged, transparent, sealing for above mentioned Pushbutton.

2.0 INSTRUMENTATION RACK

2.0.1 SYSTEM CABINET

PLC and relevant auxiliary devices shall be housed in standard cabinet. Access to the cabinet can be from front & rear doors with key lock, cabinet shall have openings on the bottom with removable cable gland plates.

System cabinet shall be of suitable mounted on the front side of instrument rack. Following indication shall be provided for main and redundant system in all racks.

- i. Power supply (Voltage)
- ii. Cabinet Temperature
- iii. Neutral to Earth (NE) voltage.
- iv. System status

The cabinet shall be provided with proper lighting and cooling fan arrangements. The power supply for fans shall be independent of system power supply and the fan failure alarm shall be configured and status shall be displayed on screen. Fan failure and temperature detection unit shall be part of the system cabinet.

- a) Size: Depth-800mm , Height 2000 mm, Width 1200 mm (approximately) with two door for housing the control system modules
- b) Size: Depth-1000mm, Height 2000 mm, Width 800 mm with door for housing the servers
- c) Exact size of the cabinet can be decided during detailed engineering
- d) Power supply positioning in the cabinet shall be preferably on the top to avoid electromagnetic interference to electronic components.
- e) The cabinet shall be supplied in complete with all necessary hardware and accessories with complete wiring. The workmanship and accessories shall be of high quality as per international standard.
- f) The base frames and accessories (bolts / anchor fasteners/ angles) required for fixing of all the equipments shall be provided.
- g) Frameworks: Self standing type 2-2.5 mm CRCS steel plates
- h) Painting: Decided during detailed engineering
- i) Cables entry / access: From the bottom
- j) Lockable front door made of tinted glass
- k) Lockable rear steel door with venting options
- l) Lockable perforated rear steel door for server cabinet
- m) Side panels with slam latches and vented top cover
- n) Cabinet access : From rear and front doors with lock and keys
- o) Copper grounding bars
- p) Cables fixing with terminals and clamps.

- q) Service Power supply socket of 230V, 50 Hz at bottom of cabinet.
- r) Power requirement and heat dissipation for all racks shall be ensured for appropriate cooling of equipments (controller, I/O cards, Servers, Network Switches etc) for continuous operation of 24 hours.
- s) Forced ventilation from top for all cabinets.
- t) Panel lighting fluorescent type with on/off switch and interlock with door.
- u) Reference Standard as per Indian or International standard valid in India.
- v) Cable duct of plastic with cover (maximum width - 150mm) sized to allow a loading coefficient of 80%.
- w) Complete wiring, the workmanship and accessories shall be of high quality as per international standard.
- x) Cable gland suitable for I/O cables is in the contractor's scope. The cable glands shall be of metal (Chromium plated).
- y) Cabinet shall be provided with Temperature indicator, Digital panel meter with suitable interface for connecting in Remote power monitoring system and Power on lamp on the front door of the panel.

2.0.2 CABINET GROUNDING SYSTEM

The system cabinet shall have two separate grounding bars, one for safety purposes and the other one for instrumentation earthing purposes.

- a) The first, known as the "power earth" for equipment / cabinets / console body grounding of appropriate size etc.

- b) The other bar, known as the “Instrument earth” for system input / output signals and system electronic module for reference zero-volt signal and with the cable shielding.

All necessary hardware and accessories shall be part of supply.

2.0.3 WIRING

- a) Wiring shall comply with the applicable IEC codes. Wiring for different voltage signals or different functions shall be terminated separately on dedicated terminal strips with colour coding.
- b) Separate colour coding to be followed for utility power (fan, temperature monitor) and process power (I/O modules, processor).
- c) Wiring shall be accomplished with flexible stranded tinned copper wires sized 18/20/22 AWG, PTFE cable in compliance with the applicable codes.
- d) Wires shall be housed in plastic raceways of suitable dimensions to accommodate system cables, I/O signal cables etc. having 20% spare space for future expansion.
- e) Suitable & sufficient size wire ways must be provided inside the cabinet for proper routing and for neat, elegant look.
- f) Raceways shall be organized to run electric wires according to their voltage level and function. Power supply wires and low voltage signal wires shall not be grouped together in the same raceways, separate raceways shall be provided.

- g) Signal & power terminals blocks in the control system cabinet shall be separated and identified properly (colour coding is preferred).
- h) All I/O cables to be terminated at lock type plug-in multi-pin connector and to be mounted at the system cabinet. Mating connector also to be supplied.
- i) All control system cabinet panels shall be supplied with complete wiring etc.
- j) The panel shall have at least 20% extra terminals for future use.
- k) Terminations, cables, wiring, components shall be properly tagged with ferruling at both sides of the termination.
- l) Terminal strips shall be of adequate size min 1.5 mm².
- m) The Powering scheme for main and redundant controller shall be independent and shall be tapped from facility UPS. The fan, light and other Auxiliary systems shall be tapped from EB.

2.0.4 CABLE Specifications

1. Single core **(wire) of 18 AWG (19/30)** Type E PTFE (Teflon) Insulated Silver Plated multi strand Copper wire in different colours.

Inner Conductor	Annealed silver plated electrolytic copper stranded conductor
Standards	MIL-W-16878 , JSS 51034, JSS 51038 & ASTM B 298
No. of cores	1
Colour	Independent cores shall be differently colour coded as per standard
No. of twists/meter	15 to 20
Conductor	
Silver thickness over conductor	1 micron (minimum)
No. of strands	19
Strand dia	0.25 mm
Conductor dia	1.1684 mm(min), 1.3208 mm (max) 1.27 mm (nominal)
Insulation	
Core insulation	PTFE tape spirally wrapped and fused
Insulation thickness	0.254 ± 0.05 mm as per standard
Diameter of core including insulation	1.63 mm (min), 1.87 mm (max)
Electrical Properties	
Max. Resistance of the conductor at 20 ° C	20 Ω/Km
Packing length	100 meters (spool/drum)± 10% tolerance

Request for Proposal on Control System for Thrust chamber Test Facility

Scope of work and services

Annexure: A

2. **Single core (wire) of 20 AWG (19/32)** Type E PTFE (Teflon) Insulated Silver Plated multi strand Copper wire in different colours.

Inner Conductor	Annealed silver plated electrolytic copper stranded conductor
Standards	MIL-W-16878 , JSS 51034, JSS 51038 & ASTM B 298
No. of cores	1
Colour	Independent cores shall be differently colour coded as per standard
No. of twists/meter	15 to 20
Conductor	
Silver thickness over conductor	1 micron (minimum)
No. of strands	19
Strand dia	0.20 mm
Conductor dia	0.9398 mm(min), 1.0414 mm (max) 1.02 mm (nominal)
Insulation	
Core insulation	PTFE tape spirally wrapped and fused
Insulation thickness	0.254 ± 0.05 mm as per standard
Diameter of core including insulation	1.37 mm (min), 1.57 mm (max)
Electrical Properties	
Max. Resistance of the conductor at 20 °C	30 Ω/Km
Packing length	100 meters (spool/drum)± 10% tolerance

Request for Proposal on Control System for Thrust chamber Test Facility

Scope of work and services

Annexure: A

3. **Single core (wire) of 22 AWG (19/34)** Type E PTFE (Teflon) Insulated Silver Plated multi strand Copper wire in different colours.

Inner Conductor	Annealed silver plated electrolytic copper stranded conductor
Standards	MIL-W-16878 , JSS 51034, JSS 51038 & ASTM B 298
No. of cores	1
Colour	Independent cores shall be differently colour coded as per standard
No. of twists/meter	15 to 20
Conductor	
Silver thickness over conductor	1 micron (minimum)
No. of strands	19
Strand dia	0.16 mm
Conductor dia	0.7366 mm(min), 0.8382 mm (max) 0.81 mm (nominal)
Insulation	
Core insulation	PTFE tape spirally wrapped and fused
Insulation thickness	0.254 ± 0.05 mm as per standard
Diameter of core including insulation	1.16 mm (min), 1.37 mm (max)
Electrical Properties	
Max. Resistance of the conductor at 20 °C	50 Ω/Km
Packing length	100 meters (spool/drum)± 10% tolerance

2.0.5 MULTIPIN CONNECTOR

Male and Female Contacts

Type	: Crimp
Contact Material	: Copper alloy-hard gold plated Au over Ni
Gold plating thickness	: 0.8 μm (Min)
Ni thickness	: 2 μm (Min)
Contact size	: 18/20 AWG and 22 AWG
Working Current	: 10 A
Working voltage	: 600 V
Insulation resistance	: ≥ 100 M ohm
Contact resistance	: ≤ 4 milliohm

Inserts:

No. of Poles	: 72, 108
Rated Voltage to UL/CSA	: 600 V
Rated current	: 10 A
Rated impulse withstand voltage	: 4 kV
Insulation resistance	: ≥ 10 Mohm
Material	: Glass fibre reinforced Poly Carbonate
Temperature Range	: -40 °C +125 °C
Mechanical service life	: ≥ 500 mating cycles
Contact resistance	: ≤ 4 milliohm

Hoods:

Materials	: Die-Cast Aluminium
Surface	: Powder coated RAL 7037(Grey)

Cable entry	: Bottom
Cable entry dia.	: M32
Protection	: IP65
<i>Base Housing (bulk head)</i>	
Material	: Die-Cast Aluminium
Surface	: Powder coated RAL 7037(Grey)
Locking Mechanism	: Double latch
Locking material	: Stainless Steel
Standards & Certifications	
Certification	: UL, CSA or equivalent
Standard	: DIN EN 60 664.1 DIN EN 61 984

2.1 ELECTRICAL POWER SUPPLY

- a) The contractor shall be responsible for providing all the DC power supplies with redundancy required for the different system components. Power supply shall be sized with 30% spare capacity considered at normal continuous load. A warning signal shall be displayed on LCD Screen for monitoring power failure.
- b) MCB shall be provided in the system cabinet.
- c) Isolating switches and fuses with reverse protection shall be employed to isolate and protect the load. The contractor shall provide the following data regarding power supply:
 - i. Total power consumed.
 - ii. Peak power requirements.
 - iii. Maximum tolerable no-voltage period.
 - iv. Power dissipated as heat.

v. Number of units to be powered.

Distribution of power shall be with proper isolation through required rating of fuses and MCB.

Note: This specification provides the minimum requirement of the system but it does not relieve the contractor from his responsibilities for completeness of the system concerning the design, the reliability and the safe operation of the supplied equipment. If required the contractor shall include additional items other than specified in **price format** given in ***Annexure-D1, D2, D3, D4, D5 & D6.***

Price format shall be submitted for all the control systems (TCS, ESS & SS) separately. Site preparation, Erection and Commissioning of the complete system work shall be quoted in **lump sum amount and not in man-hour basis.**

Moreover, it is stressed that Control System (Hardware & software) shall be of **latest proven model** and shall be supplied as a **turnkey based system.**

ANNEXURE-A3

DATA REPORTING FORMAT (ANALOG DATA)

Test Name: **Test 1**

Date: 01-01-2024

TIME mSec	MPI104 Mpa	MPI10 6 Mpa	MPI107 Mpa	MPI112 Mpa	MPI12 9 Mpa	MPI130 Mpa
-23400.000	1.20	1.37	1.19	9.85	9.68	9.84
-23399.090	1.60	1.37	1.19	9.84	9.68	9.84
-23399.080	1.20	1.37	1.19	9.84	9.68	9.84
-23399.070	1.30	1.37	2.39	9.84	9.67	9.84
-23399.060	1.20	1.07	4.89	10.35	9.67	9.83
-23399.050	1.70	2.33	6.19	11.65	9.67	9.83

MPI 104-PRESSURE-4

MPI 112-PRESSURE-5

MPI 106-PRESSURE-3

MPI 129-PRESSURE-6

MPI 107-PRESSURE-4

MPI 130-PRESSURE-8

Test Name: **Test 2**

Date: 01-01-2024

TIME mSec	MPI104 Mpa	MPI105 Mpa	MPI106 Mpa	MPI107 Mpa	MPI112 Mpa	MPI129 Mpa	MPI130 Mpa
00.100	11.65	0.94	1.37	1.19	9.843	2.79	9.84
00.150	10.35	0.94	1.33	1.18	9.84	3.01	9.84
00.200	9.20	1.94	1.38	1.19	9.84	3.24	9.84
00.250	8.26	1.83	1.47	1.19	9.83	3.60	9.83
00.300	7.90	1.74	1.27	1.18	9.84	3.75	9.83
01.350	8.26	1.83	1.33	1.18	9.85	3.28	9.84

