



TECHNICAL SPECIFICATION FOR MAIN PLANT PACKAGE

SECTION- 6 (CONTROL AND INSTRUMENTATION WORKS)

6.1 GENERAL

6.1.1 General Requirements

- i) The bidder shall provide all material, equipment and services so as to make a totally integrated Instrumentation and Control System together with all accessories, auxiliaries and associated equipment ensuring operability, maintainability and reliability. The Instrumentation and Control System shall be consistent with modern power plant practices and shall be in compliance with all applicable codes, standards, guides, statutory regulations and safety requirements in force.
- ii) The bidder shall also include in his proposal and shall furnish all equipment, devices and services which may not be specifically stated in the specification but are needed for completeness of the equipment/systems furnished by the bidder and for meeting the intent and requirements of the specification.
- iii) It may be noted that where equipment or system for the generating units are described, same refer to only one set per generating unit to be furnished by the contractor unless specifically indicated otherwise. Where equipment or systems for plant common facilities are described, it will be understood that the quantities described are the total quantities required.
- iv) The bidder shall include in his bid a detailed bill of material (BOM) for each of the systems i.e. DDCMIS, measuring instruments, power supply system, SWAS etc.
- v) The offered C&I equipment, system, instruments should have completed one (1) year of trouble free and satisfactory operation on a coal fired power station having unit size of 200MW or more.

6.1.2 Reliability and Availability

- i) Each component and system offered by the bidder shall be of established reliability. The minimum target reliability of each piece of equipment like each electronic module/card, power supply, peripheral etc. shall be established by the bidder, considering its failure rate/mean time between failures (MTBF), meantime to repair (MTTR), such that the availability of the complete C&I system is assured for 99.7%.
- ii) The bidder shall submit detailed reliability calculations for each system/equipment which (with the help of a schematic of various sub-system



connected in series or in parallel as the case may be and MTBF & MTTR values for the various equipments) shall show that availability calculation is as per IEEE Standard-P1046 or equivalent.

- iii) When more than one device uses the same measurement or control signal, the transmitter and other components/ module shall be fully equipped to provide all signal requirements. The system shall be arranged so that the failure of any monitoring device or control components or spurious intermediate grounding in the signal path shall not open the signal loop nor cause the loss or malfunction of signal to other devices using the same signal.
- iv) To ensure availability, adequate redundancy in system design shall be provided at hardware, software and sensor level to satisfy the availability criteria mentioned at Cl.6.1.2(i) above. For the protection system, independent sensing device shall be provided to ensure adequate safety of plant equipment.

6.1.3 Standardisation and Uniformity of Hardware

To ensure smooth and optimal maintenance, easy interchangeability and efficient spare parts management of various C&I instruments/equipment, the Bidder shall ensure that all instruments/devices are of the same make, series and family of hardware. For example, all 4-20mA electronic transmitters/transducers, control hardware, control valves, actuators and other instruments/ local devices etc. being furnished by the bidder for steam generator, turbine generator and other auxiliaries shall be of the same make and series for similar applications, except for the instrument integral to TG, boiler and BFP which may be manufacturer specific.

6.1.4 Operability & Maintainability

- i) The design of the control systems and related equipments shall adhere to the principle of 'Fail Safe' operation wherever safety of personnel / plant equipment is involved. 'Fail Safe' operation signifies that the loss of signal or failure of any component shall not cause a hazardous condition. However, it shall also be ensured that occurrence of false trips are avoided / minimised.

The types of failure which shall be taken into account for ensuring operability of the plant shall include but not be limited to:

- Failure of sensor or transmitter,
 - Failure of main and/or redundant controller/other modules,
 - Loss of motive power to final control element,
 - Loss of control power.
 - Loss of instrument air
- ii) The choice of hardware shall also take into account sound maintainability principles and techniques. The same shall include but shall not be limited to the following:
 - Standardization of parts.



- Minimum use of special tools.
 - Grouping of functions.
 - Interchangeability.
 - Malfunction identification facility/self surveillance facility.
 - Easy modular replacement.
 - Fool proof design providing proper identification and other features to preclude improper mounting and installation.
 - Appropriate derating of electronic components and parts.
- iii) The equipment shall employ latest state of the art technology to guard against obsolescence. In any case, bidder shall be required to ensure supply of spare parts for 15 years of the plant. In case, it is felt by the Bidder that certain equipment/component is likely to become obsolete, the Bidder shall clearly bring out the same in his bid and indicate steps proposed to deal with such obsolescence.

6.1.5 Unit Control & Monitoring Philosophy

- i) The control & monitoring philosophy for the plant envisages control from two locations:
- a) From Unit Control Room (UCR)

There shall be one common UCR for controlling the boilers, turbine-generators and auxiliaries of the two units. Accordingly, the layout of UCR shall be developed to accommodate the complete control equipment associated with each unit and the control interface equipment for common facilities as specified.
 - b) From local control stations for off site and ancillary plants
- ii) **Control & Monitoring from Unit Control Room**

The main plant equipment (namely steam generator & auxiliaries, TG & auxiliaries, regenerative cycle equipment, equipment cooling water system etc.) for this project is envisaged to be controlled from the operator workstation (OWS) mounted on the unit control desk (UCD) in the unit control room (UCR) under all regimes of operation i.e. start-up, shutdown, load throw off and emergency handling. In addition, minimum 4 nos. large video-screens of minimum size of 200-210 cm (80"-84") per unit shall be provided. All the information required for safe and efficient operation of the plant shall be displayed on TFTs at high speed and accuracy in specially designed displays suitable for power plant operation. The operation of CW pumps shall be integrated in bidder's DDCMIS with a provision of operation of CW pumps from unit OWS as well as from local control panel to be provided by the CW pump supplier (not in bidder's scope).

Operation of generator, generator auxiliary systems and breakers for 11kV (unit and station switchgears), 3.3 kV switchgear and 415 V associated with the main plant and DG sets shall also be performed through OWS as described in Section-5.



iii) **Back-up Instrumentation**

In addition to the operator work stations (OWS) & large video screens (LVS) mentioned above, minimum amount of conventional push-button (PB) stations and Indicators shall be provided for safe shut down of the unit.

iv) **Control & Monitoring of the Auxiliary Plants in Bidder's scope**

The control, monitoring & operation of the auxiliary plants (i.e. ESP system, centralized oil purification system for TG, condensate polishing system etc.) shall be carried out from local control panel/operator workstation of the respective plants. For all such plant information link shall be provided for collection of data in the DDCMIS in UCR for the information of unit in-charge /shift-in-charge etc.

v) **Information from Other Systems not in Bidder's scope**

The control, monitoring and operation of the off-site plants (i.e. coal handling plant, ash handling plant, fuel oil plant, D.M. plant etc.) will be carried out from the local control panel/operator work station. Bidder shall provide all hardware and software at his end (for minimum 12 systems) for establishing a link for collection of data in the DDCMIS in UCR, shift charge engineer etc. through a station wide LAN. However, as stated above, the operation of CW pumps shall be integrated in bidder's DDCMIS with a provision of operation of CW pumps from unit OWS as well as from local control panel.

6.1.6 Environmental Conditions

Instruments, devices and equipments for location in outdoors/indoor/air-conditioned areas shall be designed to suit the environmental conditions indicated below and shall be suitable for continuous operation in the operating environment of a coal fired station and also during periods of air conditioning failure without any loss of function, or departure from the specification requirements covered under this specification.

| Ambient temperature (outside cabinets) | Pressure | Relative humidity | Atmosphere | Required protection Class of panels/ cabinets/ desks |
|--|------------|-------------------|-------------|--|
| Outdoor Location | | | | |
| 55 degree C max. | Atmosphere | 100 % Max. | Air (dirty) | IP 55*** |
| 4 degree C min. | Atmosphere | 5 % min. | Air (dirty) | IP 55*** |
| Indoor Location | | | | |
| 55 degree C max. | Atmosphere | 95 % Max. | Air | IP 54** |
| 4 degree C min. | Atmosphere | 5 % min. | Air | IP 54** |



| Air Conditioned Areas | | | | |
|---|------------|-----------|-----|-------|
| 24 +/- 5 degree C normal | Atmosphere | 95 % Max. | Air | IP 22 |
| 50 deg C max. * | Atmosphere | 5 % min. | Air | IP 22 |
| * During air conditioning failure. | | | | |
| ** For non-ventilated enclosures. For ventilated enclosures, protection class shall be IP 42. | | | | |
| ***With a suitable canopy at the top to prevent ingress of dripping water.. | | | | |



6.2 **DISTRIBUTED DIGITAL CONTROL, MONITORING AND INFORMATION SYSTEM (DDCMIS)**

The microprocessor based distributed digital control, monitoring & information system (DDCMIS) shall be provided for the safe and efficient operation of steam generator, turbine generator and all auxiliaries under all regimes of operation.

6.2.1 **General Requirements**

- i) The requirements for distributed digital control monitoring and information system (DDCMIS) are indicated on functional basis in this specification. Bidder shall be responsible for engineering, selection and connection of all components and sub-systems to form a complete system whose performance is in accordance with functional, hardware, parametric and other requirements of this specifications. It is not the intent or purpose of this specification to specify all individual system components since the bidder has full responsibility for engineering and furnishing of a complete system.
- ii) DDCMIS shall basically consist of :
 - a) Control system of boiler, turbine & balance of plant (namely SG - C&I, TG - C&I & BOP - C&I including their respective measurement system);
 - b) Man-Machine interface and plant Information system (MMIPIS);
 - c) System programming & documentation facility;
 - d) Data communication system (DCS);
 - e) Sequence of events (SOE) recording system;
 - f) Annunciation system;
 - g) Master & slave cock system.
- iii) **System Expandability**

Modular system design shall be adopted to facilitate easy system expansion. The system shall have the capability and facility for expansion through the addition of controller modules, process I/O cards, drive control modules, hand/auto stations, push button stations, peripherals like TFT/Keyboards, printers etc. while the existing system is fully operational. The system shall have the capability to add any new control loops groups/subgroups, in control system while the existing system is fully operational.
- iv) **On Line Maintenance**

It shall be possible to remove/replace online various modules (like I/O module) from its slot for maintenance purpose without switching off power supply to the corresponding rack. System design shall ensure that while doing so, undefined signalling and releases do not occur and controller operation in any way is not affected (including controller trip to manual, etc) except that



information related to removed module is not available to controller. Further, it shall also be possible to remove/replace any of the redundant controller module without switching off the power to the corresponding rack and this will not result in system disturbance or loss of any controller functions for main controller. The on-line removal/insertion of controller, I/O modules etc. shall in no way jeopardise safety of plant and personnel.

v) Fault Diagnostics

The DDCMIS shall include on-line self-surveillance, monitoring and diagnostic facility so that a failure/malfunction can be diagnosed automatically down to the level of individual module giving the details of the fault on the programmer station TFT displays and printers. The faults to be reported shall include fault in main and standby power supplies, sensor fault, any channel fault in 2V3 channels etc. These faults shall be indicated on TFTs as well as local indication on the faulty channel/ module and on corresponding rack/ cubicle. The diagnostic system shall ensure that the faults are detected before any significant change in any controller output has taken place. Failure of any I/O modules, controller etc. shall be suitably grouped and annunciated to annunciation facia and to OWS.

vi) Fault Tolerance

The DDCMIS shall provide safe operation under all plant disturbances and on component failure so that under no condition the safety of plant, personnel or equipment is jeopardised. Control system shall be designed to prevent abnormal swings due to loss of control system power supply, failure of any control system component, open circuits/short circuits, instrument air supply failure etc. On any of these failures, the controlled equipment/parameter shall either remain in last position before failure or shall come to fully open/close or on/off state as required for the safety of plant/personnel/equipment and as finalised during detailed engineering.

vii) Signal Exchange

All the signal exchange between various functional groups of each control group (i.e. within SG - C&I, TG - C&I and BOP - C&I) shall be implemented through redundant main system bus (the main bus connecting various sub-systems) and local system bus within a sub-system as per the standard practice of the bidder. It shall be ensured that any single failure in electronics involved for such communication, e.g., communication controllers, bus interface modules, physical communication media, etc. does not result in loss of such signal exchange and there in no deterioration in specified system response and system parametric requirements. In case a controller utilises some inputs generated/ processed by any other controllers/functional group and the requirement of controller response time as specified elsewhere is not met due to inadequate communication rate/ procedure, then the bidder shall provide hardwired signal exchange for such inputs. Bidder shall furnish documentary evidence through its standard catalogues and drawings explaining as to how this requirement is being met by them.-Further, bidder to note that if his offered system cannot meet the above requirement of



communication redundancy and specified system response and parametric requirements then all the signal exchange, analog as well as binary among various functional groups shall be carried out through hardwiring only and not through bus system.

However, if in the opinion of the purchaser, a few signal exchanges are found required to be hardwired, the same shall be provided by the bidder. Control & protection signal exchange between SG- C&I, TG-C&I and BOP - C&I shall be hardwired only. Protection signals like MFT shall necessarily be hardwired even for exchange within the same sub-system.

No single failure either of equipment or power source shall be capable of rendering any part/system/sub-system of DDCMIS in-operative to any degree.

viii) System Spare Capacity

Over and above the equipment and accessories required to meet the fully implemented system as per specification requirements, DDCMIS shall have spare capacity and necessary hardware/ equipment/ accessories to meet following requirement for future expansion at site:

- a) 10% spare channels in each of the functional groups, fully wired upto marshalling cabinets.
- b) Wired-in "usable" space for 20% modules in each of the system cabinets for mounting electronic modules wired up to corresponding spare terminals in marshaling cabinets such that implementation of any additional control loop/logic can be achieved only by insertion of necessary electronic modules(s) in system cabinets, configuration of corresponding controller and connection of inputs/ outputs at 'field end' of marshaling cabinet / logic cabinet as applicable.
- c) MMIPIS shall be provided with capacity to handle 25% or at least 1 no. of each type of peripherals additionally, like TFTs, keyboards, printers, PCs etc., over and above already specified, without any additional hardware or software.
- d) Each controller shall have 30% spare functional capacity to implement additional function blocks, over and above implemented logics/ loops. Further, each controller shall have spare capacity to handle minimum 20% additional inputs/ outputs of each type (including (a) & (b) above), over and above implemented capacity. Each of the corresponding communication controller shall also have same spare capacity as that of controller.
- e) The data communication system (including main system bus and other bus system) shall have the capacity to handle the additions mentioned in clause nos. (a) to (d) above. This will be in addition to 50% spare capacity specified under this clause.



- f) Twenty (20) percent spare relays of each type and rating, mounted and wired in relays cabinets. All contacts of relays shall be terminated in terminal blocks of relay cabinets. In each of the relay cabinets 20% spare terminal blocks shall be provided so that additional relays can be mounted and wired.
- g) The spare capacity as specified above shall be uniformly distributed throughout all cubicles. The system design shall ensure that above mentioned additions shall not require any additional controller/ processor/ peripheral drivers in the system delivered at site. Further, these additions shall not deteriorate the system response time/ duty cycle, etc. from those stipulated under this specification.
- ix) Remote Input Modules and Cubicles

It is envisaged to use remote input modules and racks / cubicles at the following locations in the plant to the extended I/O bus, to minimize cabling. The exact areas where remote I/O modules are provided shall be decided during detailed engineering. However some of the areas where such remote I/O can be provided are listed below:

- a) Boiler area (for metal temperature etc.)
- b) Near transformer yard for various inputs related to transformers.
- c) SWAS room.
- d) Switchgear room

It is mandatory to provide a small room or enclosure for above which will be properly air conditioned through window a/c so that environment similar to control equipment room is met. However, the modules used for the above application shall be designed in such a way to withstand the harsh environment expected to be encountered in respective plant areas.