MPI 104-PRESSURE-4

MPI 112-PRESSURE-5

MPI 105-PRESSURE-2

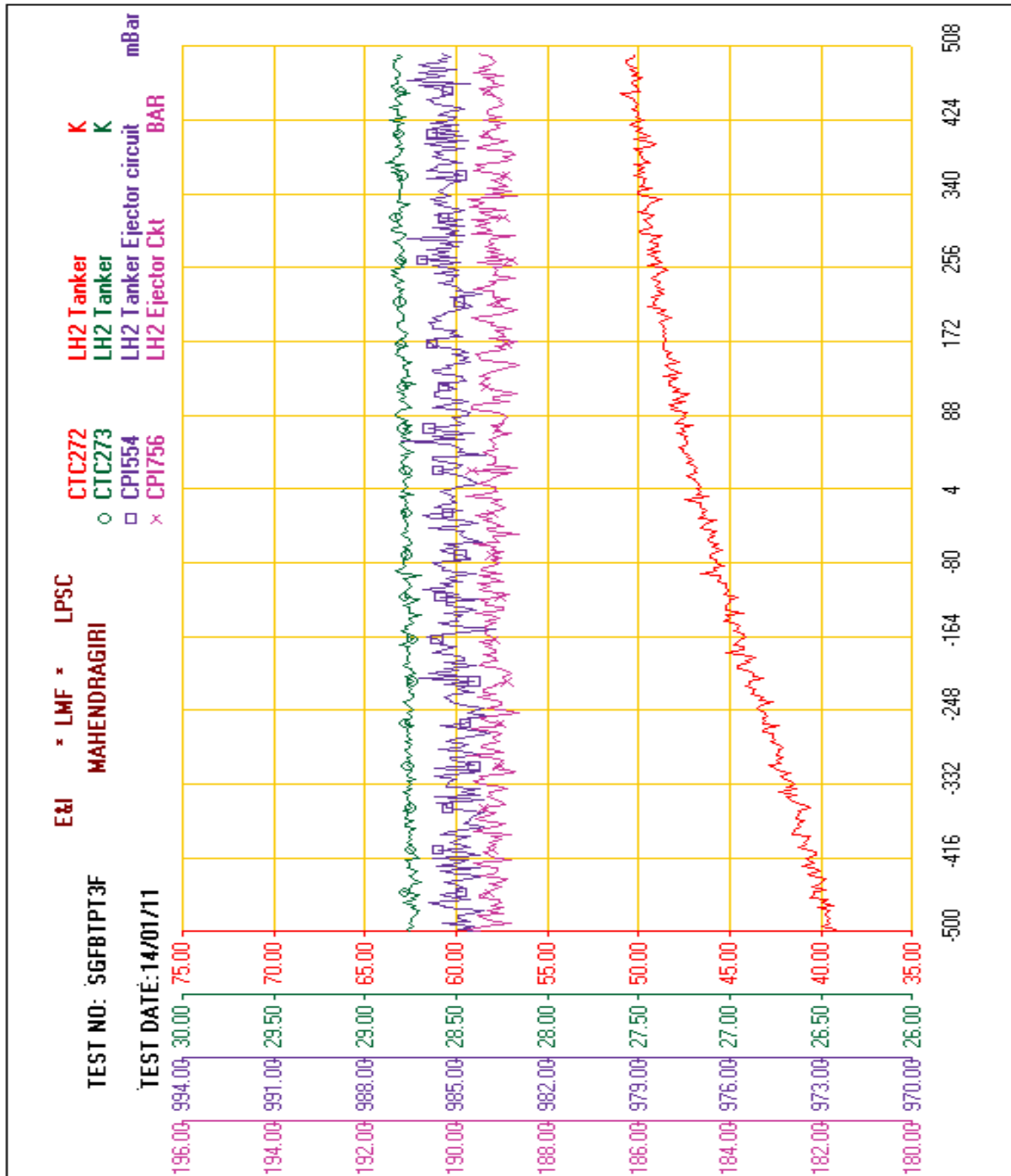
MPI 129-PRESSURE-6

MPI 106-PRESSURE-3

MPI 130-PRESSURE-8

MPI 107-PRESSURE-4

ANNEXURE-A4 TREND GRAPH FORMAT



ANNEXURE-A5
DATA REPORTING FORMAT (DIGITAL DATA)

Test Name: Test 1

Date: 01-01-2024

TIME (SEC)	VALVE TAG NAME	STATUS
-043.010	VALVE 1	COMMAND ON
-042.410	VALVE 1	START OPEN
-040.990	VALVE 1	OPEN
-033.100	VALVE 2	COMMAND OFF
-032.020	VALVE 2	START CLOSE
-031.460	VALVE 2	CLOSE
-001.380	VALVE 3	COMMAND ON
+003.010	VALVE 3	START OPEN
+003.140	VALVE 3	OPEN
+009.060	VALVE 4	COMMAND ON

ANNEXURE-A6

SAMPLE CHRONOLOGY OF OPERATION

Time	Activity
To – 02:40:50.02	Open VALVE 1 and close VALVE 2
To – 02:37:00.00	Open VALVE 3
To – 02:33:30.02	Close VALVE 4
To + 00:30:50.05	Open VALVE 5 & VALVE 6
To + 01:31:00.00	Close VALVE 5 & VALVE 6
To + 02:26:06.06	Open VALVE 7
	Close VALVE 3

ANNEXURE-A7

SAMPLE INPUT FILE FOR AUTO SEQUENCE OPERATION

EVENT	CASE	TIME(ms)	VALVE	STN	SLOT	CHNL	CMD	PO
Event1	1	26000	CVP511	4	0	13	1	0
Event2	1	28000	FBTVV	4	5	6	1	0
Event3	1	95000	SV680	2	16	4	0	0
Event4	1	100000	EPV52	4	4	13	1	0
Event5	1	105000	CVP262	2	19	12	0	0
Event6	1	106000	CVP252	2	17	1	0	0
Event7	1	116000	FBTVV	4	5	6	0	0
Event8	1	120000	EPV50	4	5	0	0	0
Event9	0	121000	CVC550	0	11	3	0	10000
Event10	0	121400	CVC501	0	11	5	0	4650

ANNEXURE-A8

INTERLOCK

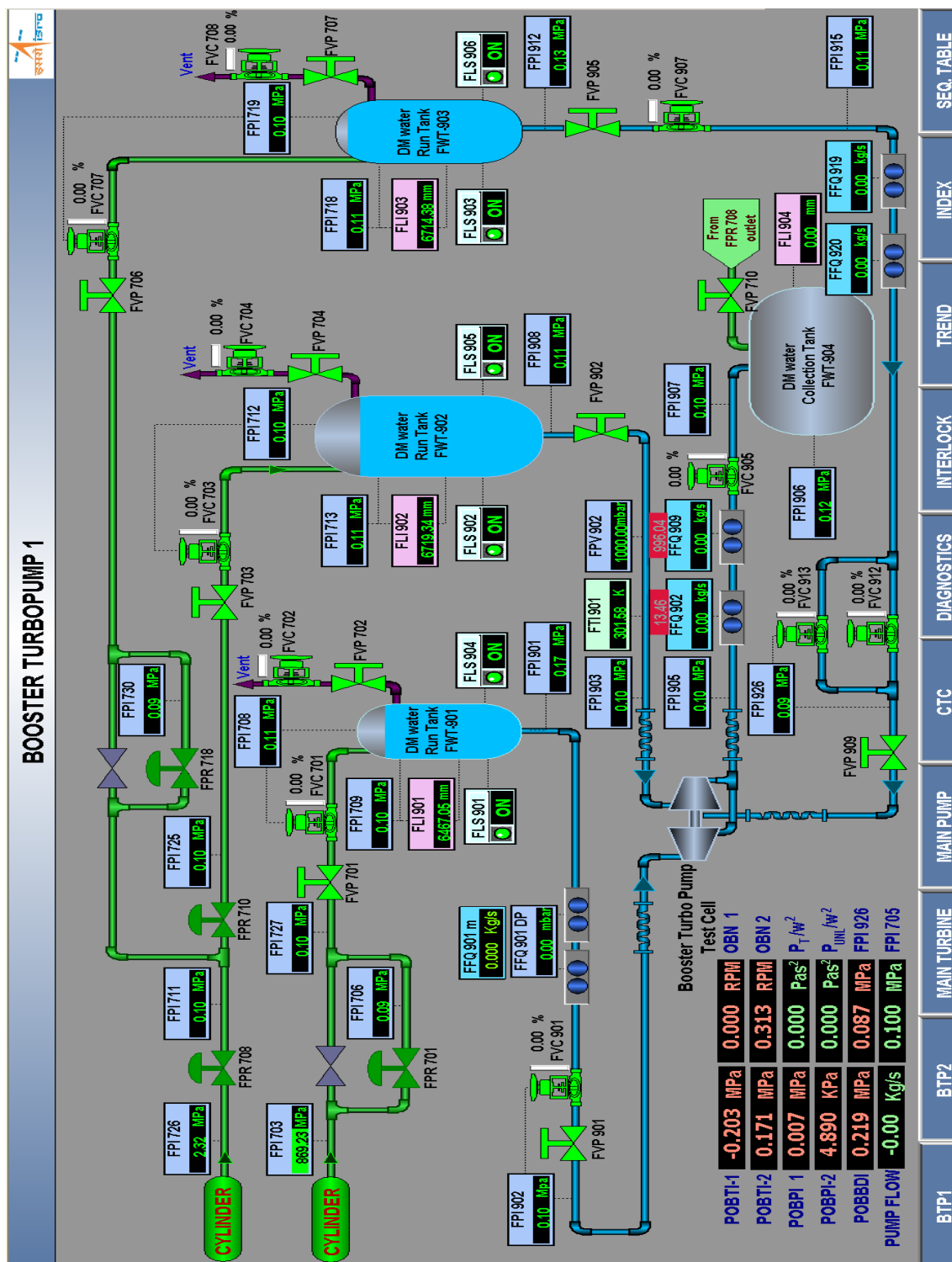
Interlock No.	Control Parameter	Interlock logic
1	PRESSURE 1 (P1) PRESSURE 2 (P2)	When P1 (OR) P2 $\geq$ 8 bar Abs, open VALVE 1, VALVE 2 & VALVE 3 and close VALVE 4 immediately and latch the aforesaid valves in the given position. Note: VALVE 2 and VALVE 3 are normally open type.
2	PRESSURE 1 (P1) PRESSURE 2 (P2)	When P1 & P2 $\leq$ 1.1 bar Abs, close VALVE 1 and latch it in closed position and open VALVE 5.

ABORT LOGIC

Abort No.	Parameter	Condition	Validity
1	PRESSURE 1 (P1) > 10BAR PRESSURE 2 (P2) > 10BAR PRESSURE 3 (P3) > 12BAR	2/3 condition	To-2 Sec. to To+60 Sec.
2	PRESSURE 1 (P1) < 2BAR TEMPERATURE (T1) > 150K	2/2 condition	To+0.5 Sec. to To+60 Sec.

ANNEXURE-A9**SAMPLE INPUT FILE FOR ABORT LOGIC OPERATION**

Abort_id	Start_time	Stop_time	Logic	Par_A	Station1	Slot1	Channel1	Limit_1	Par_B	Station2	Slot2	Channel2	Limit_2	Par_C	Station3	Slot3	Channel3	Limit_3
6	0	320000		6 DUM_AI	0	0	4	33000	DUM_AI	0	0	4	33000	DUM_AI	0	0	4	33000
1	120000	320000		0 RFBP	2	9	0	21017	RFBTP	2	9	1	21015	DUM_AI	0	0	4	30000
2	130000	320000		3 PFBO	1	8	2	6530	PFPI	1	8	3	7880	DUM_AI	0	0	4	6000
3	121000	320000		3 PHCT1	1	8	0	5021	PHCT2	2	8	1	9157	PFBI	1	8	5	4900



ANNEXURE-A11
INSPECTION, TESTING & DOCUMENTATION

1. INSPECTION AND TESTING

The supply will be subject to inspection and tests attended by Purchaser as required. The Purchaser witness does not relieve the contractor from his responsibilities for hardware, software, other accessories and services if required.

Contractor shall submit factory tests, installation, and commissioning and acceptance procedures (for hardware, the procedures shall include: purpose of test, test definition, results expected and acceptance criteria).

Tests and acceptance of the system shall be carried out as per agreed procedures and criteria based on specified guidelines and the contractor's standard procedures finalized during kick off meeting.

Client representatives are authorized to monitor supply completeness and compliance to the requirements as per specification and schedule. The contractor shall allow free access at any time to contractor works to Purchaser's representatives.

1.1. GENERAL

- a) All system shall undergo factory testing and inspection by Purchaser unless specified otherwise.
- b) Wherever inspection at manufacturer's shop is waived because of any reason, the sub contractor's own testing reports shall be verified before dispatch. In no case items shall be released without proper inspection/ verification.
- c) The inspection and testing shall be carried out as per related specifications, international codes and practices/standards, approved documents and/or any other documents attached along with specifically suggesting testing to be carried out at manufacturer' works.

- d) Testing and inspection for all items shall be carried out as per approved factory testing procedures.
- e) Performance specifications must be detailed out on each time which shall be verified by Purchaser during factory testing.

1.2. FACTORY ACCEPTANCE TEST (FAT)

- a) The contractor shall test and demonstrate the functional integrity of the system hardware and software. The test shall be carried out when the system is in full assembled condition and no equipment/modules wise test will be accepted. Contractor to provide all the needed facilities to comply with the above requirement. FAT shall be conducted by staging 100% I/Os of the system with actual configuration. The contractor shall inform the schedule for testing **30 days in advance**. The test certificate shall be given to Department during FAT for verification and acceptance.
- b) No material or equipment shall be shipped until all required tests are successfully completed and certified "Ready for shipment" by the Purchaser representative.
- c) It shall be the contractor's responsibility to modify and replace any hardware and modify the software if the specified functions are not completely achieved satisfactorily during testing and factory acceptance.
- d) Integrated System Performance will be evaluated.
- e) Contractor shall demonstrate following tests, as a part of FAT as a minimum for control systems
 - i. Cycle time under normal working conditions:
The system shall be loaded with application program,

64 PID loops with full load (with 5 mimic diagrams in all work stations). The time required for the controller to carry out and complete a cycle (consisting of synchronization, self-diagnosis, input read, Output setting, Peripheral communication, main & redundant communication and other system over heads) must be within 10 ± 1 ms. Also the time taken by the processor to carry out the individual activities is to be measured.

Cycle time 10 ± 1 ms fixed shall be demonstrated by toggling Digital Output (ON and OFF for alternate scan) from each RIO. The outputs shall be connected to Digital storage oscilloscope or external high speed data acquisition system and to be monitored for a period of 10 sec.

Time drift shall be within ± 10 ms over a period of 1000 sec and shall be demonstrated by toggling Digital Output (ON and OFF for alternate scan) from each RIO continuously for 3600 sec and data to be acquired in Digital storage oscilloscope or external high speed data acquisition system and to be demonstrated.

Ramp up & ramp down from external source to Analog Input from each RIO for a period of 1000 sec. The same AI signal shall be fed to Analog Output from each RIO to external high speed data acquisition system for a period of 1000 sec to ensure data integrity.

- ii. Digital data acquisition with 10 ms for all parameters
- iii. Analog Data Acquisition and recording at every 10 ms (100 samples/s) for any user-selected 128 parameters and for the remaining parameters at 50/100 ms (user selectable) interval.

- iv. DA & CS, Real time display & data reporting software for continuous acquisition of 24 hours.
- v. Functional verification(random) of I/O's
- vi. Updation rate of scada node (less than 500 milli Sec)
- vii. Accuracy, linearity, repeatability, filter response, stability check & response time of I/O cards.
- viii. The hot swappable/pluggable feature for the I/O cards.
- ix. Demonstrating the network speed in all layers with full load.
- x. Error diagnostics of the network failure, system failure, I/O failure, processor failure, server failure and its changes in MIMIC
- xi. Acquisition of main & redundant RIO data and its retrieval.
- xii. PID Control through SCADA
- xiii. PID loops in 100ms interval
- xiv. Cycle time under failure condition:

Under normal working conditions, the various possible faults on CPU, Power supply, Communication Processors, Remote nodes, Local Nodes, Ethernet Bus, Switches etc. of the Control System will be simulated and the cycle time under failure condition will be measured. The switch over time shall be within 20 ms.

Cycle time under failure condition shall be demonstrated by toggling one of the digital outputs and simulating the failure condition and monitoring the output and failure bit in digital storage oscilloscope and external high speed data acquisition system. The switch over time shall be within 20 ms.

After the switchover, the Cycle time $10 \pm 1\text{ms}$ fixed shall be demonstrated by toggling Digital Output (ON and OFF for alternate scan) from each RIO. The outputs shall be connected to Digital storage oscilloscope and external high speed data acquisition system and to be monitored for a period of 10sec.

Ramp up & ramp down from external source to Analog Input from each RIO for a period of 1000 sec. The same AI signal shall be fed to Analog Output from each RIO to external high speed data acquisition system for a period of 1000 sec to ensure data integrity.

- xv. 5 sample mimic, with animation which demonstrate command generation, status and display.
- xvi. File size, creation of new file & data retrieval in 5 minutes (for 1 hour acquired data) and offline processing as per the format mentioned.
- xvii. Demonstration of one sample auto sequence, interlock and abort logics using input file reading.
- xviii. Demonstration of redundant channel auto changeover in case of failure of main channel for auto sequence logic.
- xix. Demonstration of redundancy management in case of failure of processor, Network link, Remote Nodes, SCADA server & I/O.
- xx. Fail safe mode condition to be demonstrated in case of any failure of CPU, power supply, interface cards, communication, I/O cards etc. and also control shall change over from Main to Redundant system in all respects. During this change over the Input / Output should maintain the same value just before failure till

the other system takes over (Bumpless transfer). The Main & Redundant Controller change over time shall be within 20 ms without loss or interjection of data by maintaining program & I/O continuity.

xxi. Burn in test for 72 hours

xxii. Any other mutually agreed test.

f) Contractor shall demonstrate following tests, as a part of FAT as a minimum for ESS system

i. Cycle time under normal working conditions:

ii. The system shall be loaded with application program, 16 PID loops (1 mimic diagram). The time required for the controller to carry out and complete a cycle (consisting of self-diagnosis, input read, Output setting, Peripheral communication and other system over heads) must be fixed $10 \pm 1\text{ms}$. Also the time taken by the processor to carry out the individual activities is to be measured.

Cycle time $10 \pm 1\text{ms}$ fixed shall be demonstrated by toggling (ON and OFF for alternate scan) any one of the Digital Output. The output shall be connected to Digital storage oscilloscope and external high speed data acquisition system and to be monitored for a period of 10sec.

Time drift shall be within $\pm 10\text{ ms}$ over a period of 1000 sec and shall be demonstrated by switching any one digital output ON continuously for 3600 sec and data to be acquired in external high speed data acquisition system and to be demonstrated.

iii. Diagnostic feature and failure modes demonstration

- iv. Fault tolerant and fail safe condition demonstration.
 - v. The hot swappable/pluggable feature for the I/O cards.
 - vi. Digital data acquisition with 10 ms for all parameters
 - vii. Analog data acquisition with 10ms for all parameters
 - viii. DA & CS, Real time display & data reporting software for continuous acquisition of 24 hours.
 - ix. Functional verification (random) of I/O's
 - x. Accuracy, linearity, repeatability, filter response and stability check & of response time I/O cards.
 - xi. Acquisition of RIO data and its retrieval.
 - xii. One sample mimic, with animation which demonstrate command generation, status and display.
 - xiii. File size, Data retrieval in 5 minutes (1 hour acquired data) and offline processing as per the format mentioned.
 - xiv. Demonstration of one sample auto sequence input file reading.
 - xv. Fail safe mode condition to be demonstrated in case of any failure of CPU, power supply, interface cards, communication, I/O cards etc.
 - xvi. Burn in test for 72 hours
 - xvii. Any other mutually agreed test.
- g) Contractor shall demonstrate following tests, as a part of FAT as a minimum for SS system
- i. Accuracy, linearity, repeatability, filter response and stability check & response time of I/O sources.
 - ii. Real time display demonstration.
 - iii. Functional verification (random) of I/O's sources from local and remote node.

- iv. One sample GUI to demonstrate signal generation (mV, mA, ohms & Hz) and display.
- v. Demonstration of one sample auto sequence validation by generation of arbitrary signal
- vi. Demonstration of channel switching using matrix switch cards and carrying out TE for 2 pressure channels.
- vii. Burn in test for 72 hours
- viii. Any other mutually agreed test.

1.3. QUALITY ASSURANCE

Components, serviceability and maintenance of the same, which are meant to serve and provide effective and timely operation, which includes trouble free performance of the system and subsystem to the intended specification.

The contractor shall ensure for each electronic component of the system and shall conduct quality assurance test and submit report for the same. The complete system shall be assembled / wired and powered on at contractor works for specified period as per standards.

The contractor must look for the quality factors individually attributed to engineering developments, selection of equipment and components, test and acceptance procedures followed, repetitive performance achieved, risk analysis carried out etc. Each module must be manufactured and tested to international quality control standards. The test certificates shall be provided to Department.

Following tests but not limited to, shall be performed by the contractor and witnessed by Purchaser representatives:

- a) Testing for correct operation of system components under conditions of maximum allowed fluctuations of power supply voltage.
- b) Simulation of power supply break and system restart.
- c) 100% loop checking of the inputs and outputs of the system.
- d) Checking the software details, CPU & memory loading and system diagnostics checks.

1.4. SITE ACCEPTANCE TEST (SAT)

All the equipment shall be thoroughly checked after receipt on site. The tests shall include but not limited to the following in the presence of Contractor's commissioning Engineer:

Contractor shall do powering of panel at site after verifying termination at cabinets. Site acceptance test shall be started only after the satisfactory performance of loop checking and verification of records by Purchaser.

The site acceptance test shall be carried out in the presence of Purchaser's authorized representative at IPRC, Mahendragiri.

All the performance specification of the control system with the field terminations will be verified and contractor should demonstrate the following major performance 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) Contractor shall demonstrate the following tests, as a part of SAT for control system

- i. Cycle time verification 10ms along with full application program (actual program for hot tests) with full load (with all mimic diagrams in all nodes)
Cycle time 10 ± 1 ms fixed shall be demonstrated by toggling (ON and OFF for alternate scan) of the Digital Output from each RIO. The outputs shall be connected to external high-speed data acquisition system and monitored for a period of 10s. Ramp up & ramp down from external source to Analog Input from each RIO for a period of 1000 sec. The same AI signal shall be fed to Analog Output from each RIO to external high speed data acquisition system for a period of 1000 sec to ensure data integrity.
- ii. Time drift shall be within ± 10 ms over a period of 1000 seconds and shall be demonstrated by toggling (ON and OFF for alternate scan) of the Digital Output from each RIO continuously for 3600 seconds and data to be acquired in high speed data acquisition system and verified.
- iii. Demonstration of all failure cases and error diagnostic like network failure, system failure, I/O failure in mimic.
- iv. Demonstration of all system diagnostics
- v. Recording of time based and parameter based events
- vi. Demonstration of security login levels.
- vii. Acquisition of RIO data and its retrieval.
- viii. 10 ms for all Digital data acquisition
- ix. 10 and 50 ms Analog data acquisition
- x. Functional verification (random) of I/O's
- xi. Control System, Real time display, & data reporting software for continuous acquisition of 24 hours.

- xii. Updation rate of workstation at less than 500 milli second.
 - xiii. Redundancy Management in case of failure of processor, Network link, Remote Nodes, SCADA server & I/O.
 - xiv. Demonstrating the network speed in all layers with full load including operator nodes.
 - xv. Issuing manual commands from mimic from all SCADA nodes and verification of events.
 - xvi. Accuracy and response check (random) of I/O cards.
 - xvii. System behaviour test under simulated fault conditions.
 - xviii. Demonstration of the all automation modules, Auto and abort sequence, interlock and PID application program for tests with input file reading consisting of engineering unit.
 - xix. File size, creation of new file & data retrieval in 5 minutes (for 1 hour acquired data) and offline processing as per the format mentioned.
 - xx. Retrieval of Digital & Analog data with user selectable as per the requirement.
 - xxi. Plotting of Analog Data
 - xxii. Archiving of Data
 - xxiii. Demonstration of PID loops in 100ms interval, PID Control through SCADA.
 - xxiv. Checking of proper functioning of all disc drives, alarm summary, printers etc.
 - xxv. Burn in test for 72 hours & any other mutually agreed test.
- e) Contractor shall demonstrate following tests, as a part of SAT for ESS system

i. Cycle time under normal working conditions:

The system shall be loaded with actual application program followed for tests, 16 PID loops (1 mimic diagram). The time required for the controller to carry out and complete a cycle (consisting of self diagnosis, input read, Output setting, Peripheral communication and other system over heads) must be fixed $10 \pm 1\text{ms}$. Also the time taken by the processor to carry out the individual activities is to be measured.

Cycle time $10 \pm 1\text{ms}$ fixed shall be demonstrated by toggling (ON and OFF for alternate scan) of the Digital Output from each RIO. The outputs shall be connected to external high-speed data acquisition system and monitored for a period of 10s.

Time drift shall be within $\pm 10\text{ ms}$ over a period of 1000 sec and shall be demonstrated by switching any one digital output ON continuously for 3600 sec and data to be acquired.

- ii. Diagnostic feature and failure modes demonstration
- iii. Fault tolerant and fail safe condition demonstration
- iv. 10 ms for all digital data acquisition
- v. 10 ms for all analog data acquisition
- vi. DA & CS, Real time display demonstration.
- vii. Functional verification(random) of I/O's
- viii. Accuracy and response time for random I/O cards.
- ix. Issuing manual commands from mimic from all SCADA nodes and verification of events.
- x. Demonstration of the Auto sequence program for hot tests with input file reading consisting of engineering

unit.

- xi. Fail safe mode condition to be demonstrated in case of any failure of CPU, power supply, interface cards, communication, I/O cards etc.
 - xii. Burn in test for 72 hours .
 - xiii. Demonstration of ESS auto sequence upon failure of TCS system.
 - xiv. Any other mutually agreed test.
- h) Contractor shall demonstrate following tests, as a part of SAT as a minimum for SS system
- ix. Accuracy and stability check of I/O sources.
 - x. Real time display demonstration.
 - xi. Functional verification of all I/O's sources from local and remote node.
 - xii. Demonstration of real time test auto sequence validation by generation of arbitrary signal.
 - xiii. Demonstration of automation module validation by generation of arbitrary signal.
 - xiv. Demonstration of channel switching using matrix switch cards and carrying out TE for all pressure channels.
 - xv. Demonstration of V&V test case result, abort delay, sample V&V report with TCS data amalgamation, sample TE report with TCS and DAS data after amalgamation.
- i) Contractor shall demonstrate the full Integrated testing of TCS, ESS and SS as a whole, as a part of SAT.

Any malfunctioning in the system shall be rectified /replaced as required. Failure of any component shall be replaced with new one. No repaired parts/modules shall be accepted.