6.2.2 System Description

The DDCMIS shall work in full integration and conjunction with field equipment/drives like pumps, motors, valves, actuators, dampers, hydraulic control systems (e.g. for HP&LP bypass etc.) and field instruments to be provided by the bidder. The DDCMIS hardware (controllers, modules/cards etc.) shall be housed in cabinets located in control equipment room (CER) except for operation interfaces located in unit control desk (UCD) and unit control panel (UCP), if applicable, in unit control room (UCR).

i) Control System

The control system along with its measurement system, shall perform functions of closed loop control, sequence control, interlock & protection of SG, TG and auxiliaries under all regimes of unit operation. The measurement



system of control system shall perform the functions of signal acquisition, conditioning and signal distribution of various types of inputs/outputs like analog, (4-20 mA DC, thermocouple, RTD), binary, pulse, etc. The inputs which are required for only information and monitoring purposes shall be distributed suitably in various groups of the measurement system.

ii) **Man-Machine Interface and Plant Information System (MMIPIS)**

The MMIPIS shall perform control, monitoring and operation of SG, TG and auxiliaries under all regimes of unit operation, interacting with the control system. For this, MMIPIS shall primarily perform following functions.

- a) Operator interface for control system
- b) Plant supervisory functions like displays, alarm monitoring & reporting, (reports & logs, calculations, trend recording, historical and long term data storage & retrieval, etc.)

iii) **System Programming & Documentation Facility**

The programmer stations shall be provided for

- a) on-line configuration & tuning of control system
- b) on-line program development/modifications in MMIPIS

In addition, latest state of the art work-station based system documentation facility shall be provided to retrieve, generate & document all system documentation, logics, control loops, cable interconnection, etc. to achieve paperless documentation for the complete plant.

iv) **Data Communication System (DCS)**

The data communication system shall be provided for communication between control system and MMIPIS communication and signal exchange between various functional groups as well as communication between various units & off site / off line systems.

v) **Sequence of Events Recording System (SOE)**

The DDCMIS shall be capable of carrying out sequence of event recording function to scan and record events in the sequence of occurrence within a resolution of one (1) m sec.

vi) **Master and Slave Clock System**

Master and Slave Clock System shall be provided to ensure uniform time indication throughout the various plant facilities and time synchronisation between control system, MMIPIS, switchyard disturbance recorder, other PLC's etc.



vii) **Annunciation System**

Annunciation system shall be LVS based in the unit control room. The annunciation logic will be implemented as a part of DDCMIS. Top portion of all the LVS shall be reserved for annunciation with 3/4 bands for different priority.

6.2.3 Measurement Functions of Control System

All the signals coming into/going out of the control system shall be connected either directly or routed through marshalling cabinets as per the interconnection philosophy of DDCMIS. The input / output modules employed in the control system shall be separate from controller hardware. .

6.2.3.1 Analog signal conditioning & processing

- i) The conditioning and processing functions to be performed as a minimum for the analog inputs coming for control and information purposes are :
- a) Galvanic isolation of input and output signals wherever required.
 - b) Transmitter power supply with per point fuse protection or current limiting and power supply monitoring.
 - c) Transducer/transmitter signal output limit check
 - d) Implementation of multiple measurement schemes
 - e) Square root extraction
 - f) Pressure and temperature compensation.
 - g) On-line analog digital converter (ADC) gain and drift monitoring and correction at periodic intervals.
 - h) Linearisation of thermocouple signals
 - i) Reasonability check for all analog inputs.
- ii) All analog signals for control purpose shall be acquired, validated, processed and their respective data base updated at a maximum interval of 250 milliseconds except for some fast-acting control loops for which the above-referred time shall be as per process requirement. For signals required for information only, the above functions shall be performed at an interval of 1 – 2 sec. The validated analog inputs shall be converted into engineering units on a per point basis. Analog input processing (scanning to alarm checking) shall be performed once every scan cycle. It shall be possible to delete any analog input from scan or to return it to scan on demand by the operator.
- iii) The 4-20 mA input analog cards shall be suitable for interfacing transmitters giving 4-20mA analog signal along with superimposed HART interface
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signals. 4-20 mA DC signal will only be used for control purpose and superimposed HART signal will be used for configuration, maintenance diagnostic and record keeping facility for electronic transmitters and analysers etc. meeting the functionalities described elsewhere.

6.2.3.2 **Binary signal conditioning & processing**

- i) The changeover type contacts (i.e. 'NC' + 'NO' together) shall be wired to the control system for all the binary inputs required for control purposes, except for inputs from MCC/switchgear, actuators and inputs related to hardwired signal exchange among various functional group for which non-changeover type contacts ('NC' or 'NO') shall be wired to the control system. The binary inputs required for information purposes only shall be wired to control system in the form of non-changeover type contacts.
- ii) The conditioning and processing functions to be performed as a minimum for the binary inputs coming for control and information purposes are:
 - a) 24V / 48 VDC power supply for contact interrogation for all potential free contacts with per point fuse protection or suitable current limit feature/ isolation through opto-coupler.
 - b) Contact bounce filtering delay time of 15 milliseconds.
 - c) Facility for pegging the binary signal to logic one/zero or last correct value in case of failure of binary input module.
 - d) Binary signal distribution to different users shall be in such a way so as to ensure that a short/ground fault on one user is not reflected to the other user.
 - e) Implementation of multiple measurement schemes for signals for control purpose.
 - f) All binary signals shall be acquired, validated, processed, alarm checked and their data base updated within one second. In addition to this requirement, binary signals required for SOE shall have a resolution of 1ms.
 - g) Checking for excessive number of status changes for all binary/contact inputs.
 - h) Facility to delete any binary input from scan or to return to scan on operator demand.
 - i) The non-coincidence monitoring shall be provided for binary inputs for all changeover signals, namely process actuated switches required for control purpose (i.e. protection/interlock, permissive, logical intervention etc.)



- iii) Triple measurement scheme for analog inputs employing three independent transmitters connected to separate tapping points shall be employed for the most critical measurements used in analog control functions including but not limited to furnace draft, feed water flow, throttle pressure, turbine first stage pressure, drum level, deaerator level, turbine speed.

The three signals shall be auctioneered to determine the median/average value which will be used for control purpose. In case one transmitter fails or shows excessive deviation with respect to others, it will be removed from computation of median/average value and the average of the other two transmitter outputs shall be used for controls. The control loop shall trip to manual when any two of the three transmitter signals fail. The operator shall be able to select any of the transmitters or the median/average value from the control desk. The outputs of the transmitters shall be continuously monitored for excessive deviation which shall be displayed, logged and alarmed.

Individual transmitter signal, their status and selected value for control/measurement shall be available on OWS.

- iv) Dual measurement scheme for analog inputs employing two independent transmitters, connected to separate tapping points/ temperature element shall be employed for the remaining measurements used for analog control functions.

The output of the redundant transmitters shall be continuously monitored for excessive deviation. In case the deviation is within limits, the mean value shall be used for the control loop. If the deviation becomes high (with both transmitters remaining healthy), the loop will be automatically transferred to manual. However, if one transmitter fails and the other transmitter remains healthy, then the output of the healthy transmitter shall be used for control. If the other transmitter also fails, loop shall trip to manual. The outputs of the transmitters shall be continuously monitored for extensive operation which shall be displayed and logged and alarmed.

Individual transmitter signal, their status and selected value for control/measurement shall be available on OWS.

- v) For binary and analog inputs required in furnace and turbine protection triple sensing devices shall be provided. Binary and analog inputs which are required for protection of more than one equipment (e.g. flame failure, deaerator level very low, etc) as well as protection signals for turbine driven boiler feed pump (TDBFP)/ motor driven boiler feed pump (MDBFP), triple sensing devices shall be provided. For other critical binary and analog inputs required for protection and interlock purpose of other equipment (e.g. those interlocks which may result in loss of generation, non-availability of a major equipment etc.), dual sensors shall be provided. However, for bearing temperature of FD/ID/PA/MILLS/APH and its HT drives, single sensor shall be used.



- vi) Wiring scheme for inputs to control system shall be as follows :
- a) Each of the dual/ triple redundant binary and analog inputs shall be wired to separate input modules. In addition, for functions employing 2V3 controllers like BMS/turbine protection, each of the redundant binary and analog signals shall be wired to separate input modules associated with each controller and meeting requirement stipulated under clauses 6.2.4.2 & 6.2.4.3. Similarly, each of the dual redundant binary and analog inputs shall be wired to separate input modules. These redundant modules shall be placed in different racks, which will have separately fused power supply distribution. Implementation of multiple measurement scheme of these inputs will be performed in the redundant hardware. Loss of one input module shall not affect the signal to other module and also other channels of these modules can be used by other inputs of the same functional group.
- b) The single binary and analog signals required for control purposes shall be wired as follows:
- The limit & torque switches and the MCC/ Swgr checkbacks shall be wired to drive control modules wherever provided. For the drives where drive control modules are not provided, these signals shall be connected to input module only.
 - Other single analog & binary inputs shall be wired to single input modules.
- vii) The binary and analog outputs from one subsystem of the Control System to other which are required in these systems for control purposes, (only very few critical signals e.g., reheater protection or MFT, load set point to electro hydraulic turbine control (EHTC) from CLCS, etc.), shall be made available from triple/dual redundant binary and analog output modules. However, redundancy in binary and analog outputs to indicators/recorders, SOE and annunciation facia lamps is not required.
- viii) The signal conditioning functions like multiple measurement schemes, square root extraction for flow signals, pressure and temperature compensation, limit value computation can be performed either in the controllers or in signal conditioning and processing hardware outside controllers.
- ix) The maximum number of inputs/outputs to be connected to each type of module shall be as follows:
- | | | | |
|----|----------------------------------|---|----|
| 1. | Analog input module | - | 16 |
| 2. | Analog output module | - | 16 |
| 3. | Binary input module | - | 32 |
| 4. | Binary output module | - | 32 |
| 5. | Analog input & output (combined) | - | 16 |
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6. Binary input and output (combined) - 32

(**Note :** For binary inputs, one changeover contact is counted as 2 inputs)

Further, minimum 10% spare channels shall be kept in each of the input/output modules.

- x) The following requirements shall be met :
- a) Input filters to attenuate noise shall be provided.
 - b) All analog outputs shall be short circuit proof.

Any single sensor/transducer/transmitter failure alarm shall be provided on programmer station TFTs for all sensors/ transducers/ transmitters. Similarly sensor break alarm for thermocouples etc. shall also be displayed on the TFTs.

6.2.4 Control System Requirements

6.2.4.1 The control system shall be broadly divided into SG - C&I, TG - C&I and BOP - C&I.

- i) The SG- C&I part of DDCMIS system shall perform the following function as minimum but not limited to
 - a) Burner management system (BMS) including control & protection of coal mills, fuel oil system etc.
 - b) Analog control functions pertaining to secondary air damper control etc.
 - c) Soot blower control.
- ii) The TG- C&I part of DDCMIS system shall perform the following functions:
 - a) Turbine protection system function (TPS)
 - b) Turbine governing system for main turbine
 - c) Turbine stress control system (TSCS)
 - d) Automatic turbine testing (ATT)
 - e) Automatic turbine run up system. (ATRS)
 - f) HP&LP bypass control system
 - g) Turbine generator control system
 - h) EHG, interlock & protection for turbine driven BFP



- iii) The BOP- C&I system shall perform the following functions:
- a) Analog control functions, other than those covered in SG-C&I and TG-C&I, like co-ordinated master control, furnace draft control, SH/RH steam temperature control, FW flow control, heaters/deaerator/condenser level control, Auxiliary PRDS pressure & temperature control etc.
 - b) Binary control functions pertaining to main plant auxiliaries like FD/ID/PA fans, APH, BFP etc., Generator auxiliary systems and electrical breakers etc.
- iv) Functional grouping of various controllers shall be decided during detailed engineering which shall be subject to purchaser's approval. Functional grouping shall meet following general requirements:
- a) Process redundancies shall be maintained. For example, in case the mechanical equipment has been provided with redundancy, the drive shall not be controlled by a common controller i.e. for redundant set of process equipments(eg.2x60%ID fans,3x60% CEP etc.),it shall be ensured that there is no sharing of controller components between independent groups.
 - b) Stream concept shall be maintained. The different equipment shall be clubbed in such a manner that failure of a controller set affects only one stream of the process path, eg. in air and flue gas path, ID-fan A, FD-fan A, and secondary rotary air pre heater –A can be clubbed on one set of controllers.
 - c) Inter-related controls shall be provided in one group, i.e. when the loop /sequence of one equipment depends on the availability of another sequence /loop or equipment than these controls shall be preferably be clubbed together eg. PA fan controls depend on the availability of mills/mill control, so, control of half the number of mills can be clubbed with control of the relevant PA fan.
 - d) Failure mode analysis, i.e while formulating the controller group, it shall be ensured that the failure of one function does not jeopardize the plant operation or cause shut down. For example if 6 mills are required for full load plant operation, then the grouping of mills shall be done in such a manner that not more than 3 mills shall be clubbed in one set of controller.

For each of the functional groups, separate sets of controllers, I/O modules, communication controllers, power packs/ modules etc. shall be provided. Mixing of hardware of two or more functional groups (FG) shall not be acceptable. It shall be ensured that failure of any set(s) of hardware of any FG does not affect other FG(s) and data communication between other FG(s) and MMIPIS.



- v) The minimum functions to be realised in each of the above mentioned control systems shall be as per requirements specified under subsequent clauses of this specifications. The bidder shall provide all hardware/software, whether or not specifically indicated in this specification to fully meet operational, maintenance, safety requirements as well as conform to international standards and proven practices.
- vi) The control system shall function reliably under the environmental conditions as specified under cl. no.6.1.6 of this specification. It shall be immune from the interferences resulting from disturbances in power supply feeders, signal lines, inputs, outputs, etc. as experienced in a coal fired power station.
- vii) The control system shall have on-line simulation and testing facility. Further, it shall be possible to on-line configure and tune controllers through configuration and tuning station for control system.
- viii) The system shall have the flexibility to easily reconfigure any controller at any time without requiring additional hardware or system wiring changes and without disabling other devices from their normal operation mode. Modifications shall not require switching off power to any part of the system.
- ix) The executive programs for the controller modules shall be firmware based, which shall be non-volatile and shall not be alterable except by replacement of parts. The application programs for the functional controllers shall be software based which shall be maintained through power supply failure. The application program shall be alterable through the configuration and tuning station for all configuration and strategy changes, etc., and through the operator's console for set point/bias changes, device selection, etc. Parts replacement or parts removal shall not be required in order to accomplish changes in application programs including system tuning.

In case it is bidder's standard practice to have the application programs also firmware based (i.e. EPROM/ EEPROM), then the same is also acceptable. However, in that case, Bidder shall provide necessary programming device including EPROM writer/eraser etc. (2 Nos. per unit).

- x) All the 100% hot/redundant backup controllers shall be identical in hardware and software implementation to their corresponding main controllers and shall be able to perform all its tasks. The backup controller shall track its corresponding main controller. There shall be an automatic and bumpless switchover from the main controller to its corresponding backup controller in case of main controller failure and vice versa without resulting in any change in control status. In case of switchover from main controller to the 100% hot backup controller, the back-up controller shall work as the main controller.

Facility shall also be provided for manual switchover from main to 100% hot back-up controller and vice versa from the programmer's console.

The control system hardware design shall be such that it is able to withstand power line disturbances as per relevant standard.



6.2.4.2 **Burner Management System (BMS)**

- i) Fully proven microprocessor based system, based on hardware and software proven for burner management application shall be provided to achieve the boiler protection e.g. master fuel trip (MFT), control of mills & fuel oil systems etc.
- ii) The BMS shall be provided with automatic self monitoring facility. All modules to be used in this system shall be of fail safe design. Any single fault in any primary sensor, I/O modules, multifunction controllers, etc. should not result in loss of safety function. All faults should be annunciated to the operator, right at the time of its occurrence and also for alarm annunciation facia.

The BMS shall meet all applicable relevant safety requirements including those stipulated in latest editions of VDE 0116, Section 8.7, VDE 0160, NFPA 8502/ 8503 etc.

The suggested configuration of the MFT sub- group of BMS shall be submitted. The exact implementation shall be subject to Purchaser's approval during detailed engineering.

- iii) The MFT functions shall be implemented in a fault tolerant 2 out of 3 triple redundant configuration. Each of the three independent channels shall have its own dedicated processors, multi-function controllers, communication controllers, I/O modules, interface etc. All safety related process inputs shall be fed to each of the 3 channels. All the primary sensors for unit/boiler protection shall be triple redundant.
- iv) The acquisition and conditioning of binary and analog protection criteria signals for MFT shall be carried out in each of the three triple redundant channels. Each channel shall compute the 2 out of 3 voting logic and issue a trip command. The trip signals of the three channels shall be fed to a fail safe 2 out of 3 relay tripping unit for each drive. The protection criteria for tripping shall be executed by a program which shall be identical in each of the triple redundant channel. The check back contact signals of each relay of the 2 out of 3 relay tripping unit shall be fed back to each of the triple redundant channels and shall be continuously monitored for equivalence in each of them
- v) The BMS shall be designed to :
 - a) Prevent any fuel firing unless a satisfactory purge sequence has first been completed.
 - b) Prevent start-up of individual fuel firing equipment unless permissive interlocks have first been satisfied.
 - c) Monitor and control proper equipment sequencing during its start-up and shutdown.