After confirming that the control system is meeting all requirements, the total system will be switched on continuously for 3 days and performance of the system will be monitored. On successful completion of the above period, if the performance of the system is satisfactory, Department and contractor will provide the acceptance test certificate jointly.

Client shall take over the system from the contractor after the final acceptance test, which is defined as successful operation of the integrated system. The contractor's personnel shall be present up to this period.

The Purchaser shall provisionally takeover the systems from Contractor after Site Acceptance Test.

ANNEXURE-A12

**SIGNAL SIMULATOR AUTO ABORT GROUP, LOOKUP TABLE
AND T&E REPORT FORMAT**

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Sl. No	Parameter	Abort Value	Time at which abort value is be set	Sensor Maximum O/P (mV)	Typical value at abort condition	Logic
1	Pressure-1 (P1)	P1 <= 70 degree	To-20s toTf	20 mA	16.44 mA	2 out of 2
	Pressure-2 (P2)	P2 <=70 degree		20 mA	16.44 mA	
2	Pressure-3 (P3)	P3 >= 20 KPa	To-12.5s	20 mA	5.78 mA	2 out of 3
	Pressure-4 (P4)	P4 >= 20 KPa		20 mA	5.78 mA	
	Pressure-5 (P5)	P5 >= 20 KPa		20 mA	5.78 mA	
3	Pressure-6 (P6)	P6 >= 20 KPa	To-8.5s to To-8.4s	20 mA	5.78 mA	2 out of 3
	Pressure-7 (P7)	P7 >= 20 KPa		20 mA	5.78 mA	
	Pressure-8 (P8)	P8 >= 20 KPa		20 mA	5.78 mA	
4	Pressure-9 (P9)	P9>= 7.3 MPa	To-Tf	15 mV	10.937 mV	2 out of 3
	Pressure-10 (P10)	P10 >= 8 MPa		15 mV	12.026mV	
	Pressure-11 (P11)	P11 >=8 MPa		15 mV	11.945 mV	
5	Temperature -1 (T1)	T1 >= 950 K	To toTf	30 mV	26.885 mV	4 out of 4
	Temperature -2 (T2)	T2 >= 950 K		30 mV	26.885 mV	
	Temperature -3	T3 >=750 K		30 mV	18.386 mV	

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	(T3)					
	Temperature -4 (T4)	T4 >= 750 K		30 mV	18.386 mV	
6	Pressure-9 (P9)	P9 <=1.6 MPa	To+3.5s to To+15s ec	15 mV	2.386 mV	2 out of 3
	Pressure-10 (P10)	P10 <=1.4 MPa		15 mV	2.121.mV	
	Pressure-11 (P11)	P11 <=1.4 MPa		15 mV	2.061 mV	
7	Pressure-12 (P12)	P12<=2.0MPa	To+5s to To+15 Sec	15 mV	2.945 mV	2 out of 3
	Pressure-13 (P13)	P13 <=1.8 MPa		15 mV	2.663.mV	
	Pressure-14 (P14)	P14 <=1.2 MPa		15 mV	2.577 mV	
8	Speed-1 (S1)	S1 >=35720 RPM	To toTf	2500 Hz	1633.3 Hz	2 out of 3
	Speed-2 (S2)	S2 >= 35720 RPM		2500 Hz	1633.3 Hz	
	Speed-3 (S3)	S3 >= 35720 RPM		2500 Hz	1633.3 Hz	
9	Speed-4 (S4)	S1 >= 16000 RPM	To toTf	1000 Hz	799.95 Hz	2 out of 3
	Speed-5 (S5)	S2 >= 16000 RPM		1000 Hz	799.95 Hz	
	Speed-6 (S6)	S3 >= 16000 RPM		1000 Hz	799.95 Hz	
10	Pressure-9 (P9)	P9 >=0.2 MPa	To- 00:00:0	15 mV	0.2863 mV	2 out of 3

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	Pressure-10 (P10)	P10 >=0.2 MPa	1s to To- 00:00:0 .9s	15 mV	0.320.mV	
	Pressure-11 (P11)	P11 >=0.2 MPa		15 mV	0.264 mV	
11.	Pressure-15 (P15)	P15 >=0.5bar	To- 00:00:0 8.5 to To- 00:00:0 8.4	15 mV	1.364 mV	2 out of 3
	Pressure-16 (P16)	P16>=0.5 bar		15 mV	7.621 mV	
	Pressure-17 (P17)	P17>=0.5 bar		20 mA	8.44 mA	
12	Pressure-18 (P18)	P18 <=1.7 MPa	To toTf	20 mA	8.533 mA	2 out of 2
	Pressure-19 (P19)	P19<=1.7 MPa		20 mA	8.533 mA	
13	Pressure-20 (P20)	P20<=1.7 MPa	To toTf	20 mA	8.533 mA	2 out of 2
	Pressure-21 (P21)	P21<=1.7 MPa		20 mA	8.533 mA	
14	Pressure-22 (P22)	P22 <=1.7 MPa	To toTf	20 mA	8.533 mA	2 out of 2
	Pressure-23 (P23)	P23<=1.7 MPa		20 mA	8.533 mA	
15	Pressure-24 (P24)	P24<=1.7 MPa	To toTf	20 mA	8.533 mA	2 out of2
	Pressure-25 (P25)	P25<=1.7 MPa		20 mA	8.533 mA	

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16	Pressure-26 (P26)	P26<=7.4MPa	To+10s to Tf	15 mV	7.37mV	2 out of 3
	Pressure-27 (P27)	P27<=8.0 MPa		15 mV	8.047 mV	
	Pressure-28 (P28)	P28<=6.0 MPa		15 mV	8.992 mV	
17	Pressure-9 (P9)	P9>=7.3 MPa	To+4s to Tf	15 mV	10.9369 mV	2 out of 3
	Pressure-29 (P29)	P29>=7.5 MPa		15mV	11.240 mV	
	Pressure-30 (P30)	P30>=8.9 MPa		15 mV	8.874 mV	
18	Pressure-31 (P31)	P31>=25 kPa	To- 00:00:1 2.5	20 mA	6.22 mA	2 out of 2
	Pressure-32 (P32)	P32>=25 kPa		20 mA	6.22 mA	

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1. Look up table for Pressure measurements (mV)

Input (mV)	Expected (MPa)	SS	
		Simulated	Generated
0	-0.020		
4	0.223		
8	0.466		
17	1.018		
17	1.018		
8	0.466		
4	0.223		
0	-0.020		

2. Look up table for Pressure measurements (mA)

Input (mA)	Expected (MPa)	SS	
		Simulated	Generated
4	0		
8	2.5		
12	5		
16	7.5		
20	10		
16	7.5		
12	5		
8	2.5		
4	0		

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3. Look up table temperature measurements (K)

Input (ohms)	Expected (K)	SS	
		Simulated	Generated
0.430			
5.320			
59.600			
119.820			

4. Look up table thermocouple measurements (K)

Input (ohms)	Expected (K)	SS	
		Simulated	Generated
-4.221	150.150		
3.142	350.150		
15.427	650.150		
23.927	850.150		

5. Look Up table for SPEED and FLOW measurements

Input (Hz)	Expected (rpm)	SS	
		Simulated	Generated
0.000	0.000		
1000	20000.000		
1500	30000.000		
2250	450000.00		

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TCTI/CTIG/AISE/IPRC

CE20 HAT PRESSURE MEASUREMENT CHAIN TEST REPORT

MEASUREMENT No.		P6		CALIBRATED RANGE	0-1MPa	LEGEND
TEST NAME		CE20 HAT E7 ENGINE TEST AT TCT				POPI2
PARAMETER		Pressure at LOX pump inlet				
LOCATION		Inside vacuum chamber		MEASUREMENT RANGE	0-1MPa	
TRANSDUCER		MAKE		MIDAUS	MODEL	21NA
SL. NO.	L010718	EXCITATION		VOLTAGE(8V)	OUTPUT	VOLTAGE
CAL. DATE	03.07.2019	CHAIN CAL. DEVICE		YOKOGAWA CA150	CHAIN CAL. DATE	03.08.2019
CAL. COEFFICIENTS				INSULATION RESISTANCE	JB to CTR	>200MΩ
FIRST ORDER		A0	-1.453920E-2		JB to Sensor	>200MΩ

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		A1	6.090221E-2	CABLE TAG		JB to CTR	
FOURTH ORDER		A0	-1.202459E-02			JB to Sensor	-----
A1	6.017820E-02	A2	1.026045E-05	FJB	NAME	TCT FJB TAP02	
A3	2.788455E-06	A4	-4.704045E-08		PINS	148(E+),149(E-),150(S+),151(S-),152(I+),153(I-)	
RACK	RACK NO.	INPUT CONNECTOR		TIB-POWER	MAKE	P&F,KFD2-SD-Ex1.17	
	R56	TAPI06					
PINS	36(E+),37(E-),38(S+),39(S-),40(I+),41(I-)			Input	1(+),2(-)	Output	7(+),8(-)
TIB-SENSE	MAKE	P&F,KFD2-VR-Ex1.18		TIB -O/P	MAKE	P&F,KFD2-VR-Ex1.50M	
Input	4(+),5(-)	Output	8(+),7(-)	Input	4(+),5(-)	Output	7(+),8(-)
SIGNAL CONDITIONER		MAKE	PRESTON 8300 AU		Equipment No.		0901
		CHASSIS	Kinetic Systems		Chassis Sl. No.		0502
Input		8(P+),9(P-),6(S+),7(S-),1(I+),2(I-)			Output		6(+),25(-)
Excitation Voltage		8 V	GAIN	500	Fixed Gain Code		10
Variable Gain Code		0	Frequency(Hz)	100	Frequency Code		2

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RACK OUTPUT			Connector		Pin No.s			
		MAIN	TAPO5		64(+) ,65(-)			
		RED.	TAPO6		64(+) ,65(-)			
TEST ARTICLE DATA ACQUISITION SYSTEM								
	RACK/CONN.	PINS		MODULE	CARD	CHANNEL	GAIN	OFFSET
MAIN	R59/C4	11(+) ,12(-)		PXI-2206	5	21	499.92394	0.00033
RED.	R60/C4	11(+) ,12(-)		PXI-2206	5	21	499.93306	0.00117
Input (mV)	Expected (MPa)	PXI(M)			PXI(R)			
		Acquired	Deviation	Absolute Dev.	Acquired	Deviation	Absolute Dev.	
0	-0.020	-0.019	0.001	0.001	-0.019	0.001	0.001	
4	0.223	0.223	0.000	0.000	0.223	0.000	0.000	
8	0.466	0.466	0.000	0.000	0.466	0.000	0.000	
17	1.018	1.019	0.001	0.001	1.018	0.000	0.000	
ACCURACY REQUIREMENT(%FSO)			CALCULATED ERROR(%FSO)	Sensor Error(%)	Chain Error(%)		Overall Accuracy(%)	
Sensor(%)	Chain(%)	Overall(%)			PXI(M)	PXI(R)	PXI(M)	PXI(R)

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0.412	0.200	1.000		0.412	0.098	0.059	0.424	0.416
FIELD OBSERVATIONS			Earthing of FJB			Sealing of FJB, Gland		
			OK			OK		
Prepared By			Verified By			Cleared By		
ENGR. SD, TCTI			ENGR.SF,TCTI			DM, SRTI		

ANNEXURE - B
COMPLIANCE STATEMENT

Request for Proposal on Control System for Thrust chamber Test Facility
Compliance Statement

Annexure: B

1.1 Control system (TCS):

Sl.No	Specification	Required	As per quote
1	General		
1.1	Control system	Hot standby PLC	
1.2	Cycle time including I/O scan, full application program & 64 PID loops execution	10 ms	
1.3	Event Data Acquisition	10 ms	
1.4	Analog Data Acquisition	10 ms for any user selected 128 parameters and for remaining parameters at 50 or 100ms (user selectable) interval.	
1.5	Data updation in SCADA	< 500 ms	
1.6	Communication between PLC and Remote Nodes	Redundant	
1.7	Communication port in PLC and remote nodes	2 Independent ports	
1.8	Time drift over a period of 1000 seconds	< 10ms	
1.9	Switch over time from main to redundant	< 20ms	
1.10	Analog and digital I/O Data availability at PLC level	10 ms	
1.11	Operating Temperature	15-50 Deg.C	
1.12	Humidity	5-95 %, non condensing	
1.13	Hot swappable	Required	
1.14	PLC programming languages	As per IEC 61131-3 High level language with object oriented programming shall be available	
1.15	SCADA	Unlimited Tags	
1.16	Redundancy in all levels	Processor, power supply, communication controller, I/O modules, Networks, server, SCADA.	
1.17	Diagnostic feature	Required	
1.18	Servers	Hot standby	
1.19	Data logging	Data of both Main & redundant at every 10ms	
1.20	Offline data processing	Required	
1.21	System cabinet	Independent for Main & redundant	