- d) Provide equipment status feed back and annunciator indication to the unit operator.
- e) Provide flame monitoring when fuel-firing equipment is in service and effect a burner trip or master fuel trip upon warranted firing conditions.
- f) Continually monitor boiler conditions and actuate a master fuel trip (MFT) during adverse operating conditions which could be hazardous to equipment and personnel.
- g) Reliably operate and minimize the number of false trips.
- h) Provide a master fuel trip relay independent of processors and I/O modules to provide a completely independent trip path.
- i) Provide all logic and safety interlocks in accordance with National Fire Protection Association (NFPA).
- j) Include a first out feature in all controllers to identify the cause of any burner trip or boiler trip.
- k) Provide a complete BMS diagnostic system to immediately identify to the operator any system module failure.
- l) Allow burners and igniters to be started, stopped and tripped on a burner basis.
- m) Allow the automatic start and stop of burners based on boiler load. The sequence of which burner will be started or stopped will be selected by the operator from a TFT display.

6.2.4.3 **Turbine Protection System (TPS) Functions**

- i) Fully proven microprocessor based system, based on hardware and software proven for turbine protection application for the same turbine being offered for this project, shall be provided to achieve the turbine protection action.
- ii) The Turbine Protection System shall meet all applicable safety standards/requirements including those stipulated in VDE 0116 Section 8.7. The system design shall be such that safety function of the total system must not be jeopardized on occurrence of fault. Any single fault in either primary sensor, input/output modules, controller module etc. shall in no way jeopardise the safety of the turbine. All modules to be used in this system shall be of fail safe design.
- iii) The Turbine Protection System shall also be implemented in 2 out of 3 voting logic. Three independent trip channels each having its own and dedicated processing modules, controllers, input/output modules etc. shall be provided



to achieve 2 out of 3 voting logic. The outputs of the three channels will be used to implement 2 out of 3 voting logic in two relay units, the output of which will be fed to the two turbine trip relays.

As an alternative, bidder may also propose two independent trip channels, each having its dedicated processing module with hot backup. Two out of three voting logic will be implemented in each of the channels and the output of each channel to be fed to each of the two turbine trip relays.

Turbine shall be tripped when either of the above two trip relays operates. The exact implementation shall be subject to purchaser's approval during detailed engineering.

- iv) All the input signals (trip signals etc. from the field devices) shall be fed in parallel to all the two/three redundant channels of protection system as mentioned above via signal conditioning cards designed for such application. Further, the computation of field input voting logics i.e. 2 out of 3 etc. shall also be performed in the controllers of all the three/two channels of protection system which will then perform the computation of 2 out of 3 voting logic independently.
- v) Bidder shall provide all the required primary sensors etc. required for protection system as per his standard and proven practices. All trip signal inputs required for the safety of the turbine shall be based on 2 out of 3 logics. The system shall include turbine lock-out relays, redundant turbine trip solenoids and necessary hardware required for testing.
- vi) The tripping devices shall be designed to operate on DC supply. The trip coils shall be monitored continuously for healthiness and failure shall be alarmed.

6.2.4.4 **Binary Controls/Open Loop Control System (OLCS) Function**

This clause is applicable for the binary controls of SG-C&I and TG-C&I [6.2.4.1 (i) & (ii)] and BOP - C&I [6.2.4.1(iii)].

- i) The OLCS shall include sequence control, interlock & protection for various plant auxiliaries, valves, dampers, drives etc. The sequence control shall provide safe and automatic startup and shutdown of plant and of plant items associated with a plant group. The interlock and protection system shall ensure safe operation of plant/plant items at all times and shall automatically shut down plant/plant items when unsafe conditions arise.
- ii) The OLCS shall be arranged in the hierarchical control structure consisting of unit level, group level, subgroup level & drive level (as applicable).

It shall be possible to perform automatic unit startup & shutdown by issuing minimum number of command from the OWS. Thus, the unit level shall control all the control system blocks and issue appropriate startup and shutdown commands to various blocks of control system.



The group level shall control a set of functional sub-groups of drives. Appropriate start-up and shut down commands shall be issued to the sub-group control and various checkbacks shall be received from sub-groups or drives. Each sub-group shall execute the sequential start-up and shut down programmes of a set of inter-related drives along with system interlocks and protections associated with that sub-group as well as basic interlocks and protections related to individual drive falling under that sub-group. The drive level shall accept commands from the sub-groups, push buttons (wherever provided), etc., and transmit them to the respective drive, after taking into account various interlocks and protections and the safety of that particular drive.

- iii) A sequence shall be used to move a set of groups and sub-groups from an initial steady state (for instance 'OFF') to a final steady state (for instance 'ON'). The sequence initiating command for the unit and group level shall be issued from TFT/KBD.
- iv) A sequence shall be made of steps. The steps shall be executed in predetermined order according to logic criteria and monitoring time consisting of the interlock & protection requirements and checkback of previous step which shall act as pre-conditions before the sequence control can execute the command for that step.
- v) Each step shall have a "waiting time" implying that the subsequent step would not be executed unless the specified time elapses. A monitoring time shall also be defined as the maximum time required in executing the commands of any step and the time required for appearance of check back signals. In case, this is not completed within the specified time, a message shall be displayed and programme will not proceed further.
- vi) Manual intervention shall be possible at any stage of operation and the sequence control shall be able to continue at the correct point in the programme on return to automatic control. Protection commands shall have priority over manual commands, and manual commands shall prevail over auto commands.
- vii) Open or close priority shall be selectable for each drive.
- viii) The sequence startup mode shall be of the following types.
 - a) **Automatic Mode**

In this mode of operation, the sequence shall progress without involving any action from the operator. The sequence start/stop command shall be issued from the TFT/KBDs.
 - b) **Semi-Automatic Mode**

In this mode of operation, once the sequence is initiated, the step progressing shall be displayed on the TFT. But the step execution command shall be prevented and shall be sent by the operator via the keyboards. It shall be possible to bypass and/ or simulate one or more



criteria to enable the program to proceed. This facility shall allow the program to be executed even if some criteria are not fulfilled because of defective switching device, etc., while the plant condition is satisfactory. All the criteria bypassed shall be logged and displayed. It shall be possible to put the system on the auto-mode after operating it on semi-automatic mode for some steps or vice-versa, without disturbance to the sequence operation.

c) **Operator Test Mode**

It shall be possible to use the sequential control in operator guide mode/ test mode i.e. the complete system runs and receives input from the plant and the individual push button stations (where provided)/ keyboards but its command output is blocked. The whole programme, in this case shall run in manual mode. This mode shall allow the operator to practise manual operation using step and criteria indications. The actual protection should remain valid during this mode of operation also.

- ix) The sequence shall be started by putting the sequence on 'auto' and on receipt of 'start' command from the OWS or from a higher level group/ protection action as defined. The sequence shall then progress as per the defined logics. It should be possible to select alternative operation in the same sequence depending on certain process/ equipment condition. Some step can be automatically bypassed also based on certain process/ equipment condition. When the expected results of the sequence are reached the sequence is considered as "End".

If during sequence initiation or sequence progressing or during normal running of the drive, a shutdown criteria is present, the sequence shall be stopped and the shut down sequence initiated.

- x) For the drives, the command shall be provided through redundant output module and inputs (status, switchgear & process) shall be acquired through input modules. The drive logic shall be implemented in the redundant controller.

The status for the 11 KV, 3.3 KV drives and some other important drives (total approximately 40 nos. per unit) shall also be wired in parallel to redundant input modules so that on failure of the single input modules, the information regarding the status of the affected drive remains available in OLCS.

- xi) The output modules control module shall have the feature that ensures that in case of failure, all the outputs are driven to zero. The 24V DC command outputs to drives for on/open, off/close shall be separate and independent and inverted outputs shall not be employed. For inching type of drives, position transmitter power supply and monitoring of position transmitter signal shall be provided.



- xii) The termination for open/ close command for the drive actuator shall be performed in the actuators with integral starter specified elsewhere in the specification. However, open/ close and disturbance status as a minimum shall be monitored in OLCS.

The sequence interlock & protection requirements shall be finalised during detailed engineering and the same shall be subject to Purchaser's approval.

- xiii) The OLCS shall also include the control of electrical systems in addition to the auxiliaries of boiler & turbine such as open/close or on/off etc. of various electrical systems such as generator, generator auxiliary systems, breakers of 11kV, 3.3 kV, 415 V switchgears, synchronisation of unit etc. as described in Section -5. All the features and specification requirements as specified above shall also be applicable for electrical system.

6.2.4.5 Analog Controls/Closed Loop Control System (CLCS) Functions

This Clause is applicable for analog controls of SG - C&I [6.2.4.1(i)], BOP-C&I [2.4.1(iii)] and TG - C&I [6.2.4.2(ii)].

The CLCS shall continuously act on valves, dampers or other mechanical devices such as hydraulic couplings etc., which alter the plant operation conditions. The system shall be designed to give stable control action in steady state condition and for load changes in step/ramp over the load range of 60% to 100% MCR with variation or parameters within permissible limits to be finalised during detailed engineering state. The system shall have the following minimum features:

- i) The controller capability shall, as a minimum, include (i) P, PI, PD and PID control functions and their variations (ii) cascade control (iii) feed forward control (iv) state-variable based predictive control for SH/RH temperature control (v) on-off control, (vi) ratio and bias control, (vii) logical operation etc.

The loop reaction time (from change of output of the sensor of the transmitter/temperature element to the corresponding control command output) shall be within 500 milli seconds. However, for faster loops such as feed water, furnace draft, PA header pressure control loop etc. the same shall be based on actual process requirement but shall not be more than 250 milli second.

- ii) The control system shall be bumplessly transferred to manual on the following conditions as a minimum and as finalised during detailed engineering.

Control power supply failure, failure of redundant controllers, field input signal not available, analog input exceeding preset value, etc.



- iii) Any switch over from auto to manual, manual to auto and switchover from TFT operation to auto manual station operation and vice versa shall be bumpless and without resulting in any change in the plant regulations and the same shall be reported to the operator.
- iv) Buffered analog output (positioning signal) of 4-20mA DC shall be provided from CLCS to the respective E/P converters. For electrical actuators, pulse type output (bound less control) shall be preferred. CLCS shall also provide all the necessary outputs for indicators & recorders with output loop resistance of 500 ohms for each channel of the output module.
- v) The functional requirement of the CLCS loops as well as the detailed schemes shall be finalised during detailed engineering stage and shall be subject to Purchaser's approval.
- vi) The system being supplied shall be such that when permissible limits are exceeded, an automatic switchover from an operation governed by maximum efficiency, to an operation governed by safety and availability is affected.
- vii) For safety reasons, switchover logics associated with the modulating control loops, shall be performed within the closed loop control equipment.
- viii) Time supervision facility shall be provided to monitor the final control element.
- ix) It shall be possible to block the controller output on a pre-programmed basis.
- x) All controllers shall be freely configurable with respect to requisite control algorithms.
- xi) Whenever, alternate measurement is available for a control input the alternate measurement value will be automatically substituted in the control loop in case of loss of control input. All necessary software for switching and reconfiguration shall be provided. In addition, such substitution shall be balanceless and bumpless and shall be reported to the operator.

6.2.4.6 **Turbine Control System (TCS) Functions**

The Turbine control system shall consist of turbine governing system, turbine stress control system and BFP turbine Electro-hydraulic governing system HP&LP bypass system & automatic turbine testing (ATT) system. In addition to the specific requirements indicated in subsequent clauses, the requirements of CLCS as elaborated in clause 6.2.4.5 shall also be applicable for TCS.

- (i) **Turbine Governing System**
 - a) Following two alternatives for the turbine governing system shall be acceptable and bidder shall offer one of these alternatives based on his proven & standard practices.



Alternative - I

In this alternative, the turbine generator unit shall be equipped with electro-hydraulic governing (EHG) system backed-up by mechanical-hydraulic control system. The system shall be designed such that the governing of the steam turbine shall be automatically and safely transferred to mechanical hydraulic control system during operation, in the event of a fault developing in electro-hydraulic control system.

Alternative - II

In this alternative, the EHG system shall be provided with 100% hot redundancy i.e. the system shall consist of two independent channels right from sensors, transmitters, other field mounted devices, input modules, controller modules, output devices etc. of the electro hydraulic converter. Further, each of these channels shall be fed from independent power supplies.

- b) Both the above mentioned alternatives shall meet the following functional requirements.

The controls covered in this system shall basically consist of speed controller, load controller, valve-lift controller, inlet steam pressure controller and output frequency droop characteristic controller. The speed controller shall ensure controlled acceleration of the turbine generator and shall prevent overspeed without tripping of the unit under any operating condition or in the event of full load throw-off.

The speed controller shall limit the overspeed of the turbine on loss of full load to a value less than 8% of rated speed. The governing system shall be equipped with speed/load changer to control the speed or power output of the steam turbine within the limits. The speed/load changer provided shall be capable of adjusting the speed of the turbo set to any value in the range of 94% to 106% of rated speed for manual/auto synchronisation of the generator with the bus. It shall be capable of varying the load on the machine from no load to full load.

For remote control, suitable motor drive shall be provided. Indication of the speed/load changer position shall be provided on the OWS and console panel insert.

The governing system shall be equipped with a load limiting device capable of being operated both locally as well as remotely from unit control room for the purpose of limiting the amount of opening of the governor controlled valves to set the load at a pre-determined limit, while the turbine is in operation. A remote position indicator shall be provided on the console panel insert for indication of the setting of the load limit. Contacts shall also be provided on the load limiter for signaling load limited operation in unit control room.



(ii) **Turbine Stress Control System (TSCS)**

Bidder shall provide a proven turbine stress control system which will work in conjunction with turbine governing system and ATRS. The system shall be complete including measuring transducers for generator load, processing modules, microprocessor based controllers for stress calculations and turbine life calculations etc., dedicated colour TFT monitor, recorders, etc. TSCS shall meet the following functional requirements

- (a) Continuous on-line monitoring of thermal stress levels in all critical parts of the turbine such as main stop valves, control valves, HP casing, HP shaft and IP shaft etc.
- (b) Continuous on line computation of stress margins available for the above mentioned critical components of the turbine during various regimes of operation i.e. run-up, synchronisation, loading, load maneuvering, normal operation, run backs, unloading, shut-down etc.
- (c) Computation of the limits of speed and load changes allowable at any particular instant before synchronisation and after synchronisation respectively. The system shall be designed to inhibit further operation like speed/steam temperature raising or lowering wherever upper/lower temperature margins are not available (during periods prior to synchronisation) and load/steam temperature raising or lowering whenever upper/lower load/temperature margins are not available (after synchronization) within allowable limits.
- (d) Carry out a fatigue analysis for all affected components of the turbine and also to compute the percentage service life consumption of the turbine.
- (e) Display the stress margins etc. on a separate dedicated colour VDU/Printer as well as on OWS for operator guidance and storage of necessary data such as percentage service life consumption etc.
- (f) Store long term data & carry out residual life analysis.

(iii) **BFP Turbine Electro hydraulic Governing System**

- a) The drive turbine speed shall be controlled by electro - hydraulic governor, stable and satisfactory speed control over full speed range from 0% to 100%. The electro-hydraulic governing system hardware shall be microprocessor based, with hot back up.
- b) When the governing system is in auto mode, it will receive speed demand signal from FW control loop and in manual mode shall be fed either from TFT of OWS or through auto/manual stations. The actual speed of the turbine should be measured by three independent speed sensors and three independent speed measurement channels. These three signals shall be fed to the selection circuit which will choose the median value. The speed controller output shall be fed to the valve lift controller. The output of the valve lift



controller shall be fed to the electro-hydraulic converter which will vary the position of the control valve. The electro-hydraulic controller shall be designed such that the transfer between different steam sources should be bumpless.