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Sl.No	Specification	Required	As per quote
1.22	PID loops	Software : 64 Nos	
1.23	Ethernet	1000 Mbps	
1.24	Data base for analog and digital data	Required	
1.25	Data reporting software for continuous acquisition	24 hours	
1.26	Retrieval of 1 hour data	5 minutes	
1.27	Provision to display the parameters in mimic acquired using another data acquisition	Required	
1.28	Provision to simultaneously monitor and log the data from both main and redundant	Required	
1.29	Provision to start /stop the acquisition without affecting the functioning of the control system	Required	
1.30	Development of application program and mimics	Required	
1.31	Reference for the quoted configuration	To be provided	
2	ANALOG INPUT MODULE		
2.1	No. of channels	≥ 4 per module	
2.2	Input Signal	4-20mA/0-20mA, ±10VDC/0-10 VDC	
2.3	Resolution for 0-10 V	≥ 16 bit	
2.4	Filter	Type : Low pass	
2.5	Filter Bandwidth	10 to 30 Hz (selectable)	
2.6	Voltage input Impedance	≥ 1 M ohms	
2.7	Current input Impedance	≤ 500 ohms	
2.8	Accuracy @STP	≤ ± 0.1 % for voltage ≤ ± 0.2 % for current	
2.9	Conversion time	< 10 ms	
2.10	Electrical Isolation	≥ 250 V	
2.11	Reverse Polarity protection	To be provided	
2.12	Channel health monitoring and diagnostics	required for each channel	
2.13	IO redundancy	required/programmable	

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Sl.No	Specification	Required	As per quote
3	ANALOG OUTPUT MODULE		
3.1	No. outputs	≥ 4 per module	
3.2	Output Signal	4-20 mA	
3.3	Resolution	≥ 16 bits	
3.4	Conversion time	< 10 ms	
3.5	Accuracy @STP	$\leq \pm 0.2$ %	
3.6	Load Resistance for Current	$\geq 500 \Omega$	
3.7	Electrical Isolation	≥ 250 V	
3.8	Short circuit protection	To be provided	
3.9	Channel health monitoring and diagnostics	required for each channel	
3.10	IO redundancy	required/programmable	
4	DIGITAL INPUT MODULE		
4.1	No. of inputs	≥ 16 per module	
4.2	Input voltage (Nominal)	24 V DC	
4.3	Switching Threshold Low	< 10 V	
4.4	Switching Threshold High	> 12 V	
4.5	Input Resistance	≥ 2 K Ω	
4.6	Switching Delay	≤ 2 ms	
4.7	Electrical Isolation	≥ 250 V	
4.8	LED Indication	To be provided for individual channel in module	
4.9	Reverse Polarity protection	To be provided	
4.10	Channel health monitoring and diagnostics	required for each channel	
4.11	IO redundancy	required/programmable	
5	DIGITAL OUTPUT MODULE		
5.1	No. of Outputs	≥ 16 per module	
5.2	Type	Transistor	
5.3	Output Voltage	24 V DC	
5.4	ON/OFF Switching Delay	≤ 2 ms	
5.5	Continuous Current Per Output	≥ 0.1 A	

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Sl.No	Specification	Required	As per quote
5.6	Electrical Isolation	≥ 250 V	
5.7	LED Indication	To be provided for individual channel in module	
5.8	Channel health monitoring and diagnostics	required for each channel	
5.9	IO redundancy	required/programmable	
6	PULSE INPUT CARD		
6.1	Number of Channel Input	≥ 2 per module	
6.2	Input Voltage	24 V DC	
6.3	Input Current	≤ 10 mA	
6.4	Input Frequency	10 Hz to 100 KHz	
6.5	Counter Resolution	≥ 16 bits	
6.6	Input Resistance	≥ 2 K Ω	
6.7	Measurement Technique	Period measurement	
6.8	Electrical Isolation	≥ 250 V	
6.9	Channel health monitoring and diagnostics	required for each channel	
6.10	IO redundancy	required/programmable	
7	Software		
7.1	Run time	Required	
7.2	Development	Required	
7.3	Real time	Required	
7.4	Data Acquisition	Required	
7.5	Data retrieval & offline processing	Required	
7.6	System & Application software	Required	
7.7	Multitasking	Required	
7.8	Third party interface & OPC connectivity	Required	

Request for Proposal on Control System for Thrust chamber Test Facility
Compliance Statement

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1.2 ESS system (CS2):

Sl.No	Specification	Required	As per quote
1	General		
1.1	Control system	Stand alone system	
1.2	Cycle time including I/O and full application program	10 ms	
1.3	Event Data Acquisition	10 ms	
1.4	Analog Data Acquisition	10 ms	
1.5	Offline data processing	Required	
1.6	Data base for analog and digital data	Required	
1.7	Data reporting software for continuous acquisition	24 hours	
1.8	Retrieval of 1 hour data	5 minutes	
1.9	Data base for analog and digital data	Required	
1.10	Data updation in SCADA	< 500 milli second	
1.11	Operating Temperature	15-50 Deg.C	
1.12	Humidity	5-95 %, non condensing	
1.13	Hot swappable	Required	
1.14	PLC programming languages	As per IEC-61508-3	
1.15	Diagnostic feature	Required	
1.16	System cabinet	Required	
1.17	PID loops	Software : 16 Nos	
1.18	SIL standard & Certification	SIL3	
1.19	Provision to start /stop the acquisition without affecting the functioning of the control system	Required	
1.20	Development of application program and mimics	Required	
1.21	Reference for the quoted configuration	To be provided	
2	ANALOG OUTPUT MODULE		
2.1	No. of outputs	≥ 2 channel per module	
2.2	Output Signal	4-20 mA	
2.3	Resolution	≥ 12 bit	
2.4	Conversion time	< 10 ms	

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Sl.No	Specification	Required	As per quote
2.5	Accuracy	$\leq \pm 0.50 \%$	
2.6	Electrical Isolation	$\geq 250 \text{ V}$	
2.7	Certification	SIL 2 or higher	
3	ANALOG INPUT MODULE		
3.1	No. of inputs	≥ 2 channel per module	
3.2	Input Signal	0-10 V	
3.3	Resolution	≥ 16 bit	
3.4	Conversion time	$< 10 \text{ ms}$	
3.5	Accuracy	$\leq \pm 0.30 \%$	
3.6	Electrical Isolation	$\geq 250 \text{ V}$	
3.7	Certification	SIL 3	
4	DIGITAL INPUT MODULE		
4.1	No. of inputs	≥ 4 Channel per module	
4.2	Input voltage (Nominal)	24 V DC	
4.3	Reaction Time	$< 10 \text{ ms}$	
4.4	Electrical Isolation	$\geq 250 \text{ V}$	
4.5	Reverse Polarity Protection	To be provided	
4.6	Status Indication	Required for individual channel	
4.7	Certification	SIL 3	
4.8	Fail Safe Condition	Low or High configurable	
4.9	Failure Indication	Yes, provision for remote detection	
5	DIGITAL OUTPUT MODULE		
5.1	No. of Outputs	≥ 2 per module	
5.2	Output Voltage	24 V DC	
5.3	Reaction Time	$< 10 \text{ ms}$	
5.4	Current Per Output	$\geq 0.1 \text{ A}$	
5.5	Electrical Isolation	$\geq 250 \text{ V}$	
5.6	Status Indication	LED for individual channel	
5.7	Certification	SIL 3	
5.8	Fail Safe Condition	Low or High configurable	
5.9	Failure Indication	Yes, provision for remote detection	

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Sl.No	Specification	Required	As per quote
6	Software		
6.1	Run time	Required	
6.2	Development	Required	
6.3	Real time	Required	
6.4	Data Acquisition	Required	
6.5	Data retrieval & offline processing	Required	
6.6	System & Application software	Required	

1.3 Signal Simulator (SS)

Sl.No	Specification	Required	As per quote
1	DC (mV) Source		
1.1	Signal Output Range (selectable)	$\pm 50/\pm 100$ mV DC	
1.2	Number of channels	≥ 4 per module	
1.3	Voltage Resolution	≤ 5 μ V	
1.4	Accuracy	$\leq 0.15\%$	
1.5	Output resistance	≤ 5 ohms	
1.6	Settling time	< 5 milli second	
2	DC (V) Voltage Source		
2.1	Signal Output Range	± 10 V DC	
2.2	Number of channels	≥ 4 per module	
2.3	Voltage Resolution	≤ 2 mV	
2.4	Accuracy	$\leq 0.1\%$	
2.5	Output resistance	≤ 5 ohms	
2.6	Settling time	< 5 milli second	

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Sl.No	Specification	Required	As per quote
3	DC (mA) milli Ampere Source		
3.1	Signal Output Range	4-20 mA	
3.2	Number of channels	≥ 4 per module	
3.3	Resolution	16 bit	
3.4	Accuracy	≤ 0.2% FSR	
3.5	Load resistance	min 500 Ω (drivable)	
4	Resistance (ohm) Low range Source		
4.1	Signal Output Range	0.5 Ω to 100 Ω	
4.2	Number of channels	≥ 2 per module	
4.3	Number of wires	4 wire RTD	
4.4	Resolution	0.05 ohm	
4.5	Accuracy	≤ ±0.1% or better	
4.6	Settling time	< 5 milli second	
5	Resistance (ohm) High range Source		
5.1	Signal Output Range	100 Ω to 1 K Ω	
5.2	Number of channels	≥ 2 per module	
5.3	Number of wires	4 wire RTD	
5.4	Resolution	0.125 ohm	
5.5	Accuracy	≤ ±0.2% or better	
5.6	Settling time	< 5 milli second	
6	Frequency (Hz) Source		

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Sl.No	Specification	Required	As per quote
6.1	Signal Output Range	1 Hz to 5 KHz	
6.2	Number of channels	≥ 2 per module	
6.3	Counter Resolution	≥ 32 bits	
6.4	Accuracy	±1Hz or better	
6.5	Voltage Level	TTL or 24 V open CC	
7	Digital Input Card		
7.1	No. of inputs	≥ 4 per module	
7.2	Digital Input voltage(Nominal)	24 V DC	
7.3	Input Resistance	≥ 2 KΩ	
7.4	LED Indication	To be provided for individual channel in module	
8	DIGITAL OUTPUT CARD		
8.1	No. of Outputs	≥ 4 per module	
8.2	Output Voltage	24 V DC	
8.3	Current Per Output	≥ 0.1 A	
8.4	LED Indication	To be provided for individual channel in module	
9	Matrix Switch card		
9.1	Number of relay cross points	512	
9.2	Maximum Switching current	0.5 A per channel	
9.3	Maximum Switching power	10 Watts per channel	

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Sl.No	Specification	Required	As per quote
9.4	DC path Resistance	< 1 Ω	
9.5	Resistance of Open channel	> 1 G Ω	
9.6	Bandwidth for two wire configuration	> 100 Hz	
9.7	Cross Talk	-90 dB @ 10 KHz	
9.8	Isolation	90 dB @ 10 KHz	
9.9	Relay operate time	< 300 us	
9.10	Relay release time	< 300 us	
10	Controller & Chassis		
10.1	System	Distributed architecture with local and remote I/O. Remote I/O configured in Mobile Portable Rack	
10.2	Chassis	Synchronised chassis with compatibility of all proposed cards	
10.3	Status LEDs	Chassis temperature, power supply voltage and fan monitoring	
10.4	Monitoring Functions	Chassis voltage level monitoring, Power supply monitoring/control, Cooling fans monitoring/control, Chassis temperature monitoring	
11	Software		
11.1	Run time	Required	
11.2	Development	Required	
11.3	Real time	Required	
11.4	Data Acquisition	Required	

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Sl.No	Specification	Required	As per quote
11.5	Data retrieval & offline processing	Required	
11.6	Application software	Required	
11.7	V&V report Generation	Required	
11.8	T&E report Generation	Required	
11.9	Programming languages	High level languages preferably python	

1.4 Cycle Time Breakup:

Cycle time for TCS system:

Sl. No.	Description		Time in msec (for main and redundant I/Os combined)
1	Read Scan time for	Digital Inputs : 3184 Nos	
		Analog Inputs : 640 Nos	
2	Program Execution Time	System & Application program	
		64 PID loops	
3	Communication Overheads (inclusive of 2000m OFC)		
4	Write Scan time for	Digital Outputs : 2528 Nos	
		Analog Outputs : 128 Nos	
5	Time for Acquisition/ data transfer to server		
6	Miscellaneous Overheads		
7	Wait Period		
Total Cycle Time			

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Cycle time for ESS system:

Sl. No.	Description		Time in msec
1	Read Scan time for	Digital Inputs : 56 Nos	
		Analog Inputs : 8 Nos	
2	Program Execution Time	System & Application program	
		16 PID loops	
3	Communication Overheads		
4	Write Scan time for	Digital Outputs : 88 Nos	
		Analog Outputs : 16 Nos	
5	Time for Acquisition / data transfer to server		
6	Miscellaneous Overheads		
7	Wait Period		
Total Cycle Time			

ANNEXURE-C

TERMS & CONDITIONS

1 TERMS & CONDITIONS

1.1. ENTIRE AGREEMENT

- 1.1.1. The Contract to be entered into shall convey the final agreement between the Department and the Contractor on the terms and conditions and be a complete and exclusive statement of the terms of the agreement.
- 1.1.2. In the event of conflicts between general conditions of Contract and the specification furnished by the Department, the latter will take precedence.

1.2. MODIFICATIONS IN THE CONTRACT

This Contract may be amended or modified only in writing signed by both the parties or their duly authorized agents or representatives by a change order issued by the Department and accepted by the Contractor, pursuant to the terms stated therein.

1.3. CANCELLATION OF CONTRACT

- 1.3.1. The Department will have the right, at any time, to cancel the Contract either wholly or in part by giving 1 month notice. The Contractor shall undertake to observe the instructions of the Department as to the winding up of the Contract both on his own part and on the part of his sub-contractors.
- 1.3.2. In the case of cancellation of the Contract by the Department without any fault of the Contractor, the Contractor shall forthwith take the necessary steps to implement the Department's instructions. The period to be allowed to implement shall be fixed by the Department after consultation with Contractor and, in general, shall not exceed 2 months.

1.3.3. The Department will, in no circumstances, be liable to pay any sum which, when added to the other sums paid, due or becoming due to the Contractor under the Contract and its amendments, if any, exceeds the Contract payment for the work set forth in the Contract and its amendments, if any.

1.3.4. The ownership of all materials, part and unfinished work paid for by the Department under the provisions of this Section shall be vested in or transferred to the Department as soon as they have been paid for.

1.4. CONTRACTOR'S DEFAULT LIABILITY

1.4.1. The Department shall reserve the right to terminate the work in the circumstances detailed hereunder:

- a. If the Contractor fails to rectify or replace any defective system/ sub-system/ equipment within a period of 60 days after the Department having given a notice to the Contractor to rectify or replace the said defective system/ subsystem/ equipment or the Contractor delays, suspends or is unable to complete the system/ subsystem/ equipment by the date mutually agreed upon
- b. If the contractor commits breach of any of the terms and conditions of the Contract.
- c. If the Government of India decides to terminate the Contract in public interest.

1.4.2. When the Contractor makes themselves liable for action under the circumstances mentioned above, the Department will have power to forfeit the bank guarantee of Contractor and the Contractor shall have no claim for damages whatsoever on such forfeiture.

1.4.3. The work remaining to be completed at the time of termination of the Contract shall be got executed through

any other Contractor, in which case the expenses, which may be incurred in excess of sums, which would have been paid to the original Contractor, had the whole work been executed by them, shall be borne by the original Contractor and shall be recovered from them.

1.5. CHANGES AND MODIFICATIONS TO SPECIFICATIONS AND QUALITATIVE REQUIREMENTS

- 1.5.1. The Department shall reserve the right at any time to modify the qualitative requirements, specifications, patents or drawings related to the work covered by the Contract. The Contractor shall inform to the Department within 20 days, of any objections they have to the modifications required.
- 1.5.2. The Department may also accept the modification proposed by the Contractor on his own initiative or on behalf of sub-contractors or as a result of detailed engineering review.

1.6. SUB-CONTRACTING

The Contractor shall not assign or sub-contract the work or any part of the work without the written approval of the Department. In the event of approval of sub-contractors, the detailed specifications and drawings of sub-contracted items shall be approved by the Department. All the works carried-out by such sub-contractors shall also be scrutinized, inspected and approved by the Department. However the responsibility of such sub-contracted systems shall lie with the Contractor. Any delay in carrying out the work by the sub-contractor which affects the overall schedule of the work does not absolve the Contractor from payment of compensation for the delays. All terms and conditions applicable to the Contractor shall also be applicable to sub-contractor.

1.7. COMPLIANCE WITH STANDARDS

All the materials supplied or used shall be of new and first quality and manufactured and tested in accordance with the latest editions of the relevant Indian/ International standards. Wherever imported components are used, they shall be manufactured in accordance with the relevant standards published in the country of manufacture after allowing for specific aspects under Indian conditions such as tropical climate, etc. Any material or work, where no specific standard is applicable, shall be fabricated as per the instructions and directions of the Department.

All the electrical equipments used shall conform to the latest Indian Electricity rules as regards safety, earthing and other essential provisions specified therein for installation and operation of electrical parts.

1.8. SECRECY

The technical information, drawings, specification and other related documents forming part of enquiry or Contract are the property of the Department and shall not be used for any other purpose, except for execution of the Contract. All rights, including the rights in the event of grant of a patent and registration of designs are reserved. The technical information, drawings, specifications, records and other documents shall not be copied, transcribed, traced or reproduced in any other form or otherwise in whole and/ or duplicated, modified and/or disclosed to a third party and/or not misused in any other form whatsoever without the Department's consent in writing except to the extent required for the execution of the work. This technical information, drawings, specifications, records and other documents shall

be returned to the Department with all approved copies and duplicates, if any, immediately after they have been used for the agreed purpose.

1.9. INSPECTION OF WORK

1.9.1. The Department or any person appointed by it shall have access and right to inspect the work, or any part thereof, at all times and places during the progress of the work. The inspection and supervision is for the purposes of assuring the Department that the plans and specifications are being properly executed and while the Department and its representative(s) will extend to the Contractor all desired assistance in interpreting the plans and specifications, such assistance shall not relieve the Contractor of any responsibility for the work. Any work which is proved faulty shall be corrected by the Contractor without delay. The fact that faulty work or work which is not in accordance with plan and specifications was not pointed out by the Department will not relieve the Contractor from correcting such work as directed by the Department without additional compensation.

1.9.2. The Department's representatives shall at all reasonable times have free access to the works and/ or to the workshops, factories or other places where materials are being prepared or fabricated for the work and also to any place where the materials are lying or from where they are being obtained, and the Contractor shall give every facility to the Department's representatives for inspection and test of the materials and workmanship even to the extent of discontinuing portions of the work temporarily or of uncovering or taking down portions of finished work.

1.9.3. The Department has no obligations to discover defects patents or otherwise and it shall be the sole responsibility of the Contractor. The inspection and clearance for dispatch by Department's representatives shall not absolve the Contractor's obligations and duties under terms and conditions herein.

1.10. CO-ORDINATION WITH OTHER CONTRACTORS AND INTERFACING OF THE WORKS

The Contractor shall extend all co-operation to other Contractors of the Department to perform their works at site simultaneously. The Contractor shall so arrange their activities so as to ensure smooth and timely execution of the project, minimize interference with the works of the other Contractors and allow the other Contractors to use the facilities engaged by them for erection activities. For this purpose, the Contractor shall plan such works and indicate such interfaces in an interface schedule. They shall not be entitled to any extra payment on this account.

1.11. FORCE MAJEURE

On the occurrence of any unforeseen event, beyond the control of either Party, directly interfering with the delivery of Services arising during the currency of the contract, such as war, hostilities, acts of the public enemy, civil commotion, sabotage, fires, floods, explosions, epidemics, quarantine restrictions, strikes, lockouts, or acts of God, the affected Party shall, within a week from the commencement thereof, notify the same in writing to the other Party with reasonable evidence thereof. Unless otherwise directed by the Procuring Entity in writing, the contractor shall continue to perform its obligations under the contract as far as reasonably

practicable and shall seek all reasonable alternative means for performance not prevented by the Force Majeure event. If the force majeure condition(s) mentioned above be in force for 90 days or more at any time, either party shall have the option to terminate the contract on expiry of 90 days of commencement of such force majeure by giving 14 days' notice to the other party in writing. In case of such termination, no damages shall be claimed by either party against the other, save and except those which had occurred under any other clause of this contract before such termination.

1.12. INDEMNITY TO DEPARTMENT AGAINST INFRINGEMENT OF LABOUR LAWS

The Contractor shall indemnify the Department against any action, claim or proceedings relating to infringement of all or any of the prevailing labour laws of India like Workmen's Compensation Act 1922, Work Labour (Regulation and Abolition), Central Rules 1971, Employees Liability Act 1928, Industrial Disputes Act 1947, Employees Provident Funds and Miscellaneous Act 1952 as amended from time to time during erection and commissioning at Department's site.

1.13. PATENT RIGHTS

The Contractor shall fully indemnify the Department against any action, claim or proceedings relating to infringements or use of any patent or any design or any alleged patent or design rights and shall pay any royalty which may be payable in respect of any claims made under or any action brought against the Department. In respect of such matters as aforesaid, the Contractor shall be set at liberty, at their own expense, to settle any dispute or to conduct any litigation

that may arise there-from. The Contractor shall not be liable to indemnify the Department on the infringement of the patent or design or any alleged patent or design right which is the direct result of an order passed by the Department.

1.14. ARBITRATION

Except matters in respect of which the decision of the Department is final as specified in the Contract, any dispute, disagreement or question arising out of or relating to or in consequence of the work or fulfilment or the validity of the enforcement thereof which cannot be settled mutually, shall within 30 days from the date that either party informs the other in writing that such dispute or disagreement exists, be referred to arbitration. The arbitration proceedings shall be in compliance with either the Indian Arbitration and Conciliation Act 1996 and its amendments. The performance under this work shall continue during the arbitration proceedings and no payment due or payable by the Department will be withheld unless any such payment is or forms part of the subject matter of the arbitration proceedings.

1.15. ASSIGNMENT

The work shall be binding upon the successors and the assignees of the parties hereto. It shall not be assigned in whole or in part by either party without prior written consent of the other. If the Contractor becomes insolvent or being a firm or a company whether incorporated or not is dissolved or goes into bankruptcy or is caused to be wound up except for re-construction purposes or carried on its business under a receiver, the representatives in law of estate of the Contractor or any such receiver, liquidator or any person in whom the agreement may be vested shall forthwith give

notice thereof in writing to the Department and shall remain liable for the successful performance of the Contractor or the successors of their obligations under this Contract under any circumstances.

1.16. JURISDICTION AND APPLICABLE LAW

The work shall be governed by the laws of India for the time being in the force. The courts of India only shall have jurisdiction to deal with and decide any legal matters or dispute whatsoever arising out of the work.

1.17. EXECUTION OF WORK

The specifications of the work are intended to describe and provide for a complete finished system. It is to be understood and agreed by the Contractor that the work described shall be complete in every detail, even though every item necessarily involved is not particularly mentioned. The Contractor shall be required to provide all labour, materials and equipments necessary for the completion of the work described and shall not avail themselves of any manifesting unintentional error, omission or inconsistency that may exist. The Contractor shall carry out and complete the work in every respect in accordance with the Contract and the directions and to the satisfaction of the Department.

1.18. RIGHTS OF THE DEPARTMENT

1.18.1. RIGHT TO ILLUSTRATE AND EXPLAIN PLANS

- a. The various parts of the Contract are intended to be complementary to each other but if any discrepancies appear or any misunderstanding arises, the explanation of the Department will be final and binding.

- b. The corrections of any errors or omissions of specifications may be made by the Department, when such correction is necessary to bring out clearly the intention that is indicated by a reasonable interpretation of the specifications as a whole.
- c. Wherever in the specifications which are a part of the work or which may be furnished to the Contractor for directing the work, the terms and descriptions of various qualities of workmanship, materials, structures, processes, plant or other features of the work are described in general terms, the meaning of fulfilment of which must depend upon individual judgements, then in all such cases, the question shall be decided by the Department and said material shall be furnished, said work shall be done and said structure or feature shall be constructed, furnished or carried out in full and in accordance with their interpretation of the same and to their full satisfaction and approval, provided such interpretation is not in direct conflict with the specifications or generally accepted good practice.

1.18.2. RIGHT TO DIRECT WORK

- a. The Department will have the right to direct the manner in which all work under this Contract shall be done, in so far as it may be necessary to secure the safe and proper progress and the specified quality of the work and all work shall be done and all material shall be furnished to the satisfaction and approval of the Department.
- b. Whenever, in the opinion of the Department, the Contractor has made marked departure from the schedule of completion laid down in the Contract or when untoward circumstances force departure from the said schedule, the Department in order to assure

compliance with the schedule and the provisions of the work, shall direct the order, pace and method of doing the work, which shall be adhered to by the Contractor.

- c. If, in the judgment of the Department, it becomes necessary at any time to accelerate the overall execution of the work, the Contractor when ordered and directed by the Department will cease the work at any particular point and transfer their men to such other point or points and execute such portion of their works, as may be required, to enable others to hasten and properly engage and carry on their work, as directed by the Department.
- d. The work by the Contractor at the site beyond normal working hours (08:45 to 17:15 hr) on working days and any time on holidays (including Saturdays and Sundays) shall be permitted only with prior approval of the Department. The Department may also direct the Contractor to operate extra shifts over and above normal day shift to ensure completion of the work on schedule if, in the opinion of the Department, such work is required.

1.19. CONTRACTOR'S FUNCTIONS

1.19.1 The Contractor shall provide everything necessary for proper execution of the work according to the intent and meaning of the specifications whether the same may or may not be particularly shown or described therein, provided that the same can reasonably be inferred there-from and if the Contractor finds any discrepancy there-in, they shall immediately and in writing refer the same to the Department whose decision shall be final and binding on the Contractor.

1.19.2 In the execution of the work, no person other than the Contractor, or their duly appointed representatives, their

sub-contractors, and their workmen, shall be allowed to work at the site except by special permission, in writing by the Department.

- 1.19.3 The Contractor shall proceed with the work to be performed under this Contract and each and every part and detail thereof, in the best and most workmen-like manner by engaging qualified, careful and efficient workers and to the several parts thereof at such time and in such order as the Department directs and finish such work in strict conformance with the drawings and/or specifications and any changes, modifications thereof made by the Department.
- 1.19.4 The Contractor's personnel shall not be permitted to reside inside the Department's premises after the work. The Contractor shall arrange for transportation, accommodation, food, health care, communication, etc. for their personnel.
- 1.19.5 In respect of observance of local rules, administrative orders, working hours and the like, the Contractor and their personnel shall co-operate with the Department.