The electro-hydraulic control system to be provided by the bidder shall be of proven design, whose configuration and hardware implementation should have been employed in at least six(6) turbine driven pumps of equivalent capacity which are in operation for not less than two(2) years.

- c) A 220 V split-series field, reversible, totally enclosed DC motor along with an electronic controller, shall be provided for remote speed changing operation.

(iv) **HP&LP Bypass System**

a) **LP bypass control system**

The LP Bypass control system shall consist of steam pressure control loop and steam temperature control loop. The LP bypass control shall be implemented through a set of redundant controller modules, I/O modules etc. The LP bypass control shall suitably interface with other TG control like HP bypass, EHG etc. Further, condenser exhaust hood spray valve shall be interlocked to open whenever LP bypass comes into operation.

b) **HP bypass control system**

The system shall consist of steam pressure control loop & steam temperature control loop. HP bypass system shall be implemented through a set of redundant controller modules, I/O modules etc. The system shall be supplied with redundant primary sensor and suitable interface with other TG - C&I controls like LP bypass, EHG etc.

(v) **Automatic On Line Turbine Testing (ATT) System**

The bidder shall provide ATT system for on load testing of turbine protective equipment automatically in a sequential manner without disturbing normal operation and keeping all protective functions operative during the test. The ATT facility shall include but not be limited to the following.

- a) Opening and closing of emergency stop and control valves, reheat stop and interceptor valve.
- b) Over-speed trip
- c) Low vacuum trip
- d) Electrical remote trip.

ATT mentioned at item b), c) & d) above shall be possible to be carried out on 100% load.



6.2.4.7 **Other SG - C&I Functions**

The SG control functions shall also consist of secondary air damper control, soot blower control, auxiliary PRDS etc. in addition to the burner Management system and shall meet the requirements of measurements system, binary and analog control system as described above

6.2.4.8 **Other TG -C&I Functions**

The TG control functions shall also, consist of turbine generator control system like seal oil, primary water, hydrogen system etc. and TDBFP interlock & protection and shall meet the requirements of measurements system, binary and analog control system as described above.

6.2.5 **Man-Machine Interface System and Plant Information System (MMIPIS) Requirements**

- 6.2.5.1 i) Man-Machine Interface system shall be designed and engineered for safe, efficient, reliable and convenient operation. MMIPIS shall employ high-performance, non-proprietary architecture to ensure fast access and response time and compatibility with other system. MMIPIS shall be used primarily for the following functions :
- (a) As operator interface for control operation of the plant or accepting data from and issuing commands to SG -C&I, TG-C&I and BOP- C&I systems etc.
 - (b) To perform plant supervisory, monitoring and information functions
- ii) The plant data pertaining to one unit shall be available in the MMIPIS of the respective unit. Data from common system shall be available in the MMIPIS of both units.

6.2.5.2 **Operator Interface to the Control System**

- i) The operator interface of the MMIPIS shall consist of colour TFTs/ KBDs of OWS, colour ink-jet printers, colour plotter etc. Each OWS shall include one TFT, one keyboard and touch screen or mouse for ease of operation. The TFT operation shall employ powerful menu-driven and window supported input facilities for operational ease and comfort.

The following functions shall be provided as a minimum:

- a) Each keyboard set shall comprise of ASCII/ Numeric keyboard, function keyboard, control keyboard, cursor control keyboard etc.
- b) All OWS of the MMIPIS shall be fully interchangeable i.e. all operator functions including (for quick access to displays & other operator functions)



control, monitoring and operation of any plant area on drive shall be possible from any of the OWS at any point of time without the necessity of any action like downloading of additional files. Each OWS shall be able to access all control information related data under all operating conditions including a single processor/computer failure in the MMIPIS. Further, simultaneous operation of at least two drives of control system shall be possible from a single display without calling additional displays for multiple drive operation.

- c) No single failure in MMIPIS shall lead to non availability of more than one OWS and two printers. In such an event i.e., single failure leading to non availability of any OWS, it shall be possible to operate the entire plant under all regimes of operation including emergency conditions from each of the other available OWS.
 - d) Operator functions, displays, structure of the keyboard assembly and key assignment shall be finalised during detailed engineering. Further, all frequently called important functions including major control loop display shall be assigned to dedicated function keys for the convenience of the operator.
- ii) The operator functions for control on each OWS shall as a minimum include control system operation, alarm acknowledge, call control displays, demand/printout of various displays, logs, summaries etc.

The display selection process shall be optimised so that the desired display can be selected with the barest minimum number of key strokes / steps by the operator.

The control related displays on the TFT shall as a minimum include mimic displays, overview displays, area displays, individual loop/drive display, closed loop control displays, open loop control displays etc.

6.2.5.3 **Plant Supervisory, Monitoring and Information Functions of MMIPIS**

The MMIPIS shall be designed as an on-line system which shall process, display and store information to provide the operator, either automatically or on demand, the relevant information as indicated in subsequent clauses. The following minimum functions shall be performed by MMIPIS:

- i) **Calculations**
 - a) Basic calculations

All the algebraic/logical calculations related to analog points (e.g., sum/difference/average/integration, etc.), digital point (e.g., AND/OR/COMPARE. etc.), transformations, flow calculations, time projection or rate of change calculations, frequency etc. shall be provided. All the calculated values of the plant shall be available in the database.



b) Performance calculations:

The performance calculations shall use high level language calculations shall be made using floating point arithmetic. These equations shall be changeable on-line at the job site. An extensive set of steam property subroutines based on 1967 ASME steam tables shall be included in the system. The results of these calculations shall be available through data base for appropriate logs and operator displays. The calculation shall be carried out at 30% unit load or higher. The calculation frequency shall be selectable at site from 10 minutes to 1 hour, with a step of 10 minutes.

The performance calculations shall be broadly subdivided into two classes:

Class I : Equipment protection calculations

Class II : Plant/equipment efficiency calculation.

The Class I calculations are generally for the purpose of detecting and alarming unit malfunctions. These shall include cold reheat steam approach to saturation temp, superheater spray outlet approach to saturation temp., turbine steam-metal temp. differences, turbine metal temp. rates of change, feedwater heater terminal temp. difference, feedwater heater drain cooler approach, excess air deviation from standard, feed water heater temp. deviation from standard, drum water saturation temp. rate of change, metal temp. difference for SH 'Y' and RH 'Y' piece etc.

The Class-II performance calculations shall be performed to determine the performance of individual items of equipment and the overall unit. The periodicity of these calculation shall be selectable from 10 minutes to 60 minutes in increments of 10 minutes. These shall include calculations for boiler efficiency, gross turbine generator heat rate, gross unit heat rate, net unit heat rate, operating hours, plant load/availability factors, HP,IP,LP turbine enthalpy drop efficiency, performance of condenser, deaerator, economizer, airheater performance, unit availability calculations, merit order rating, deviation from expected values for each calculation shall also be computed.

c) Other Calculations

Variable alarm limit calculations, heat rate deviations and revenue calculations, frequency excursion time integration etc. shall also be provided.

ii) **Alarm monitoring and reporting**

The system shall display history of alarms in chronological order of occurrence on any of the OWS. The MMIPIS shall have the capability to store a minimum of 1000 alarms each with paging features allowing the operator to view any page. The OWS keyboard shall have all alarm functions and related function keys like alarm acknowledge, reset, paging, summaries etc. Other design features like prioritisation, set point/dead band adjustments, alarm report format etc., shall be as finalised during detailed engineering.



iii) **Displays**

Various displays on the TFTs shall as a minimum include P&ID displays or mimic, bar chart displays, X-Y & X-T plot (trend) displays, operator guidance message displays, group displays, plant start-up/shutdown message displays, generator capability curves, heat rate deviation displays, system status displays etc. Number of displays and the exact functionality shall be on as required basis and as finalised during detailed engineering.

Other types of displays as applicable for convenience of operation shall be provided by Bidder. However, the minimum quantity of major types of displays shall be as follows:

| | | |
|----|---|-----|
| a) | Control displays (group/ sub-group/ sequence/loop) | 500 |
| b) | P&ID/ mimic display | 100 |
| c) | Bar chart | 100 |
| d) | X-Y/ X-T Plot | 100 |
| e) | Operator guidance message | 100 |
| f) | Plant starting/ shutdown guidance message | 100 |
| g) | Other misc. displays | 25 |
| h) | System status & other diagnostic displays on as required basis. | |

The system shall have adequate storage capacity for storing the last 72 hours of data at scan rate for a minimum 500 points (operator selectable) for use in trend displays.

iv) **Logs/Summaries**

The system shall generate three basic types of reports/logs i.e., event activated, time activated and operator demand log & summaries. The log format and point assignment for each logs/ report and other design features shall be as finalised during detailed engineering. The system shall have the facility for viewing of time activated and operator demand logs/summaries on the TFT(s).

- (a) Event activated logs shall as a minimum include alarm log, trip analysis log, start-up - shutdown logs (Boiler start-up log, turbine run-up log, turbine shutdown analysis log/ turbine recall log) & control related logs.

The trip analysis log shall record a minimum of 30 pre-trip and 30 post-trip readings for the pre-defined parameters but not less than 250 points, sub-divided in to 25 groups. The data collection rate shall be variable, i.e. faster near the trip point and gradually slower with time. The exact details shall as finalised during detailed engineering.

The system shall be capable of generating and printing SG & TG start-up and shutdown logs.



- (b) Time activated logs shall as a minimum include shift log and daily logs. Each of these shall provide hourly record of a minimum 225 points sub divided into 15 groups.
- (c) Operator demand logs shall include, as a minimum, trend log, maintenance data log, summary log, performance logs and some special logs as decided during detailed engineering stage.

The system shall be capable of generating and printing trend log for a minimum of 80 groups of 15 points each.

Maintenance data log shall provide schedule of preventive maintenance and routine equipments inspection.

- (d) Various summaries shall include off scan summary, constants summary, point quality summary, substituted values summary, peripheral status summary etc.
- (e) The assignment of logs to any of the printers shall be possible from MMIPIS TFTs/ keyboards and programmer station.

v) **Log Generation Utility**

The bidder shall offer a log generation utility to generate a log/report having following facilities as a minimum.

- (a) Define format of the log like header information, time, date etc.
- (b) Selection of any point (scanned and calculated) from the data base and assign it to a log group.
- (c) Selection of log data collection process initiating event, collection intervals (1, 2, 3, 5, 10, 30, & 60 minutes) for each point of a particular log group.

Facility shall also be provided for selection of 100 points at a collection intervals of 1, 2, 3, 5, 10, 20, 30 seconds.

- (d) Assignment of log printout initiation on event or time including, selection of the printing interval for particular log group and time of printing. (For time initiated logs)
- (e) Assignment of no. of samples to be collected for each point.
- (f) Select points for which minimum, maximum accumulation over a selected period, average, etc., values can be printed. Also facility shall be provided to tag the time at which the parameter passed through maximum/minimum.

It shall be possible to define 100 log groups of 15 points each. Any log group can have any point from the database. One log shall include at the maximum 10 such groups.



(vi) **Historical Storage and Retrieval system (HSRS)**

The HSRS shall collect, store and process system data form MMIPIS data base. The data shall be saved online on hard disk and automatically transferred to erasable dual Magneto-optical disk (removable type) once in every 24 hours periodically for long term storage. Provision shall be made to notify the operator when optical disk is certain percentage full. The disk capacity shall be sufficient to store at least seven days data.

The data to be stored in the above system shall include alarm and event list, periodic plant data, selected logs/reports such as event activated logs, sequence event log, trip analysis log, start-up log etc. The data/information to be stored and frequency of storage and retrieval shall be as finalised during detailed engineering.

The system shall provide operator function to retrieve the data from historical storage. The operator shall be able to retrieve the selected data on either colour TFT or printer and suitable index files/directories shall be provided to facilitate the same.

In addition to the HSRS, the system shall also have facility to store and retrieve important plant data for a very long duration (plant life) on Magneto-optical disk.

A PC alongwith a laser printer shall be provided for this purpose. This PC shall be connected with the system bus, on which all the data can be accessed.

vii) **Quality Tag**

- a) The system shall identify and tag the quality of all data (scanned and calculated points) in a way that makes all users (control, calculations, logs, displays, etc.) aware of its quality. Quality of data other than 'good' shall be clearly identified in all printouts and displays by appending quality character to the value/status of point. The quality tagging shall include good, bad, substitute, doubtful, suspect, etc.
- b) DDCMIS shall provide fault alarm analysis guiding the operator to the most likely cause of fault. The alarm system shall be designed in such a manner that main auxiliaries tripping can be traced to the originating cause.
- c) Trend alarms shall be provided in DDCMIS for slowly varying process parameters, so that appropriate corrective actions are taken in time. These alarms shall be suitably provided in OWS, which will be decided during detailed engineering stage.
- d) An integrated unit startup system shall be implemented in DDCMIS incorporating all operational curves for SG, TG and auxiliaries. This shall guide the operator to take appropriate actions at appropriate time to bring the rated parameters safely within the specified time.



6.2.5.4 MMIPIS Hardware

- i) The MMIPIS as specified shall be based on latest state of the art workstations and servers and technology suitable for industrial application and power plant environment. Two possible alternatives for MMIPIS can be offered by the bidder. For alternative-I, the no. of redundant servers shall be as required to achieve the processing capability to meet all the functional requirements of this specification. For alternative-II, the workstations other than OWS shall be configured in such a way that loss of one workstation does not result in loss of any function.

The actual size of the main and bulk memory shall be sufficient to meet the functional and parametric requirements as specified with 25% additional working memory and 50% additional bulk memory over and above the memory capacity required for system implementation. The exact system configuration and sizing shall be as approved by Purchaser.

- ii) The workstation/servers employed for MMIPIS implementation shall be based on industry standard hardware and software which will ensure easy connectivity with other systems and portability of purchaser developed and third party software. These will be 32 bit/ 64 bit machines. Each workstation/server shall be provided with an UPS each for 60 min. back-up with output messaging facility for loss of input power.
- iii) Redundant sets of communication controllers shall be provided to handle all the communication between the MMIPIS and redundant system bus and to ensure specified system response time and parametric requirements. Each communication controller shall have message checking facility.
- iv) Power fail auto restart (PFAR) facility with automatic time update shall be provided.
- v) All the peripherals shall be as approved by purchaser during detailed engineering. The LAN to be provided under MMIPIS shall support TCP/IP protocol (ethernet connectivity) and shall have data communication speed of minimum 100 MBPS. All network components of LAN and servers/workstations shall be compatible to the LAN, without degrading its performance. It shall be ensured that failure of network component (s), shall in no way affect individual unit's operation monitoring & control in any way.
- vi) Servers/ workstations shall be as per latest configuration available and subject to approval of the purchaser during detailed engineering.

6.2.6 Program Development/ Modification, System Maintenance and Documentation Facility

6.2.6.1 Bidder shall provide programming facilities/systems as a minimum for control system and MMIPIS.

- i) The programming tools shall have inbuilt safety features which will protect the system against inadvertent and unauthorised use of these tools. Necessary hard key locks and software locks, etc. shall be provided for this.



- ii) The system shall also have facility to permit the programmer to add test information at the beginning and end of each program, wherein programmer will list out his name, time, date, the change which has been made, name of the person who has authorized the change, etc.

6.2.6.2 **Control system structuring/configuration/tuning facilities**

- i) Structuring, configuring and tuning facilities shall be provided for structuring, modification, storing, loading, testing, tuning, monitoring, etc. of all the microprocessor based controllers of the control system. The configuration and tuning unit shall be hooked up with the system bus. In case different hardware is employed for different parts of control systems and it is not possible to provide structuring/ configuration and tuning of these from the same station, bidder shall provide necessary number of stations for the purpose.
- ii) It shall be possible to configure the system with ease without any special knowledge of programming or high level languages. Control strategy shall be implemented using familiar and conventional automation function blocks (software implemented). Whenever any change in configuration is done, it shall be recorded and modified configurations shall be available for printing and documentation and shall be stored in non-volatile memory. All the system configuration, tuning/fixed parameters shall be documented and printed in form of function diagrams and lists respectively.

On-line tuning of the control loops shall be possible without causing any disturbance in the execution of the control loops. Provision to store and retrieve on immediate and long term basis the system configuration, data base etc. on some device such as floppy disk shall be included. Facility shall be provided to reload/down-load the system or controller module from the already stored data, on-line.