1.20. SUPPLY OF TOOLS, AND OTHER MATERIALS

For full completion of the work, the party shall, at their own expense, furnish all erection tools, power tools, cables, wiring tools, test instruments, and all associated protective equipments, appliances, materials required to accomplish the work under the contract unless otherwise provided for. Adequacy of such tools shall be subject to final determination of the Department.

The party shall not dispose, transport or withdraw any tools, equipments and materials provided by them for the contract without taking prior written approval from the Department and the Department at all times shall have right to refuse permission for disposal, transport or withdrawal of tools,

equipment and material if in their opinion, the same will adversely affect the efficient completion of the work.

1.21. PROTECTION OF WORK

- 1.21.1. The Department will not be responsible or held liable for any damage to person or property consequent upon the use, misuse or failure of any fabrication tools and equipment used by the Contractor or any of their sub-contractors.
- 1.21.2. The Contractor shall effectively protect all the works from action of weather and from damages or defacement and shall cover finished parts where required for their thorough protection.
- 1.21.3. The Contractor shall cover the work by a Contractor's all-risk policy during the currency of the contract.

1.22. SITE PERSONNEL

The party shall identify a Site Supervisor who shall be personally present to supervise the work under the contract. The Site Supervisor shall have full technical capability and complete administrative and financial powers to expeditiously and efficiently execute the work under the contract. Any written orders or instructions which the Department may give to the party's Site Supervisor shall be deemed to have been given to the party.

1.23. FIRST AID

The Contractor may have access to the Departments qualified first aid personnel and ambulance in case of accidents, subject to the availability of the same. However, the Contractor shall make his own medical and transport arrangements to take care of his employees in case of

accident. The Contractor shall provide a first aid kit at the work site to meet the requirements of minor injuries.

1.24. REPORTING

The Contractor must report the following information to the Department by the end of every week during the work at Department's site.

- a) Progress achieved
- b) Expected dates for completion of individual works
- c) Any actual or likely delay in the execution of work

1.25. WORKING AND SAFETY REGULATIONS

The Contractor shall observe all statutory and legal requirements enforced by Central and State Government applicable to the work as well as any local regulations applying to the site issued by Department or any other authority. Particular attention is drawn to the following;

- a) In case of accident, the Department shall be informed in writing forthwith. The Contractor shall strictly follow the regulations laid down by the Factory Inspector, Central and State Government authorities in this regard.
- b) Compliance with all electricity regulations.

1.26. ELECTRICAL SAFETY REGULATIONS

In no circumstances will the Contractor interfere with fuses and electrical equipment belonging to the Department or other Contractors. Before the Contractor connects any electrical appliance to any plug or socket belonging to other Contractor or Department, he will

- a) Satisfy the Department that the appliances are in good working condition

- b) Inform the Department about the maximum current rating, voltage and phase of the appliance
- c) Obtain permission from the Department detailing the sockets, to which the appliance may be connected

1.27. POWER

Electricity will be supplied at free of cost. Contractor must provide power supply distributor with isolator for taking power for his equipments. Contractor should obtain Electrical safety clearance from CMG group and Safety division of IPRC before starting the work.

1.28. WATER

Free supply of water will be made available by the Department.

1.29. CLEAN-UP OF WORK SITE

The party shall not store or place the equipment, materials or erection equipment on the drive ways and streets and shall take care that their work in no way restricts or impedes traffic or passage of men and material. All waste materials are to be disposed off safely to the location specified by the Department

1.30. SAFETY AND RELIABILITY

Since the systems are highly complex in nature, the philosophy and criteria to be adopted shall be highly safety-and-reliability-oriented for their systematic and proper functioning. The designs of the sub-systems, components, equipments to be carried out by the Contractor shall specifically address essential safety provisions both in-built and external. Reliability is a prime factor, which has to be embedded in the process of realization of the systems. To

ensure that the sub-system design, development, selection of equipment, components, material, etc are in compliance with the standard engineering practices, it is necessary to follow established design codes and standards.

1.31. SECURITY DEPOSIT

The Contractor shall deposit an interest free amount equivalent to the 3% (Three PERCENT) of the total order value towards Security Deposit for the due performance of the Purchase Order within 14 days from the date of Purchase Order. The Security Deposit can be submitted either in the form of Account Payee Demand Draft or Fixed Deposit Receipt or Banker's Cheque is drawn on any commercial bank in India, favouring Accounts Officer, IPRC or as Bank Guarantee issued by a commercial bank in India, as per our prescribed format in Non-judicial Stamp Paper of appropriate value. This security deposit shall be returned to the Contractor only upon successful completion of all the contractual obligations or shall be adjusted / forfeited against non-fulfilment of any of the contractual obligations.

1.32. QUALITY ASSURANCE

The reliability of Instrumentation is a combination of specification of the equipments/ components, serviceability and maintenance of the same, which are meant to serve and provide effective and timely operation, which includes trouble-free performance of systems and sub-systems to the intended specifications.

The Contractor must look for the quality factors individually attributed to engineering developments, redundancy philosophy adopted, selection of equipments and components, test and acceptance procedures followed,

repetitive performance achieved, risk analysis carried out, etc. each and every module must be manufactured and tested to international Quality Control standards. The test certificates shall be provided to Department.

The quality assurance is an unified approach that attempts to control the quality right from design stage to commissioning stage, which includes the checking of the adequacy of the equipments/ components for materials, fabrication, installation, testing. It is the combined responsibility of the Contractor and the Department to ensure that all possible failure modes are exercised and validated during FAT.

1.33. PURCHASE OF MATERIALS

The selection of equipments, components, materials, etc. with appropriate and suitable specifications shall be the responsibility of the Contractor, as overall performance of the system rests with the Contractor. Accordingly, the selection and purchase tasks shall be handled by the Contractor immediately after the approval of Detailed Engineering documents by the Department.

The criteria for selection of particular product and the reasoning involved therein shall be submitted to the Department for necessary approval. However, Department's decision will be final.

The Department will provide necessary end-use certificate for obtaining the required license for import of items if requested by the Contactor.

In keeping with the terms of the Contract, the Contractor shall undertake the responsibility for handling, packaging and transportation involved to the accepted level of any sub-systems/ equipment covered by the work in the Contract.

1.34. EMPLOYMENT OF LABOURS

The contractor shall deploy Indian National only for execution of the work.

Only skilled employees with experience of this particular work shall be employed.

No person below the age 18 years shall be employed.

The Contractor shall pay to each person, wages not less than those specified by Minimum Wages Act.

The employees / labour, for carrying out all the site works shall be identified well in advance by the contractor and necessary approval shall be obtained from the Department for entry permit to the work site.

1.35. GATE PASS

For Contractor's equipment, tools, materials, etc. which are to be taken out from IPRC, Mahendragiri campus after completion of work, proper entry shall be made at the main gate duly endorsed by CISF. The Department shall issue necessary gate passes for taking out the Contractor's materials, as and when required and after completion of work.

2 INSTRUCTIONS TO BIDDERS

The proposals are invited on behalf of the President of India by the Senior Purchase & Stores officer, IPRC, Mahendragiri, from reputed Contractors of high competence for the following work for IPRC, Mahendragiri, Tirunelveli District, Tamil Nadu State, India.

2.1 SCOPE OF WORK

The scope of the work includes Detailed Engineering, supply, Integration of hardware, Wiring of IOs, Installation of system software, training at contractor's site, Factory Acceptance

Test (FAT), delivery of the system to site, installation and commissioning of the system at Department site, training at Department site, Site Acceptance Test (SAT) and local support for a period of three years after SAT of Control System for Integrated Engine Test Facility as per the specification given in this document. The bidder is required to submit quotation for the entire works mentioned herein. The incomplete quotations shall be summarily rejected. The deviation, if any, in the bidder's proposal with respect to this document shall be explicitly mentioned in the schedule of deviations to be provided in the quotation. If the bidder does not mention any deviation, it shall be construed by the Department that the bidder agrees to comply with each and every aspect of this document.

2.2 EXECUTION PERIOD

The entire work is to be completed **as table shown below** from the date of award of Contract. The bidder shall submit a master schedule about their realisation plan so as to comply with the overall execution period. The bidder shall indicate, in the quotation, the schedules for various work phases, which shall not exceed the overall contract period. Upon award of contract and before commencement of work, the contractor shall prepare a detailed and comprehensive schedule for review and approval by the Department. The approved schedule shall form the basis for all works to be performed by the contractor.

Sl. No	Scope of work	Period	Responsibility
1	Date of Receipt & acknowledgment of	T0	Contractor/ Department

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Sl. No	Scope of work	Period	Responsibility
	purchase order		
2	Detailed engineering	T0 + 30 days	Contractor
3	Date of receipt of Engineering clearance from IPRC	T0 + 60 days	Department
4	Readiness of system for FAT & Training & Clearance	T0+ 150 days	Contractor/ Department
6	Shipment	T0+165 days	Contractor
7	Site erection and Commissioning at Department site including Application software development and testing & training at site	T0 + 210 days	Contractor
8	SAT clearance	T1	Department
9	Site acceptance test (SAT)	T1+30 days	Contractor and Department

However, the overall period for completion of projection shall not exceed 9 months.

2.3 COMPENSATION FOR DELAY

Delivery, commissioning and FAT are the essence of the contract. If the contractor fails to complete execution of the

contract or fails to meet delivery specified in the contract or any extension thereof, the Department will recover from the Contractor as Liquidated Damages (LD) a sum of 0.5% of the total contract price for each calendar week of delay or part thereof. The total liquidated damages shall not exceed 10% of the contract price.

2.4 DELIVERY TERM

For all imported items, the delivery point shall be C&F (Carriage and Freight to) Trivandrum. The Department will arrange customs clearance and transportation from Trivandrum to Mahendragiri. For Indigenous item, delivery point shall be FOR, Mahendragiri.

2.5 LANGUAGES AND MEASURES

All documents pertaining to the Contract including specifications, schedules, notices, correspondence, operating and maintenance instructions, drawings or any other writings shall be written in ENGLISH Language only.

2.6 DOCUMENTS

All operating, maintenance and technical manuals, drawings and diagrams in English Language relevant to the systems/components shall be supplied by the Contractor.

2.7 GUARANTEE

The performance of the system shall be guaranteed by the Contractor for a period of 12 months from the date of final acceptance (after SAT) of the system at the Department's site. The Contractor shall furnish a Performance Bank Guarantee (PBG) for 3% of the contract price for the same.

2.8 POST WARRANTY MAINTENANCE & SUPPLY OF SPARES

The system shall be maintained by the Contractor or Indian Agents, after completion of SAT for a period of 3 years (Refer Annexure A: 2.10 Operation and Maintenance (O&M) support).

Spare supply shall be ensured for a period of 10 years.

Contractor shall quote for non comprehensive maintenance rate. The Contractor or Indian Agents shall attend to preventive maintenance once in six months and shall also attend to breakdown maintenance as and when required within 24 hours of intimation by the Purchaser. A separate AMC will be signed by the Department and Contractor and commence after the completion of Operation and maintenance (O&M) support.

2.9 SYSTEM PERFORMANCE

The Contractor shall provide guaranteed performance of the system under the contract as per the specifications. The Contractor shall successfully demonstrate the performance during the commissioning. If the Contractor is unable to demonstrate the performance as per specifications, within the stipulated period, and if the commissioning test results deviate from the specifications, the Contractor shall correct them at no extra cost for the Department and repeat the tests within a reasonable period of time as agreed by the Department. The Contractor shall make effort practicable to correct the deficiencies. The Department reserves the option to reject the bad performance of equipments/systems and when this option is exercised by the Department, the Contractor shall replace the rejected equipments/ systems by new ones at his own cost to the Department's satisfaction

within a reasonable period of time indicated by the Department.

On the other hand, if the Department accepts the system, though it fails to meet the specification fully, the Department will, at their own discretion, make necessary recoveries for such shortfall in performance.

In the event of rejection, in order to minimize the consequential losses, faulty equipment shall be retained until a new replacement arrives at site for installation. It should be noted that the faulty equipment has not been accepted and not taken over by the Department, the responsibility for it lies entirely with the Contractor. During this period, the Contractor shall not limit the use of faulty equipment except for reasons of safety during operation both for personnel and equipment.

2.10 INSURANCE

The contractor should take all necessary steps including the necessary insurance cover till the system are dispatched & delivered at Department site. The contractor shall be responsible until the entire Goods contracted arrive in good condition at destination. The contractor shall cover the transit risk in this respect by getting the Goods duly insured at its own cost. The contractor shall obtain the insurance cover in its name and not in the name of the Procuring Entity or its Consignee.

2.11 PACKING

The contractor shall pack the control system and its accessories and make the identification names at the top of each pack with order/ contract Number.

The marking of the Goods must comply with the Goods of the

laws relating to merchandise marks for the time being in force in India.

The packing for the Goods to be provided by the contractor should be strong and durable enough to withstand, without limitation, the entire journey during transit, including transshipment (if any), rough handling, open storage etc., without any damage, deterioration etc. If necessary, the size, weights, and volumes of the packing cases, the remoteness of the goods' final destination, and availability or otherwise of transport and handling facilities at all points during transit upto the final destination shall also be considered.

Unless otherwise provided in the contract, all containers (including packing cases, boxes, tins, drums, and wrappings) in which the contractor supplies the Goods shall be considered non-returnable and their cost included in the contract price.

2.12 FORM OF QUOTATION

The quotation shall be submitted separately for

- a. Technical and commercial
- b. Price

The technical and commercial quote shall contain the technical and commercial aspects and bill of material **without** the price and shall be opened first.

The price quotation shall contain prices as per the price format and the revision in prices thereof if any submitted subsequently based on authorisation from the Department, shall be opened only after the evaluation of the technical and commercial quotation.

The Department reserves the right to reject any or all quotations in whole or part without assigning reasons

thereof.

2.13 PRICES AND PAYMENTS

The bidder shall quote **firm and fixed prices** valid during the execution of the Contract until commissioning and final acceptance of the systems to the satisfaction of the Department. We are exempted from payment of all duties. Taxes shall be paid extra.

The bidder shall provide the individual item wise break-up prices as given in Annexure-D1, D2, D3, D4, D5 & D6 price format. However, bidder is advised to quote the item-wise break-up prices of the various items forming the sub-systems, to such fine extent as necessary and possible.

Milestone payments: Milestone payment as given below will be considered:

1. **20%** on completion of detailed engineering review and approval of configuration by department. Payment will be against BG and valid until receipt of item to site.
2. **30%** on completion of Factory Acceptance Test and on clearance of FAT documents and receipt of item to site.
3. **30%** upon SAT clearance.
4. **20%** upon satisfactory completion of final site commissioning of system against exchange of Performance Bank Guarantee (PBG).

The Contractor is required to provide Performance Bank Guarantee (PBG) for 3% (Three PERCENT) of the total order value towards due performance of system during Warranty period. The performance security shall be submitted in the form of Account Payee Demand Draft or Fixed Deposit Receipt or Banker's Cheque is drawn on any commercial bank in India, favouring Accounts Officer, IPRC or as Bank Guarantee issued by a commercial bank in India, as per our prescribed

format in Non-judicial Stamp Paper of appropriate value for a period of 12 months from the date of final acceptance of the system at the site by the Department.

2.14 Validity:

The quoted price should be valid for a period of 6 months from the date of opening of the technical and commercial quotation.

BIDDER'S PROFILE

The bidder shall elaborately bring out in their quotation their company profile, which shall be commensurate with the level demanded for the execution of the work specified in this document. The details shall include the following and the bidder's capacity will be evaluated based on the PQC:

2.15 Pre-qualification criteria (PQC)

- a. The bidders shall suitably fill-up the information solicited in "Item specification" and submit as part of the Techno-Commercial Bid (TCB). Those Bidders who comply with the PQ criteria only will be screened in for opening and evaluation of the price bid. The Information to be submitted in the TCB shall be complete in all respects substantiated by valid documents and there shall not be any further opportunity for the bidders to submit any information or document unless the department solicits so at their own discretion.
- b. Any lack of information or incomplete/ ambiguous information or false information or information non-complaint with the PQ criteria shall be treated as sufficient cause to summarily reject such bids.
- c. Previous experience in the execution of projects of the nature and quantum on par minimum cycle time (10 ms) with those specified in this document. The bidder shall

be required to submit the copies of previously executed purchase orders with corresponding Performance certificate/ Completion certificate from the clients for the values not less than Rs.200.00 lakhs in single order or Rs.100.00 lakhs in two orders for the last ten years.

- d. System Integrator: The bidder shall be system house integrator of reputed PLC manufacturers like and proof of the same to be submitted.
- e. Clientele, specifying the clients to whom they have executed works of nature similar to that specified in this document. The address, telephone, fax, e-mail and contact person of the clients shall also be specified.

A Memorandum of Undertaking, as per the following format, shall be submitted by the bidder along with the quotation.

MEMORANDUM OF UNDERTAKING

I / We hereby submit the quotation for the execution, to the President of India of the work specified in the underwritten memorandum within the time specified in such memorandum at a total price as specified and in all respects in accordance with the specifications, design, drawings and instructions in writing referred to in this document and with such materials as provided for by and in all other respects in accordance with such conditions as are applicable.

Should this tender be accepted in whole or in part, I / We hereby agree to abide by and fulfil all the terms and provisions contained in the tender enquiry documents which have been read by me/ read and explained to me so far as applicable or in default thereof to forfeit and pay to the President of India or his successors in office the sum of money mentioned in the said conditions.

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Terms & Conditions

Annexure: C

I/ We agree to execute all the works referred to in the tender enquiry documents upon the terms and conditions contained or referred to therein and to carry out such deviation / variation as may be ordered in excess of original scope at the rates to be determined in accordance with the provision contained in this document.

Witness

Bidder

(Signature)

(Signature)

Name:

Name:

Designation:

Designation:

Address:

Address:

ANNEXURE-D
PRICE FORMAT

ANNEXURE-D1**Price Format for Control System TCS**

Sl. No.	Description (Bill Of Material)	Qty for TCS (Nos)	Unit Price	Tax	Total Price
1	Processor	As per RFP requirement			
2	Redundancy module				
3	Power Supply Unit				
4	Communication Interface Module				
5	I/O Racks				
6	Remote I/O controller				
7	Analog Input channels	640			
8	Analog Output channels	128			
9	Digital Input channels	3168			
10	Digital Output channels	2528			
11	Pulse Input Card	16			
12	I/O chassis	As per RFP requirement			
13	I/O rack power supply unit				
14	I/O rack communication module				
15	Dummy modules				
16	Memory units				
17	SCADA node / operator stations with complete Accessories	35 Nos			
18	Engineering/ Programming / data processing Node with complete accessories	4 Nos			
19	SCADA server/Data server with complete Accessories	4 Nos			
20	Printer	2 Nos			

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Price Format

Annexure: D

Sl. No.	Description (Bill Of Material)	Qty for TCS (Nos)	Unit Price	Tax	Total Price
21	Printer (color)	2 Nos			
22	Console switches & accessories				
23	Ethernet Switch	As per RFP requirement			
24	Networking accessories				
25	System cables				
26	Power cable				
27	Fiber optic cable				
28	Grounding cable				
29	Other interconnecting cables				
30	Connectors				
31	Accessories				
32	Software for Control System				
33	Software for SCADA				
34	Software for graphic pages, display pages, reports etc				
35	Development Software				
36	Run Time Software				
37	Driver Software and Life Time License				
38	Detailed Engineering Document				
39	System Documentation (hard copy + softcopy in CD]				
40	Documentation for Software				
41	Factory Acceptance test				
42	Training for at purchaser site.				
43	Site preparation, Erection and Commissioning of the complete system and Site acceptance test				
44	System Cabinet				

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Price Format

Annexure: D

Sl. No.	Description (Bill Of Material)	Qty for TCS (Nos)	Unit Price	Tax	Total Price
	(Including Cooling Fans, Air Filters, Fan Failure & temp detection unit)				
45	Packing & Forwarding				

Note: It is mandatory that contractors have to indicate and quote for any other item /module used in the system which is not specified in the above list.

It is mandatory to provide price breakup as per the price format for TCS.

ANNEXURE-D2**Price Format for Emergency Shut Down System – ESS**

Sl. No	Description (Bill Of Material)	Qty (Nos)	Unit Price	Tax	Total Price
1.	Processor	As per RFP requirement			
2.	Power Supply Unit				
3.	Communication Interface Module				
4.	I/O chassis				
5.	Remote I/O controller				
6.	Analog Input channels	8			
7.	Analog Output channels	16			
8.	Digital Input channels	56			
9.	Digital Output channels	88			
10.	Dummy modules	As per RFP requirement			
11.	Memory units				
12.	SCADA node / operator stations with complete Accessories	2 Nos			
13.	Engineering/ Programming / data processing Node with complete accessories	2 Nos			
14.	Ethernet Switch	As per RFP requirement			
15.	Networking accessories				
16.	System cables				
17.	Power cable				
18.	Grounding cable				
19.	Fiber optic cable				
20.	Other interconnecting cables				
21.	Connectors				
22.	Accessories				
23.	Software for ESS Control				

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Price Format

Annexure: D

Sl. No	Description (Bill Of Material)	Qty (Nos)	Unit Price	Tax	Total Price
.	System				
24.	Software for ESS SCADA				
25.	Software for graphic pages, display pages, reports etc				
26.	Development Software				
27.	Run Time Software				
28.	Driver Software and Life Time License				
29.	Detailed Engineering Document				
30.	System Documentation (hard copy + softcopy in CD]				
31.	Documentation for Software				
32.	Factory Acceptance test				
33.	Training at purchaser site.				
34.	Site preparation, Erection and Commissioning of the complete system and Site acceptance test				
35.	System Cabinet (Including Cooling Fans, Air Filters, Fan Failure & temp detection unit)				
36.	Packing & Forwarding				

Note: It is mandatory that contractors have to indicate and quote for any other item /module used in the system which is not specified in the above list.

It is mandatory to provide price breakup as per the price format for ESS.

ANNEXURE-D3**Price Format for Signal Simulator – SS**

Sl. No.	Description (Bill Of Material)	Qty (Nos)	Unit Price	Tax	Total Price
1.	Power supply Unit	As per RFP requirement			
2.	Chassis				
3.	Controller				
4.	DC Milli Volt (mV) channels	32			
5.	DC Voltage (V) channels	16			
6.	DC Milli ampere (mA) channels	32			
7.	Resistance (ohm) (Low range) channels	8			
8.	Resistance (ohm) (High Range) channels	8			
9.	Frequency (Hz) channels	9			
10.	Digital Input channels	8			
11.	Digital Output channels	8			
12.	Matrix switch	As per RFP requirement			
13.	Remote module				
14.	Programming Node with complete accessories	1 No			
15.	Data processing node with complete accessories	1 No			
16.	Connectors	As per RFP requirement			
17.	Accessories				
18.	Software for SS, GUI , report generation, Merging of TCS & PXI				
19.	Development Software				
20.	Run Time Software				
21.	Driver Software and Life Time License				
22.	Detailed Engineering Document				

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Price Format

Annexure: D

Sl. No.	Description (Bill Of Material)	Qty (Nos)	Unit Price	Tax	Total Price
23.	System Documentation (hard copy + softcopy in CD)	As per RFP requirement			
24.	Documentation for software				
25.	Factory Acceptance test				
26.	Training for at purchaser site.				
27.	System cabinet (Including cooling Fans, Air Filters, Fan Failure & Temp detection unit)				
28.	Site preparation, Erection and commissioning of the complete system and site acceptance test				
29.	Packing & Forwarding				

Note: It is mandatory that contractors have to indicate and quote for any other item /module used in the system which is not specified in the above list.

It is mandatory to provide price breakup as per the price format for SS.

ANNEXURE-D4**Price Format of Spares for Control System (TCS)**

Sl. No.	Description (Bill Of Material)	Qty (Nos)	Unit Price	Tax	Total Price
1	Processor	2			
2	Communication Interface Module *	2			
3	RIO Controller/module *	2			
4	Power Supply Unit	4			
5	Analog Input channels	136			
6	Analog Output channels	32			
7	Digital Input channels	640			
8	Digital Output channels	512			
9	Pulse Input channels	4			
10	I/O rack power Module	8			
11	Back plane / chassis	4			
12	Memory units/card	3			
13	Mimic/ Display Node	3			
14	Ethernet Switch	8			
15	Server	2			
16	System cables/Network cables each type	5			
17	Connectors/termination modules each type	5			

Note:

- All spares parts shall comply with the same standards and specifications as the original equipment and shall be fully interchangeable with original parts.
- All spares shall be marked with the manufacturer's part number, name and/or reference number.
- All spares shall be packed separately from the main instrument, and shall be properly protected to prevent

deterioration and damage during shipment and storage.

- d) Minimum 10 years spares supply shall be ensured.
- e) * SL.No 2,3 if it is integral and same as Sl.No1, Quote for SL no1 alone.
- f) The Spares cost will be considered for calculating overall Lowest.

ANNEXURE-D5**Price Format of Spares for ESS System**

Sl. No.	Description (Bill Of Material)	Qty (Nos)	Unit Price	Tax	Total Price
1	Processor	1			
2	Power Supply Unit	1			
3	Digital Input channels	16			
4	Digital Output channels	24			
5	Analog Input channels	4			
6	Analog Output channels	4			
7	Remote I/O controller	1			
8	I/O rack power module	2			
9	I/O rack communication module	2			
10	Memory units/card	2			
11	Back plane / chassis	2			
12	System cables/Network cables each type	5			
13	Connectors/termination modules each type	5			

Note:

- All spares parts shall comply with the same standards and specifications as the original equipment and shall be fully interchangeable with original parts.
- All spares shall be marked with the manufacturer's part number, name and/or reference number.
- All spares shall be packed separately from the main instrument, and shall be properly protected to prevent deterioration and damage during shipment and storage.
- Minimum 10 years spares supply shall be ensured.
- The Spares cost will be considered for calculating overall Lowest.

ANNEXURE-D6

Price Format for AMC

Sl. No.	Description (Bill Of Material)	Unit Price	Tax	Total Price
1	Operation and Maintenance (O&M) support			
2	Annual Maintenance Contract (AMC)			

It is mandatory to provide price breakup as per the price format as per Annexure-D1, D2, D3, D4, D5 & D6. Contractor shall provide breakup cost as per Annexure-D1, D2, D3, D4, D5 & D6. Quoting lump sum price is not acceptable.