6.2.6.3 **MMIPIS program development/modification and system maintenance facilities**

Standalone online system shall be provided for programme development/modification to achieve various functions including development, modification and testing of software of MMIPIS, generation and modification of graphics, logs, HSRS functions in an interactive manner, MMIPIS database modification/creations, downloading the software with associated data base from the console and other features necessary for system maintenance. All operator functions shall also be available on MMIPIS programmer station. Also facility shall be provided to print system fault as detected by the online self diagnostic routine.

6.2.6.4 **System Documentation Facility**

- i) The system shall have the facility to generate the associated documentation for both the control system & MMIPIS. The bidder shall furnish detailed information about system documentation facilities in his offered system along with the bid. The document, to be generated by the system shall include



P&ID drawings, control loop drawings, sequence drawings, signal distribution list/drawings, system interconnection drawings, cabinets general arrangement drawings, measurement list, drive schedule, alarm schedule, system hardware and functional configuration drawings for displays, logs, trends, graphics etc. The system shall also include all required software and hardware tools for creating, modifying and printing CAD drawings to achieve paperless documentation for DDCMIS.

- ii) To realise all of the functions mentioned above, the bidder shall provide standalone stations for configuration & tuning functions of control system and MMIPIS programming, hardware of which shall be separate from the hardware of the respective system and connected to system bus. The bidder shall provide 2 nos. of programmer stations for control system and 1 no. programmer station for MMIPIS. Each of the programmer station shall also have a colour inkjet printer. The hardware for system documentation facility may be a part of either configuration and tuning unit for control system or MMIPIS programmer station if all the functions specified above can be achieved in these programmer stations. Otherwise a separate workstation and a colour inkjet printer shall be provided for documentation facility with necessary software. The hardware of workstation shall be same as that of OWS.

6.2.7 Data Communication System (DCS)

6.2.7.1 The DCS shall include a redundant main system bus and local system buses for major subsystems with hot back-up and other applicable bus systems like cubicle bus, local bus, I/O bus etc except back plane which can be non-redundant. The DCS shall have the following minimum features :

- i) Redundant communication controllers shall be provided to handle the communication between each functional group of controllers of control system and the system bus. The design shall be such as to minimise interruption of signals. It shall ensure that a single failure anywhere in the media shall cause no more than a single message to be disrupted and that message shall automatically be retransmitted. Any failure or physical removal of any station/module connected to the system bus shall not result in loss of any communication function to and from any other station/module.
- ii) If the system bus requires a master bus controller philosophy, it shall employ redundant master bus controller with automatic switchover facility.
- iii) Built-in diagnostics shall be provided for easy fault detection. Communication error detection and correction facility shall be provided at all levels of communication. Failure of one bus and changeover to the standby system bus shall be automatic and completely bumpless and the same shall be suitably alarmed and logged.
- iv) The design and installation of the system bus shall take care of the environmental conditions and hazardous area classification as applicable to similar services.



- v) Data transmitting speed shall be sufficient to meet the responses of the system in terms of displays, control etc. plus 50% spare capacity shall be available for future expansion.
- vi) Passive coaxial cables or fibre optic cables shall be employed for system bus.
- vii) The redundant buses shall be physically separate and shall be routed separately.
- viii) The Bidder shall furnish details regarding the communication system like communication protocol, bus utilisation calculations etc.
- ix) In case of any distance or other limitation in the DCS, bidder will provide suitable repeaters, MODEMS, amplifiers, special type of cables like optical fibres as required to make the DCS fully operational.

6.2.7.2 **Station LAN**

The servers/ethernet LAN of the each unit shall be connected to a station wide ethernet Wide Area Network (LAN). Connections for PCs at various plant locations and PLC/PC based systems provided both by bidder as well as by purchaser, shall be connected to this station wide ethernet LAN through TCP/IP protocol. The station head/O&M head & shift in-charge stations shall be located in this LAN to monitor data of all units as well as of the common plant location and off-site plants.

A server shall be provided for this station wide LAN. All networking functions of LAN, calculation including merit order calculation shall be performed in this server.

6.2.8 **Sequence of Events Recording/ Annunciation Functions**

6.2.8.1 **SOE Function**

- i) The system shall monitor SOE inputs with a resolution of one millisecond at all times for all SOE inputs including spare inputs. That is, all SOE points entering status change shall be reported and time tagged within 1 (one) millisecond of their occurrence. Input card shall be equipped with digital filters with filter delay of minimum 4ms (identical for all points) to eliminate contact bounce such that field contact which is changing state must remain in the new state for successive 4 ms to be reported as one event. The start of data collection for SOE report shall be reported to OWS within 1 sec of SOE data collection initiation. The system shall also have provision of rejection of chattering inputs.
- ii) The system shall also include provision for historical storage and retrieval of SOE reports for 3 months period.
- iii) The SOE report collection shall begin on occurrence of change of status of any SOE point and shall be printed after an operator selectable time interval of 1 to 3 min. or 100 status changes have taken place after the first event.



Adequate memory to accommodate 6 (six) SOE reports i.e., two buffers of 100 status changes each shall be provided. Seventh SOE report shall overlap the first SOE report memory and so on.

- iv) The SOE reports shall also include a list of major equipment trip in chronological order and include the points which initiated SOE collection.

6.2.8.2 Annunciation system Function

- i) The annunciation system shall be implemented as an inbuilt function of the DDCMIS. The field contacts shall be acquired through DDCMIS only. The annunciation sequence logic shall be implemented as a part of the DDCMIS controllers. The annunciation window lamps mounted on unit control panel shall be driven through contact output modules of the control system of DDCMIS. In case, the annunciation sequence logic is not performed within the controllers for MFT (BMS), TPS etc., then these signals can be transmitted through some other controller through bus and processed therein.

However, the annunciation system shall have the facility of driving independent lamp box in the event of failure of MMIPIS or system bus in case the annunciation system is affected due to the same.

6.2.9 Master & Slave Clock System

- i) The bidder shall provide a date insensitive master and slave clock system with adequate number of output signals to provide uniform timing throughout the various plant facilities supplied by bidder as well as those not in bidder's scope. The system shall be complete with receiving antennae (for receiving time from satellite & radio signal), receiver and associated electronics, redundant master clocks, slave clocks, interconnecting cables, cubicles, power supplies & any other accessories. However, a provision shall be kept for synchronisation of the master clock with other source as decided during detailed engineering.
- ii) The master clock shall drive the slave display units. It shall be ensured that loss of any slave display unit does not affect the display of any other slave unit. The MMIPIS, shall be synchronised with the master clock once in every hour. The switchyard event recorder and other plant PLCs shall be synchronised with the master clock once every minute.
- iii) The master clock shall be located in the control room and shall have facility for automatic synchronising with external radio/satellite signals.
- iv) The Bidder shall provide a minimum 25 number of slave clocks which shall be located at the various plant facilities as finalised during detailed engineering stage.

6.2.10 Power Supply & Grounding

- i) Bidder shall provide totally reliable & quality power supply for total DDCMIS.



- ii) All panels, desks, cabinets shall be provided with a continuous bare copper ground bus. The ground bus shall be bolted/ welded to the panel structure and shall efficiently ground the entire structure. All individual cabinet grounds shall be connected to separate earthing riser to be provided for C&I system signal grounding. The grounding requirements of various parts of the C&I system shall be properly co-ordinated by the Bidder with design of plant earthing system. The exact grounding scheme shall be as finalized during detailed engineering.

6.2.11 System Software Requirements

- i) The bidder shall provide all software required by the system for meeting the intent and functional/ parametric requirements of the specification.
- ii) The system shall have user oriented programming language & graphic user interface.
- iii) All system related software including real time operating system, file management software, screen editor, database management software, on line diagnostics/debug software, peripheral drivers software and high level language compilers shall be furnished.
- iv) All application software for control system functioning like input scanning, acquisition, conditioning processing & control alongwith communication among various control system functional blocks, MMIPIS and system bus, MMIPIS software for operator interface of monitors, displays, trends, curves, bar charts etc., performance calculations (with steam properties routines utilities) historical storage and retrieval utility, sequence of events recording system functions shall be provided.
- v) The bidder shall provide software locks and passwords to purchaser/ project manager at site for all operating & application software in order to prevent unauthorised access so that only purchaser's authorised representatives is able to do modifications at site.

6.2.12 System Documentation

The bidder shall furnish detailed system and equipment documentation. It shall include detailed system and components description covering the installation, operation, care and maintenance of all system components. All final system documentation for DDCMIS hardware and related software shall be furnished. The same shall be complete, accurate and fully representative of the supplied system and its elements. All documentation/catalogues etc., shall be furnished in English language. In addition to the hard copies, CD ROM based documentation system shall also be provided. The same should be compatible to the on-line document generation facility indicated elsewhere in the specification.



6.2.12.1 Hardware documentation

- i) Detailed technical literature, reference manuals, user's guide/manuals for the complete hardware like control system hardware, MMIPIS hardware, I/O hardware, bulk memory units, peripherals and their controllers, communication hardware including controllers, man-machine interfaces programmers unit, power supply modules etc., shall be furnished by the bidder.
- ii) Operation and Maintenance manual

6.2.12.2 Software documentation and software listings

- i) All technical manuals, reference manuals, user's guide etc., in English required for modification/ editing/ addition/ deletion of features in the software of the DDCMIS shall be furnished. The bidder shall furnish a comprehensive list of all system/application software documentation after system finalisation for Purchaser's review and approval.
- ii) The software listings shall be submitted by the bidder for source code of application software and all special-to-project data files

6.2.13 Training

- i) Further to the relevant clauses regarding training specified elsewhere, Bidder's experienced personnel engineers shall also provide training courses on offered DDCMIS to purchaser's engineers in the following areas:
 - 1. Operator training
 - 2. Hardware maintenance training
 - 3. Software training
 - 4. Any other specialised training as required for system operation and maintenance
- ii) The maintenance training shall include lectures and hands on experience on a similar type of equipment/system at manufacturer's works and recently commissioned operating plant and/or training simulator. The purchaser shall require training of hardware and software engineers. The details of hardware and software training shall be finalised during detailed engineering and shall be subject to purchaser's approval.

6.2.14 Warranty

- i) The bidder shall provide an unlimited warranty on all equipment and software for one year after the start of the warranty period, i.e. after satisfactory completion of initial operations. This warranty shall include repair, replacement or correction of identified software or hardware discrepancies at no cost.



- ii) No repairs/replacement shall normally be carried out by the purchaser when the plant is under the supervision of bidder's supervisory engineers. If in the event of any emergency, in the judgment of the purchaser, delay would cause serious loss or damage, repairs may be made by the purchaser or a third party chosen by the purchaser without advance notice to the bidder and the cost of such work shall be paid by the bidder.
- iii) In case of any hardware failure which hampers normal operation, the bidder during the warranty period must provide on-site technical expertise to repair/rectify the problem within a week and if any component is not available at site, the bidder must arrange to supply these components at site within another 48 hours. If a software problem is identified, this problem shall be corrected within one week.
- iv) After six months of DDCMIS operation, the bidder shall provide the list of parts and expandables utilized for the period. The same information will be provided at the conclusion of the warranty.
- v) The bidder shall depute and/or station additional specialist to rectify the problem to ensure 99.7% availability of system. The availability of system shall be calculated as specified elsewhere.

6.2.15 Performance Requirement of the DDCMIS

- i) The DDCMIS shall permit the performance of the following dynamic load tests while maintaining safe furnace conditions, major process parameters and without endangering other equipment. All tests will be performed with the system in automatic mode :
 - a) Drop 50 percent of maximum load capability from approximately full load at a rate of 10 percent per minute.
 - b) Drop load from full rated output to the lowest runback limit, at a rate corresponding to the fastest run back rate
 - c) Pick up 50 percent of the maximum load capability from approximately 50 percent load at a rate of 10 percent per minute.

During transient conditions causing deviation of process variables, the control system furnished under the specification shall not permit deviations which exceed those permitted by the manufacturers of the controlled process equipment, for load changes as indicated above. The exact parameters to be monitored for this test are given in the following table The control loops shall perform to return the controlled variable to the set point in a stable manner without cycling in the shortest possible time and without any loop interactions or cycling of generation when generation matches unit load demand.



Performance Requirements for Closed Loop Control System (Table 6.2.1)

| Sl. No. | Load/Rate of load change (% of MCR per min.) | Maximum Deviation of Parameters from Set Point | | | | | |
|---------|--|---|---|------------------------------------|---|---|---------------|
| | | Throttle pressure deviation (Kg/cm ²) | Flue gas oxygen deviation (% O ₂) | Furnace pressure deviation (mmwcl) | S.H. steam temperature deviation (Deg. C) | R.H. steam temperature deviation (Deg. C) | Drum level mm |
| A. | Steady state condition | | | | | | |
| | 1. 90% to 100% | ± 2.0 | ± 0.4 | ± 8.0 | ± 5.0 | ± 5.0 | ± 15.0 |
| | 2. 60% | ± 2.0 | ± 0.4 | ± 8.0 | ± 5.0 | ± 5.0 | ± 15.0 |
| B. | Ramp test (change for max. duration of five minutes) | | | | | | |
| | 1. ± 3% | ± 3.0 | ± 0.6/- 0.4 | ± 12.0 | ± 8.0 | ± 8.0 | ± 25.0 |
| | 2. ± 5% | ± 3.0 | ± 0.8/- 0.4 | ± 12.0 | ± 10.0 | ± 10.0 | ± 30.0 |
| | 3. ± 10% | ± 4.0 | ± 1.0/- 0.5 | ± 15.0 | ± 15.0 | ± 15.0 | ± 50.0 |
| C. | Step load changes | | | | | | |
| | 1. From 100% to 80% at the rate of 10% per minute | ± 5.0 | ± 1.5/- 0.5 | ± 20.0 | ± 15.0 | ± 15.0 | ± 50.0 |

Notes:

- a. Sufficient time shall be allowed as setting period between conducting the tests.
 - b. Plant operating condition, i.e. main equipment status, availability of auxiliaries, operational and equipment constraints, which can influence the test, shall also be recorded.
 - c. Control system shall be running in the coordinated master control (CMC) mode i.e boiler master, fuel flow, air flow, feed water and turbine load control shall be in automatic mode. Load set point, maximum and minimum load set point, rate of raise / lower of load shall be set through the TFT, keyboard/conventional console.
- ii) The bidder shall also guarantee that the control system provided by him will be responsive and stable and will maintain the deviation of controlled variables from set point within the limits specified so that the equipment



being controlled will operate as specified over the range required. The controls shall operate automatically, with no assistance from the operator. The controller shall successfully demonstrate the performance of Closed Loop Control Systems before acceptance and taking over of this system by the owner.

- iii) The following parametric tests shall also be conducted under worst case loading conditions
- a) For control system
CPU loading, cycle time/controller reaction time and memory spare capacity
 - b) For MMIPIS
CPU loading, spare duty cycle, spare memory capacity
 - c) Spare duty cycle for system bus
 - d) Various display response time
 - e) System accuracy
 - f) TFT update time
- iv) For the parametric test, the following requirements shall be met
- a) Processor spare duty cycle (free time)
Under worst case loading of MMIPIS and system bus each MMIPIS processor shall have 40% free time when measured over any two second period and 50% free time when measured over any one minute period.

Under worst case loading conditions of control system control system processor shall have 20% free time when measured over any one minute period.
 - b) System bus spare duty cycle (free time).
The Bidder shall furnish all necessary data to fully satisfy the owner that the processor spare duty cycle figures quoted by the Bidder are realistic and based on configuration and computation capability of the offered system and these shall be actually achieved in the fully implemented system as commissioned at project site.

The system bus shall have min. 50% free time during the worst case loading conditions of control system, MMIPIS and the system bus, measured over any 2 seconds interval.



c) Display response time

The system shall acknowledge all operator requests in one of the following manners within one second of pressing of the last button:

Commencement of the requested display

OR

Acknowledgment of operator request in a suitable manner.

The display response time as defined above, under the worst case loading conditions shall not be worse than the following:

| | |
|--|-----------|
| All control related displays | 1 sec |
| Point details display (single point) | 1-2 secs |
| Bar chart display (20 points, current data) | 1-2 secs. |
| Operator guide / plant start-up guide message display (full screen of alphanumeric information and a maximum of ten numbers of dynamic data items) | 1-2 secs. |
| Plant mimic display of fair complexity with a minimum of 120 numbers of dynamic data items e.g., values, macros, line segment, etc. | 2-3 secs. |
| Group review display (current values of twenty points) | 2-3 secs. |
| X-Y plot display (2 X-Y- plots and a single display requiring both historical as well as current data) | 3-4 secs. |
| X-T plot display (trend of 6 analog points and a single display requiring both historical as well as current data) | 3-4 secs. |
| Plant summary display (e.g., bad point summary, limit check removed point summary. Assume the whole data base search is required and the summary display contains ten points only). | 3-4 secs. |



The response time for screen update after the execution of the control command from the time the command is issued (for example command to start a motor to the time the screen is updated) shall be two seconds (excluding the drive actuation time).

d) System accuracy requirements

The overall system accuracy from signal input terminals to output presentation on TFT display and printers for the least accurate input range and maximum scan rate shall be not worse than +/- 0.2% of full scale of the process range.

e) TFT updated rates

All TFT displays shall be updated at least every two seconds.

6.2.16 Large Video Screen (LVS)

Large video screens, complete with projectors, screens, control units (graphical generators) & associated accessories shall be supplied as per the following specifications.

- | | | |
|----|---------------------------|---|
| 1. | Size (diagonal) | 80 inch |
| 2. | Type | LCD projection type with rear - screen configuration (other type proven technology e. g. that based on digital light processing shall also be acceptable subject to purchaser approval). |
| 3. | Resolution of each screen | 1280 x 1024 pixels |
| 4. | Configuration of LVS | Double tier with screens seamlessly combined with provision of expansion of one screen on each side. |
| 5. | Control unit | Same as operator work station without the TFT LCD monitor. Facility of projecting a particular display on a selectable area of the screen upon activation of a predefined event shall be provided. |
| 6. | Video signal interface | Interfacing with video signals, to receive & project pictures from CCTV, purchaser's Live camera, VCP Signal types : PAL, NTSC or SECAM in S-VHS/VHS |



No. of channels : 16

Remote unit for switching between video signal & HMI signal, selecting the video signal channel (live camera no./location typically) shall be provided.

- | | | |
|----|--|---|
| 7. | Illumination level | To be finalised during detailed engineering. |
| 8. | Degree of viewing in horizontal & vertical | To be finalised during detailed engineering. |
| 9. | Other features | |
| | a) | LVS shall be designed for continuous viewing (24 hours in a day) under normal room ambient lighting without any need to darken the room. Suitable darkening of the projection screen for light absorption shall be provided for this purpose. |
| | b) | Adjustment of the projections shall be performed. Suitable mounts on installation and all other components shall be adjusted in the factory and shall not require further adjustment at site. Maintenance work on the LVS shall be confined to easy replacement of the lamps and cleaning of the fans, which shall be performed in few minutes by the purchaser's staff without any special training. Suitable means (operating hours displays etc.) shall be provided to indicate the need of replacement of lamp. Power switch shall be provided for isolation during replacement of the lamps. |
| | c) | The LVS and its accessories shall be designed in such a way that the brightness in the centre of the screen and the edges of the screen is uniform and there is no perceivable difference in the quality of the picture on the centre and on the edges of the screen. If any extra hardware has to be provided for achieving the above feature, same shall be provided by the contractor at no extra cost. |
| | d) | The screen should be flicker free and there shall not be any screen burn in due to display of same information for a long time. |
| | e) | Auto brightness adjustment between each screen. |



10. The hardware/software of the control unit shall be such that the command execution time of any control command from the LVS shall be same or better than the execution time from the OWS. If during any stage of the contract, the command response times as stated in specifications are not achieved, the contractor shall upgrade the hardware/software of the control unit in order to achieve the same at no extra cost to the purchaser.
11. In the event of failure of LVS interfacing with SG & TG package, any of the other LVS shall be capable of being used in place of the failed LVS .The contractor shall provide a suitable network/switching facility for this purpose.

The exact arrangement of LVS shall be decided during detailed engineering.

Suitable facility shall be provided to the operator for transferring the screens, without any need of changing of hardware/wiring or software.

12. Master control unit shall be capable of projecting displays over a part of screen to multiple screens. Any communication of windows shall be possible. Facility for overlays shall be provided.



6.3 OTHER SG&TG RELATED CONTROL & INSTRUMENTATION SYSTEM/ EQUIPMENTS

6.3.1 Flame Monitoring System

- i) The purpose of the system is to detect the individual flame and to enhance the boiler/furnace safety, to avoid spurious and unwarranted trips and to increase operational reliability, availability and efficiency of the Steam Generator such that the consumption of fuel oil shall be reduced to optimal minimum.
- ii) Flame monitoring system shall be fail safe and easily maintainable which shall include flame detectors of proven design for the type of fuel, environmental condition and other conditions, of established reliability at all loads of the steam generator. It shall be designed to work under all adverse conditions such as wide variation in fuel/air input ratio, wide variation in fuel characteristics, variation in operating temperature, maximum temperature under interruption of cooling air supply. The system shall conform to NFPA recommendation and location of detectors as per NEC requirements.
- iii) Flame detectors shall be working on the dynamic and static properties of primary combustion zone of each type of fuel and flicker frequency of flame. It shall pick up only the flame to which it is assigned and shall not respond to the adjacent and background flame or other radiations generated in the furnace. The design shall also take into account the absorption by a coal shroud, recirculated dust or other deposition on the flame detector head. The complete system shall provide the discrimination between oil and coal flame. Intensity indicators for main flame shall be provided alongwith galvanically isolated 4-20 mA DC signals and hooked to DDCMIS.
- iv) The system should be easily maintainable and include automatic self test facility at regular interval.
- v) The bidder shall also provide a portable flame detector testing kit with built in stabiliser, capable of simulating both oil and coal flame, and testing of flame detector head unit at field. The testing kit shall also have facility for testing all type of electronic cards as being used in the flame monitoring system.
- vi) In case of tangentially fired boiler, the bidder shall arrange flame detectors in such a manner that coal flame detectors are available both above and below each coal burner and separate oil flame detectors are provided for each oil burner. In case bidder has discriminating type flame detectors capable of detecting and discriminating both oil and coal flame, with the help of a single scanner, the same can also be utilised for monitoring both oil and coal flame. For any other type of firing i.e. non-tangential type the flame detectors shall be provided for each coal and oil burner responding only to the flame of its associated burner.
- vii) Bidder shall furnish the details of the flame detector locations and justification for the same.



- viii) The Bidder shall demonstrate the complete performance of flame detectors in cold start up test and load condition test. In cold start up test, capability of detectors to detect oil flame under varying oil pressure shall be checked. In load test, the detector shall be able to detect when only oil is present, only coal is present and both coal and oil are present. It shall be ensured that the detectors are able to detect the proven flame at very low load with oil guns withdrawn. The above tests shall be performed for every coal and oil elevation.
- ix) Provision of scanner air for cooling the flame detectors by 100% redundant scanner air fans, one AC and other DC operated, shall be provided. The dampers associated with scanner air fans shall be pneumatically operated with DC solenoid valves.

6.3.2 Coal Feeders Control and Instrumentation

- i) Bidder shall provide a microprocessor based coal feeder C&I system. It is preferable to use the same family of hardware as that of DDCMIS for implementation.
- ii) Bidder shall provide a minimum of two independent speed sensors, pulser units and associated amplifiers, etc. for each of the coal feeders. Output from the speed sensors will be used to provide at least four number isolated 4-20 mA DC analog signals corresponding to coal flow rate in tons per hour and any other signals that may be required for the control of the coal feeder. In addition, one pulser unit shall also be provided with two pulse outputs-one for use in control system and the other for remote integrator.
- iii) Each coal feeder shall receive signals from DDCMIS for feeder speed control. The signal to be provided by DDCMIS shall be in the form of galvanically isolated 4-20 mA DC. All required power amplifier units/interface devices to accept this 4-20 mA signal shall be included.
- iv) All associated electronics like buffer amplifiers, frequency to current converters etc. shall be provided for each raw coal (RC) feeder with local and remote speed indicators and integrators. The speed sensors and pulser units shall be totally enclosed, fire, dust and weather proof, suitable for the service conditions.
- v) The control cabinet shall be provided with reset push buttons and individual lights to signal the individual internal trip conditions.
- vi) Each feeder shall be provided with a four position switch located at the feeder for remote off, local run (when there is no coal on conveyor) and calibration purpose.
- vii) If there is any electronic modules mounted local to the feeder body then these shall be suitable for operating in a non-air-conditioned area in a suitable enclosure to combat the effect of noise, vibration, entry of dust etc.



- viii) All necessary paddle switches and other detectors to monitor coal on belt, feeder discharge plugged etc. should be provided to ensure safe operation of the feeders.

6.3.3 Electromatic Safety Valves

The electromatic safety valve shall be an automatic, electrically actuated pressure relief valve. It shall be possible to set the value for one percent or less differential between opening and closing pressure. The electromatic safety valve shall be provided complete with all accessories like pressure measuring devices, controller units, local PB station, solenoid assembly, impulse piping etc. Provision shall also be kept to operate the electromatic relief valves from the DDCMIS TFT/KBD and miniature PB stations on the UCP, if applicable. The operation of the valve shall be accomplished by operator command or by means of pressure sensitive element which shall precisely and automatically relieve the pressures within very close limits.

6.3.4 Furnace Temperature Probes

Bidder shall provide two numbers of furnace temperature probes before platen superheater and/or before reheater regions and shall be electrically operated, fully retractable type. The furnace temperature probes shall be furnished with complete actuating mechanism and all the logics required for the actuating mechanism. The probe shall be provided with position transmitters, limit switch and indicator for remote indication. Each temperature probe shall have a duplex thermocouple suitable for the measurement range. Bidder shall furnish complete details of the temperature probe along with all the technical catalogues including the details of the actuating mechanism, position transmitters and limit switch which shall be subject to purchaser's approval. The logics for furnace temperature probes shall be implemented in the DDCMIS.

6.3.5 Acoustic Pyrometers

Acoustic pyrometers are to be provided to determine the average flue gas temperatures and complete flue gas temperature profile at furnace exit plane (for FEGT measurements) and at economiser outlet.

For each temperature measurement plan/section, a PC based system complete with all required software, comprising of minimum eight nos. of acoustic transreceivers, signal processor, interface unit, PC & colour Inkjet printer (common for one unit) shall be provided. The system shall be able to eliminate the varying high noise environment both in and out of an operating boiler

The transit time of each of the associated transmitters/receivers shall be transmitted to the central processing unit (to be located at CER) for storage and analysis through suitable interface device. A temperature profile shall then be determined and displayed by analysing the mean temperature across every transit section using deconvolution technique. The time interval to take a complete cycle of eight transceivers should be less than one minute.



The measuring range should be sufficient to cover the entire regime of boiler operation and shall not be less than 1900°C. The mean temperature and profile temperature accuracy shall be $\pm 2\%$, & $\pm 4\%$ of reading respectively or better. Full colour VDU display and colour printer output shall be provided. The system shall also provide 4-20mA DC output for SG -C&I and BOP-C&I part of DDCMIS.

The transducers shall not be placed directly in the hot gas stream. The system shall be of proven design and its performance must be proven using similar type of fuel. The components to be located at boiler area shall be able to withstand the stringent environmental condition expected at such locations with operating boiler.

6.3.6 Mill and Air Heater Fire Detection System

Adequate number of thermocouples type fire detection system for each mill and air heater shall be provided as a composite and complete units with all required signals and accessories with adequate redundancy.

The controls & protection required for the mill fire detection system shall be implemented in the SG-C&I and air heater fire detection system shall be implemented in the BOP -C&I, Part of DDCMIS using rate-of-rise algorithm taking care of manufacturer's recommendation.

6.3.7 Furnace and Flame Viewing System

- i) Bidder shall include in his proposal a furnace and flame viewing system. The flame cameras shall be suitable for direct online continuous viewing in the central control room of the coal and oil flame and condition of the furnace internals including slagging of the water walls and any other deterioration in the furnace condition. The nos. of such flame cameras to be included in the proposal shall be selected by the bidder appropriate to his boiler design subject to minimum of four (4) numbers.

The flame camera system will consist of the following facilities/ components as a minimum: -

- a) 19" High resolution color monitor.
- b) Facility for zooming and adjustment of iris from the monitor
- c) Proper cooling arrangement (preferably air) and protection against cooling medium failure.
- d) Weatherproof local control box for mounting of electronics.
- e) All necessary remote/ local programming tool.
- f) All interconnecting cable and termination device.
- g) Any other accessory to make the system completely operational.



- ii) The cameras and the total system shall be suitable for the furnace design as being offered by the main boiler vendor, the firing arrangement, the fuel being fired considering the ash content of worst coal. The cameras should be expected to withstand the temperature expected in the furnace of the offered boiler but shall not be less than 1600 deg C.
- iii) The viewing angle of the camera shall be commensurate with the furnace size, the camera location and the positioning of the burners. The system shall conform to PAL and number of TV lines shall be adequate for a clear image of the furnace.
- iv) The offered flame camera system shall have a record of trouble free performance of minimum one (1) year in a coal-fired boiler of size 500 MW or above where the firing arrangement is similar to the offered boiler.
- v) The system shall be capable of transmitting the image to the DDCMIS system where it should be possible to display the same on the monitors of operator workstation.

6.3.8 Electronic Remote Drum Level Monitoring System

Bidder shall provide electronic remote drum level monitoring system working on principle of difference in electrical conductivity between steam and water. The monitoring system shall meet the requirements as indicated below:

- i) Each end of the drum shall have independent pressure vessels with adequate no. of electrodes covering the entire range for indication for each end of drum. Further, independent and separate pressure vessels shall also be provided for each end of drum/vessels along with electrodes to provide validation for low low trip setting.
- ii) The sensing electrodes shall be placed in equal pitch. The maximum distance (gap) between two electrode shall be 50 mm and the electrodes shall be arranged in such a way that the last and the first electrode shall not be at any alarm or trip level. In any case, the number of electrodes shall not be less than 16 for indication and 8 for validation.
- iii) Both indication and validation systems shall be supplied with double isolation valves in water, steam, drain and vent lines with mechanical key interlock system, that is, the total number of key interlocks shall be 4 (four) nos. per boiler. The provision of key interlock system shall ensure a fool proof safety feature and the details of the same shall be brought out clearly in the offer.
- iv) The detector unit (if not located locally), logic units, 2x100% redundant power supply units/packs (to be located in control equipment room) shall be housed in separate and independent cubicles for pressure vessel on each side of the drum. The detector units, logic units etc. shall be independent for each pressure vessel.



- v) Indication shall be provided at field for both indication and validation system. Remote indication is to be provided for indication system at the unit control panel and firing floor.
- vi) Each cubicle shall be provided with 2x100% redundant power supply pack converters to be fed from two feeders of 24V DC or 240V AC UPS system. These two power supplies shall be internally fused and failure of one power supply shall not affect the performance of the system. Self monitoring facility to detect and alarm the loss of power supply shall be provided.
- vii) The pressure vessel shall be constructed in such a way that density level error between drum and pressure vessel shall not be more than 25 mm upto the design temperature and pressure of boiler drum. All vents, drains and isolation valves shall meet 1.5 times the max. design conditions.
- viii) Electrode assembly shall have blow out and leakage proof sealing arrangement. Field proven ceramic/zirconia probe with insulation suitable for design pressure and temperature are to be provided.
- ix) The system design shall be such that it shall ensure that failure of one probe circuit shall not affect another probe circuit and failure of any electrode will not hamper the system function and operation. Further, the entire system shall be of proven fail-safe design.
- x) The logic shall be such that the trip and alarm relay circuits shall be independent for each for low, low-low, high and high-high levels of drum. Monitoring of set time for trip generation and provision of setting time delay shall be available in the system. Trip logic shall be independent and separate from fault finding logic.
- xi) The system shall have fault diagnostic features such as process fault, system hardware fault, probe failure, circuit board failure, shorted wire etc. Further, the system shall be able to distinguish between a cable fault and an electrode fault.
- xii) The necessary relays and relay modules for the output contacts shall be of proven design and each contact shall be rated for 5A, 240V AC/0.25A 220V DC rating. All these contacts shall be SPDT type.
- xiii) The system shall be proven and approved by IBR, Factory mutual, USA or equivalent etc.

6.3.9 Turbine Supervisory System (TSS)

- i) The turbine supervisory equipment shall be complete including sensors, transmitters, converters, limit value monitors, measuring and amplifier modules, power supplies etc. with the required accessories including twisted and shielded instrumentation cables, compensating cables, junction boxes etc.
- ii) Following measurements shall be provided as minimum.



- (a) Shaft eccentricity detection.
 - (b) Absolute as well as relative shaft vibration measurement, of each bearing in both X & Y direction.
 - (c) Differential expansion of rotor and cylinder for HPT, IPT and LPT.
 - (d) Overall expansion of HPT and IPT.
 - (e) Absolute bearing vibration measurement of each bearing in both X & Y directions.
 - (f) Stator winding vibration measurement in radial and tangential directions.
 - (g) Axial shift of the rotor, (three sensors).
 - (h) Turbine speed, (3 sensors).
 - (i) Emergency stop and control valve position.
 - (j) Main steam and hot reheat steam inlet temperature and pressure.
 - (k) Bearing metal and drain oil temperature.
 - (l) Turbine metal temperature.
 - (m) In case of vibration, shaft mounted reference detectors and required supervisory instrument circuitry shall also be provided.
 - (n) Any other measurement recommended by the turbine manufacturer or required for the safe and reliable operation.
- iii) The system shall be provided with suitable hardware for necessary signal processing. The system should be capable of signal distribution and interfacing with other control systems. The system should suitably interface with MMIPIS system supplied by bidder.

For all vibration measurements indicated under (ii) above, a Microprocessor/computer based system shall also be provided to achieve the following functions

- a) On-line spectrum/harmonic analysis
- b) Identification of the exact nature of failure resulting in increase in bearing vibration and direct message on the TFT indicating the exact nature of fault e.g. misalignment, shaft crack, bearing looseness etc through use of intelligent software packages.
- c) Storage and comparative analysis of vibrations.
- d) Generation/ analysis of bode plot/ orbit plot and time waveform/ nyquist plot/ shaft centre line plot/ cascade and water fall plot.
- e) All the vibration parameters as well as turbine supervisory parameters shall also be fed to the turbine control system (TCS) through hardwiring or through suitable link so that all these parameters are suitably displayed on the TG



control TFTs. All required I/O cards and other processing modules etc. shall be provided for this purpose.

- f) Test calibration jigs for site calibration of all sensors of TSS shall be provided. Telephone jacks shall be incorporated in all the TSS cubicles for communication during site calibration etc.

6.3.10 BFP Turbine Supervisory Instruments

- i) In addition to the instruments specified previously, the following instruments shall be provided for supervisory purpose. The supervisory equipment shall include detection, indication and recording of the following as a minimum.
 - (a) Shaft eccentricity
 - (b) Axial shift, (with three pickups)
 - (c) Differential expansion.
 - (d) Overall expansion.
 - (e) Speed (triple pickups)
 - (f) Turbine casing and bearing metal temperature for all bearings.
 - (g) Stop valve metal temperature
 - (h) Bearing pedestal vibration (both in horizontal and vertical direction)
- ii) Duplex K-type thermocouples/duplex 100 ohm platinum RTD's shall be provided for the metal temperature and on the thrust bearing faces. All the elements of the thermocouples shall be terminated by appropriate extension cable to cold junction compensation boxes.
- iii) Separate and independent hardware/electronics shall be employed for each of the TDBFPs.

6.3.11 Plant Performance Analysis, Diagnosis & Optimization (PADO) Software

The contractor shall provide PC based on- line plant performance analysis, diagnosis & optimization (PADO) system for the station. The PADO system shall incorporate the complete thermal design model of each unit. The model of each unit shall work together from the same PC for the complete plant. The system shall use the measured data from the C&I system through appropriate interface to be provided by the bidder. Instruments, which are specifically required for implementation of PADO, shall also be in the scope of contractor.

The PADO system shall provide the following functions in a modular and seamlessly integrated environment, using a common plant model and a dynamically shared database:



- i) **Performance analysis and monitoring of systems and components**
- a) Calculate thermal performance status of the plant and efficiency of generation using measured data.
 - b) Calculate all the key system performance indicators at system level such as heat rate, plant and equipment efficiency, generator output and controllable losses.
 - c) Analyze the impact of individual component performance on overall losses or gains in total megawatt generation.
 - d) Perform detailed analysis of each component including calculation of key performance indicators such as efficiency, heat transfer coefficient, TTD, DCA, and fouling factor.
 - e) What if analysis at system and component level.
- ii) **Emission analysis and monitoring**
- a) Monitor, track and analyze plant emissions such as SO₂, NO_x, CO and CO₂ in real time.
 - b) Monitor and analyze ESP and stack conditions such as temperature, humidity, gas flow rate and opacity.
 - c) Facilitate obtaining lowest emission while maintaining combustion efficiency.
 - d) Facility to set alarms to highlight conditions that violate predefined limits.
- iii) **System and performance diagnosis**
- a) Evaluate system and component performance degradation to detect worn plant equipment
 - b) Expert system diagnostics using neural and Bayesian belief networks and historical data for quick identification of problem pinpointing down to the component.
 - c) Identify degradation of measuring instruments.
- iv) **System and performance optimization**
- a) Recommend to operator controllable parameter settings to optimize given process or activity at the measured operating condition, using state of the art optimization techniques.
 - b) Optimize control system design to determine the optimum values of parameters for individual control loops.
- v) **Other functions**
- In addition to the above functions, the PADO system shall possess the following analytical features:
- a) Verify the accuracy and provide the correct estimated value of the faulty or missing measurements.



- b) Data created by one function shall be used to perform analysis using another set of functions without any processing or conditioning of the data.
- c) Simultaneous use of functions by one user on a single workstation or multiple users across multiple workstations.
- d) Create alternative configuration of a unit, to study the impact of component replacements or changing the routing of fluid flows.
- e) The PADO system should be fully compatible with the functions of BPOS

vi) Boiler performance optimization system

The contractor shall provide a PC based on-line boiler performance optimization system (BPOS) for each steam generator. The BPOS shall incorporate the complete thermal design model of the boiler capable of both forward and backward calculation of complete boiler thermal performance. The model shall be calibrated and made "Site Specific" based on series of field trials of thermal performance of the boiler during startup and prior to trial operation. The input for the BPOS shall be based on accurate and continuous on line grid measurement of the following:

- a. Flue gas temperature at economizer outlet using acoustic pyrometer.
- b. Flue gas oxygen.
- c. Other fluid temperature(s) entering and exiting various heat transfer banks.
- d. Coal characteristics

The BPOS shall be capable for continuous on-line calculation of the thermal performance of the boiler for the operating conditions indicating performance prediction zonal absorption, metal temperature and shall have necessarily the following features:

- Fuel switching capability.
- "WHAT IF" capability.
- Selective soot blowing of furnace/super heater based on trends of zonal absorption.
- Expert system diagnostics for quick identification of the 'Root Cause' of deviations from the predicted parameters.

The computer modeling and arriving at factors to make it "Site Specific" shall be to the approval of the owner.



The BPOS shall be furnished complete with the appropriate computer hardware to the approval of the owner.

vii) Other requirements

The PADO System, as described above, shall also include the following:-

- a) Boiler performance optimization packages including the optimized operation of soot blowing System.
- b) Boiler stress condition analyzer.
- c) Interactive water and gas chemistry management system.
- d) Regenerative cycle performance optimization system.

viii) Hardware requirements

- a) The hardware shall include a computer server and at least 5 workstations along with the complete networking in a LAN network.
- b) The implementation of all the associated hardware, networking and related work shall be the responsibility of the bidder in order to successfully operate the software.
- c) Values calculated by PADO software shall be available as calculated data base points in unit MMI database of distributed control system (DCS) (In purchaser's Scope) through appropriate interface to be provided by the bidder for display and recording.
- d) The supplier free of cost shall support the tools under warranty for a period of 5 years from the date of trial operation.



6.4 MEASURING INSTRUMENTS (PRIMARY AND SECONDARY)

- i) Measuring instruments/equipment and subsystems offered by the bidder shall be from reputed experienced manufacturers of specified type and range of equipment, whose guaranteed and trouble free operation has been proven. Further, all instruments shall be of proven reliability, accuracy, repeatability requiring a minimum of maintenance. They shall comply with the acceptable international standards and shall be subject to purchaser's approval. All instrumentation equipment and accessories under this specification shall be furnished as per technical specifications, ranges, make/ numbers as approved by the purchaser during detailed engineering.
- ii) Every panel mounted instrument requiring power supply shall be provided with a pair of easily replaceable glass cartridge fuses of suitable rating. Every instrument shall be provided with a grounding terminal and shall be suitably connected to the panel grounding bus.
- iii) All local gauges as well as transmitters, sensors, and switches for parameters like pressure, temperature, level, flow etc. as required for the safe and efficient operation and maintenance as well as for operator and management information (including all computation) of equipment under the scope of specification shall be provided.
- iv) The necessary root valves, impulse piping, drain cocks, gauge-zeroing cocks, valve manifolds and all the other accessories required for mounting/erection of these local instruments shall be furnished, even if not specifically asked for, on as required basis. The contacts of equipment mounted instruments, sensors, switches etc. for external connection including spare contacts shall be wired out in flexible/rigid conduits, independently to suitably located common junction boxes. The proposal shall include the necessary cables, flexible conduits, junction boxes and accessories for the above purpose. Double root valves shall be provided for all pressure tapings where the pressure exceeds 40 kg/sq cm.
- v) For protection purposes, transmitters can be considered in place of switches.

6.4.1 Configuration, Maintenance, Diagnostics & Record-Keeping facility for Electronic Transmitters and Analysers.

- i) The bidder shall provide a dedicated and standalone PC based system with suitable interface to DDCMIS system for each of the generating units for centralised configuration, maintenance, diagnostics & record-keeping for all electronic transmitters.

The analog input modules in the Control System will use 4-20 mA analog signals and segregate the superimposed digital signal to be used in the PC based system referred above. The PC based system shall access these information either through the system bus or through any dedicated network as per Bidder's standard practice.



- ii) The bidder shall provide following facilities as a minimum through software:
- (a) Constant scanning to monitor faults of changes to instrument configuration.
 - (b) Purchaser-defined and standard calibration and configuration procedures for all transmitters.
 - (c) Constant signal data collection facilities to maintain continuously updated records.
 - (d) Automatic tracking of configuration changes made in the field, such as may be introduced by hand-held communicator. All configuration function associated with hand-held communicators shall be available in the system.
 - (e) Event and log reports on screen as well as on printer.
 - (f) Any addition/deletion of transmitter will be reported on printer and logged in hard disk.

6.4.2 Specification for Electronic Transmitter for Pressure, Differential Pressure (DP), Flow and Level

| Sl. No. | Features | Essential/ minimum requirements for electronic transmitter |
|---------|---------------------|---|
| 1. | Type of transmitter | Microprocessor based 2 wire type, HART protocol compatible. |
| 2. | Sensor type | Capacitance/Piezo-electric |
| 3. | Accuracy | $\pm 0.1\%$ of span |
| 4. | Output signal range | 4-20 mA DC (analog) along with superimposed digital signal (based on HART protocol) |
| 5. | Turn down ratio | 30:1 |
| 6. | Stability | $\pm 0.1\%$ of calibrated span for six months up to 70 Kg/cm ² and $\pm 0.25\%$ for range more than 70 Kg/cm ² (g). |
| 7. | Zero and span drift | $\pm 0.015\%$ per deg. C at max span and 0.11% per deg. C at min. span. |



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| | | |
|-----|--------------------------------------|---|
| 8. | Load impedance | 500 ohm (min.) |
| 9. | Housing | Weather proof as per IP- 67 with durable corrosion resistant coating |
| 10. | Over Pressure | 150% of max. operating pressure |
| 11. | Connection (Electrical) | Plug and socket type |
| 12. | Process connection | 1/2 inch NPT (F) |
| 13. | Span and Zero adjustability | Continuous, tamper proof, remote as well as manual from instrument with zero suppression and elevation facility. |
| 14. | Accessories | (a) Diaphragm seal, pulsation dampeners, siphon etc. as required by service and operating condition (b) 2 valve manifold for absolute pressure transmitters, 3 valve manifold for gauge/ vacuum pressure transmitters and 5 valve manifold for DP/ level/ flow transmitters. (c) For hazardous area, explosion proof enclosure as described in NEC article 500. |
| 15. | Diagnostics | Self indicating feature |
| 16. | Power supply | 24V DC \pm 10% |
| 17. | Adjustment/ calibration/ maintenance | Centralised PC based system as per clause 6.4.1. In addition total five (5) no. of hand held calibrators per unit shall be provided. |
| 18. | Response time | Suitable to meet closed loop control reaction time specified elsewhere |



Notes

- (i) In case it becomes necessary to use a DP transmitter for pressure measurement (furnace pressure & condenser vacuum etc.) then a 3 valve manifold should be used in place of 2 valve manifold (furnace pressure, condenser vacuum etc.).
- (ii) Type of transmitter i.e. gauge pressure or absolute pressure, shall be as per specific requirement and as approved by purchaser.
- (iii) For heavy fuel oil (HFO), light fuel oil (LFO) applications, stainless steel(SS) capillary with wafer element with ANSI RF flanged ends are to be provided.
- (iv) For heater level applications ultrasonic/radar type can be considered.

6.4.3 Temperature Sensing Elements and Cold Junction Compensation Boxes

i) Temperature Elements

| Sl. No. | Features | Essential/minimum requirements |
|---------|-------------------------------|---|
| 1. | (a) Type of thermocouple | 16 AWG wire of chromel-Alumel (Type K) or 24 AWG wire Pt-Rhodium Pt (Type R); ungrounded type depending on operating temperature range. |
| | (b) Type of RTD | 3 wire/4 wire - Pt RTD 100 ohm (as per DIN-43760) class-A |
| 2. | No. of elements | Duplex |
| 3. | Housing/Head | IP-55/die-cast aluminium |
| 4. | (a) Sheathing of thermocouple | Swaged type magnesium oxide insulation |
| | (b) Sheathing of RTD | Metal sheathed, ceramic packed |
| 5. | Calibration and accuracy | As per IEC-751/ANSI-C-96.1 0.5% of range for RTD. |
| 6. | Characteristic | Linear with respect to temp, within $\pm 1/2$ percent of top range value |
| 7. | Accessories | - Thermowell (as specified below) and shall be spring loaded for positive contacts with the well. |



- Compensating cable up to CJC box.
- Plug in connectors.

8. Standard ANSI C 96.1 for thermocouple and ASME PTC-19.3 for thermowell

For turbo generator set, following are also applicable-

- a) Thermocouples for stator core shall be of copper compensation, grounded type of size 0.5mm². Thermocouple for bearing babbit temperatures shall be type K, Ni-Cr-Ni of size 6x0.5mm².
- b) Sheathing is not applicable for generator stator core thermocouples in case the same is as per contractor's schedule.

ii) For detection of leakage of various drain valves, drain pipe metal temperature thermocouples shall be provided (approx 60 nos. minimum) as per the following specification. Also for Drum, SH, RH metal temperature thermocouples shall be provided with following specification.

- a) Measuring medium : Metal temperature
- b) Metal of thermocouple element : Chromel- Alumel Type K
- c) Type of thermocouple : Duplex with separate hot junctions, ungrounded type.
- d) Insulation : Mineral insulation
Magnesium Oxide
- e) Thermocouple wire gauge : 16 AWG
- f) Protective sheath : SS 321
- g) Protective sheath dia : 8 mm O.D
- h) Characteristics of thermocouple : Special limits of error as in ANSI MC 96.01.1975
- i) Mounting accessories : 1/2" BSP SS sliding end connector, weld pad, weld on clamps of heat resistant steel SS310.
- j) Cold end sealing : SS pot seal with colour coded PTFE headed sleeve insulated flexible tails. Sealing compound - Epoxy resin.



- k) Minimum bending radius : 30 mm
- l) Length of T/C : 30 mtr. (minimum)

iii) **Thermowell (for process temp. elements)**

- (a) Shall be one piece solid bored type of 316 SS of stepless tapered design. (As per ASME PTC 19.3 1974)
- (b) For mill classifier outlet long life solid sintered tungsten carbide material of high abrasion resistance.
- (c) For air & flue gas 316 SS protecting tube with welded cap.
- (d) For furnace zone, impervious ceramic protecting tube alongwith Incoloy supporting tubes and adjustable flanges.

iv) **C J C Boxes**

- a) Ref. temp. $60^{\circ}\text{C} \pm 1.3^{\circ}\text{C}$ for type K thermocouple
 $60^{\circ}\text{C} \pm 2^{\circ}\text{C}$ for type R thermocouple
- b) Effect of ambient temp. variation $\pm 0.1\%$ per 10°C
- c) Material 4 mm thick fibreglass reinforced polyster
- d) Protection class of CJC boxes IP 55
- e) Cable entry Bottom with gland plates suitable for cables used along with blanking facility
- f) Temp. control Automatic with remote temperature monitoring
- g) Power supply 240 V AC, 50 Hz

v) **Temperature Transmitter**

The temperature transmitter of following types (2-wire temperature transmitter directly powered from 4-20mA input cards of DDCMIS) fully compatible with



thermocouples and RTDs shall be provided. Temperature compensation of the thermocouples shall be performed in the temperature transmitter itself.

a. Single Input Head mounted Temperature Transmitter

These shall be suitable for mounting in the head of temperature element itself. The protection class of head of thermo well along with its plug-in connector shall be min. IP65.

b. Single Input DIN-rail mounted Temperature Transmitter

These shall be suitable for mounting on DIN-rails in JB's. Protection class of JB's shall be IP 65 minimum. This temperature transmitter shall be the ones which are especially designed for DIN-rail mounting with IP 20 protection class. These shall have terminals for input/output provided on front side when mounted on DIN-rail. Head mounted temperature transmitter with clamps to make it suitable for DIN-rail mounting shall not be acceptable under this category.

c. Dual-input Temperature Transmitter With Indicator:

These shall be suitable for mounting on pipes/ supports. Indicator shall be provided with these transmitters. These transmitters shall have bump-less change over facility to second sensor in case first sensor fails. This change-over is to be alarmed. Protection class shall be IP65 minimum.

The exact applications for which this type of transmitter is to be provided shall be finalized during detailed engineering.

d. Common requirements for each of the above type of temperature transmitters

| | |
|-------------------------------|--|
| Output | 2-wire (power supply from input card of Control System) with 4-20mA output with superimposed HART protocol signal. |
| Input | Same transmitter shall be capable to handle Pt-100 RTD , Thermocouples – K&R types (input type to be selectable at site through HART terminal) |
| Isolation | min. 500 V AC |
| EMC compatibility | as per EN 61326 |
| Operating ambient temperature | 0 to 85 deg C (without indicator) 0 to 70 deg C (with indicator) |
| Power supply | compatible with input module of Control System |



| | |
|---------------------------------------|--|
| Accessories | Mounting arrangements including clamps etc. |
| Composite Accuracy (Refer note 2) | (a) For head mounted and DIN-rail mounted types: RTD= $<0.4\%$ of 0-250 deg C span T/C-K type= $<0.4\%$ of 0-600 deg C span T/C-R type= $<0.4\%$ of 0-1000 deg C span CJC accuracy (for thermocouples) shall be $=< 1$ deg C (b)For dual-input type: RTD = $<0.25\%$ of 0-250 deg C span T/C-K type= $<0.2\%$ of 0-600 deg C span CJC accuracy (for thermocouples) shall be $=< 1$ deg C |

Notes:-

1. In case of failure (open or burn-out) of RTD/thermocouple, temp. Transmitter shall provide low temperature output.
2. Composite Accuracy is to be calculated as summation of all applicable accuracies of temp transmitter, for converting sensor input to output in 4-20 mA (e.g., basic accuracy, digital accuracy, D/A accuracy, etc.) and temperature effect on these accuracies at ambient temperature of 50 deg C, based on the figure/ formula given in the standard product catalogue for span as specified above for various types of Temperature Elements specified. All such accuracy/ temp effect figures in catalogue shall be first converted to deg C, and then percentage of this converted accuracy in specified span shall be calculated to compare with the specified composite accuracy figures.

6.4.4 Flue Gas Analyser Instruments:

i) Common to all analysers

- | | | | | |
|----|------------------------|--------|---|----------------------------|
| a. | Output signals: | Analog | : | 4-20 mA DC |
| | | Binary | : | 2 NO + 2 NC for high alarm |
| b. | Zero & span adjustment | : | | Available |
| c. | Ambient temp. | : | | 60°C |
| d. | Indication | : | | Digital |



| | | | |
|----|-----------------------------|---|--|
| e. | Enclosure type/material | : | Weather & dust proof (IP 55) die- cast aluminium/ SS |
| f. | Type of electronics | : | Microprocessor based with self diagnostic facility |
| g. | Digital signal transmission | : | RS 232 link and to suit connections protocol to DDCMIS |
| h. | Calibration | : | Auto & Manual (from Remote) |
| i. | Error diagnostic | : | To be provided |
| j. | Others : | | If analyser provides superimposed HART signal on 4-20 mA DC output, it shall also be connected to PC based station specified under clause 6.4.1. |

ii) Specific requirements of flue gas analysers

| Specification requirements | SO2 analyser and NOx analyser cum monitor (combined) | Oxygen analyser cum monitor | CO analyser cum monitor | Dust density stack opacity monitoring |
|-----------------------------------|---|--|---|--|
| a) Type of instrument | Sampling type | Heated type in-situ | In-situ type | In-situ dry type visible light (through LED) stack |
| b) Principle of measurement | Radiation absorption | Partial-pressure using Zirconium Oxide Cell | IR double beam absorption | Transmission and absorption |
| c) Measurement range | 0-200/0-1000-0-2000 selectable in mg/m ³ | 0-25% oxygen programmable up to min.0.5% of O ₂ | 0-999 selectable in 0-100, 0-200, 0-500, 0-999ppm | 0 to 999mg/ m ³ |
| d)Accuracy | ± 1% of F.S. | ± 1% of F.S. | ± 5% of F.S. | ± 0.2% of F.S. |



Section 6 (Control and Instrumentation Works)

| | | | | |
|--|--|------------------------|-----------------------------|----------------------|
| e)Linearity | $\pm 1\%$ of F.S. | $\pm 1\%$ of F.S. | $\pm 2\%$ of F.S. | $\pm 1\%$ of F.S. |
| f) Repeatability | $\leq 0.5\%$ of Span | $\leq 0.5\%$ of Span | $\leq 0.5\%$ of Span | $\leq 0.5\%$ of Span |
| g)Response time (upto 90% of full scale) | 5 sec. or less | 5 sec. or less | 5 sec. | 5 sec. |
| o Temperature drift | $\pm 1\%$ / 10 deg. C | $\pm 0.005\%$ 2 deg. C | Automatic temp compensation | 1% in 24 hrs. |
| o Zero drift | < 1% span/ week | | <1% span/ week | |
| o Span drift | < 1% measured value/week | | <1% measured value/ week | |
| h)Sensor type | Luminiscence/ /IR | . zirconium oxide cell | IR | Luminiscence |
| i)Operating temperature range | 0-300 deg.C | 0-450 deg.C | 0-300 deg.C | 0-300 deg.C |
| j)Filter | Ceramic 3.5 micron | Ceramic 3.5 micron | Ceramic 3.5 micron | Ceramic 3.5 micron |
| k)Sampling system | With dual sampling through heavy duty pumps (with bypass pump), solenoids filters etc. alongwith coolers and flow meter and level switch in gas coolers for auto draining purpose, moisture detection/ alarm unit. | Not applicable | Not applicable | Not applicable |



| | | | | |
|--|---|---|---|---|
| l)Accessories purging system | Yes (auto scavenging facility) | Purging system | Yes | Yes |
| m)Compensation for temp., Pr., moisture, for O2 including cables upto JB | Yes to be provided and shutter solenoid for isolating lens during unit trip and purge air failure automatically | Automatic temperature control of heating circuit through thermostat.. | Yes to be provided and shutter solenoid for isolating lens during unit trip and purge air failure automatically | Yes to be provided and shutter solenoid for isolating lens during unit trip and purge air failure automatically |
| n)Location | Chimney | Airheater inlet | Airheater inlet and on chimney | Chimney |

6.4.5 Vibration Monitoring System

- i) Microprocessor based vibration monitoring system shall be provided for ID fans, FD fans, PA fans, CEPs , BFPs ,and all other pumps/ fans operating on 3.3kv/11kV.The number of bearing locations to be monitored on each fan/ pump shall be as per requirements finalized during detailed engineering but not less than 2 bearing locations for each fan/pump (except for vertical pumps for which one bearing location may be sufficient).
- ii) The vibration monitoring system shall be furnished on a system basis including vibration transducers with low noise flexible cables in flexible conduit, terminated in local terminal boxes, necessary pre-amplifier/electronics mounted in local weather proof boxes, vibration monitors, mounting racks and cabinets. The vibration monitoring system shall include all power supplies, interconnecting cabling, calibration equipment, indicators, integrating units, signal conditioning devices and all other accessories required for monitoring of vibration at each point.
- iii) Bidder shall offer 2 channel vibration monitors for each measurement location catering for horizontal and vertical measurements. Offered vibration monitors shall be modular in construction, plug in type and suitable for 19" rack mounting.
- iv) Eddy current type proximity transducers shall be used. However, the finally selected sensor type shall also depend on recommendation of the equipment manufacturer & suitable for application requirement. Transducers shall be furnished in weatherproof housing suitable for field conditions.



- v) Vibration monitoring system shall give buffered output of 4-20 mA DC for each point monitored. The signal shall be suitable for use as an input to DDCMIS as well as for analog recording & analysis, linear in proportion to vibration velocity as well as displacement. Monitor shall provide vibration indication calibrated in velocity units along with provisions of changing to displacement unit (field-programmable) for each measurement point in both horizontal & vertical planes. For each vibration monitor, two independent potential free contacts shall be made available for alarm & trip purposes.
- vi) The vibration monitor racks with power supplies shall be mounted in a separate self standing cabinet to be located in CER. The number of racks and power supplies shall be such that on failure of a single power supply/module, not more than four monitors shall be affected. The vibration monitoring cabinet shall be fed from redundant UPS feeders with auto changeover scheme.
- vii) The functional requirement for vibration monitoring system shall include but not be limited to the following:
- a) Vibration monitor front face status indications shall be available for indications of healthy conditions of pick up circuit, monitor circuit and power supply. Also set point indication with set point adjustment facility for setting alarm & trip levels shall be provided.
 - b) The facility shall be available from front of mounting rack for functional checking of monitors with inhibition of alarm and trip contact outputs during test. Alarm inhibition shall also be provided during start-up.
- viii) All vibration monitoring equipment shall be functionally tested for circuit continuity and output response. All the components & interconnection cables shall be tested to ensure compliance with the specification requirements and all other applicable codes & standards.

In case it is the proven standard practice of a Bidder to provide vibration monitoring TFTs instead of dedicated monitors with the signal conditioning equipment in control equipment room, the same shall also be acceptable. However, all relevant functional requirements detailed above shall be met and the system shall be subject to purchaser's approval.

6.4.6 Specification for Flow Elements

i) Orifice Plate

| Features | Essential/minimum requirements |
|----------|--|
| a) Type | Concentric as per ASME PTC-19.5 (Part-II), ISA RP-3.2, 1960 or BS-1042 |



| | |
|---|---|
| b) Material | 316 SS |
| c) Thickness | 3 mm for main pipe diameter up to 300 mm and 6 mm for main pipe dia above 300 mm. |
| d) Material of branch pipe | Same as main pipe |
| e) Root valve type | Globe |
| f) Root valve material | 316 SS |
| g) Root valve size | 1 inch |
| h) Tappings | Flanged weld neck. 3 pairs. of tapping. |
| i) Beta Ratio | 0.34 to 0.7 |
| j) Beta Ratio calculation to be submitted | Yes |
| k) Assembly drg. and flow Vs DP curves | Yes |
| l) Accessories | Root valves, flanges, vent/drain hole(as required) |

Contractor shall submit certified flow calculation and differential pressure versus flow curves for each element for purchaser's approval. Sizing calculation, precise flow calculation for all the flow elements, fabrication and assembly drawings and installation drawings shall be submitted for purchaser's approval. One flow element of each type shall be calibrated in the test laboratory for validation of computed flow calculations.

ii) Flow Nozzle

| | |
|--------------|---|
| Features | Essential/minimum requirements |
| a) Type | Long radius, welded type as per ASME PTC-19.5 (Part-III) or BS-1042 |
| b) Material | 316 SS 321 SS for high temperature and corrosive atmosphere |
| c) Thickness | Suitable for intended application. |



| | |
|---|-----------------------------------|
| d) Material of branch pipe | Same as main pipe |
| e) Root valve type | Globe |
| f) Root valve material | 316 SS |
| g) Root valve size | 1 inch |
| h) Tapping | D and D/2 (3 Nos. of tappings) |
| i) Beta ratio | Around 0.7 |
| j) Beta ratio calculation to be submitted | Yes |
| k) Assembly drg. and flow Vs DP curves | Yes |
| l) Accessories | Root valves, vent and drain hole. |

Contractor shall submit certified flow calculation and differential pressure versus flow curves for each element for Purchaser's approval. Sizing calculation, precise flow calculation for all the flow elements, fabrication and assembly drawings and installation drawings shall be submitted for purchaser's approval. One flow element of each type shall be calibrated in the test laboratory for validation of computed flow calculations.

6.4.7 Specification For Local Gauges & Rotameter

i) Local Gauges

| Sl. No | <u>Features</u> | <u>Essential/ minimum Requirements</u> | | |
|--------|------------------------------|---|---|--|
| | | Pr. gauge/ DP gauge/ Draft gauges | Temperature gauge | Level gauge |
| a) | Sensing Element and material | Bourdon for high pressure, diaphragm/ bellow for low pr. of 316 Stainless steel | Mercury in steel for below 450°C and inert gas actuated for above 450°C of SS bulb and capillary. | Tempered * toughened borosilicate gauge glass steel armoured reflex or transparent type. |
| b) | Body material | Die-cast aluminium | Die-cast aluminium | Forged carbon steel/ 304 SS |
| c) | Dial size | 150mm | 150 mm | Tubular covering entire range |



| | | | | |
|----|-------------------------------|--|-------------------------------------|---|
| d) | End connection | 1/2 inch NPT (F) | 3/4inch NPT (F) | Process connection as per ASME PTC and drain/vent 15 NB |
| e) | Accuracy | ±1% of span | ± 1% of span | ± 2% of span |
| f) | Scale | Linear, 270° arc graduated in metric units | Linear, 270° arc graduated in °C | Linear vertical |
| g) | Range selection | Cover 125% of max. of scale | Cover 125% of max. of scale | Cover 125% of max. of scale |
| h) | Over range test | Test pr. for the assembly shall be 1.5 to the max. design pr. at 38°C. | | |
| i) | Housing | Weather and dust proof as per IP-55 | Weather and dust proof as per IP-55 | CS/ 304 SS leakproof |
| j) | Zero/span adjustment | Provided | Provided | -- |
| k) | Identification | Engraved with service legend or laminated phenolic name plate | | |
| l) | Accessories | Blow out disc, siphon, snubber, pulsation dampener, chemical seal (if required by process) gauge isolation valve | SS Thermowell | Gasket for all KEL-F shield for transparent type Vent and drain valves of Steel/SS/ CS/Alloy as per process requirement |
| m) | Material of Bourdon/ movement | 316 SS / 304 SS | 316 SS / 304 SS | |

Notes:-

*Bicolour type level gauges will be provided for applications involving steam and water except for condensate and feed water services.

Length of gauge glass shall not be more than 1400 mm. If the vessel is higher, multiple gauge glasses with 50 mm overlapping shall be provided.



Where the process fluids are corrosive, viscous, solid bearing or slurry type, diaphragm seals shall be provided. Parts below the diaphragm shall be removable for cleaning. The entire volume above the diaphragm shall be completely filled with an inert liquid suitable for the application.

For HFO, LFO applications, SS capillary with thin wafer element with ANSI RF flanged ends are to be provided.

ii) Specification for Rotameters

| Sr. No. | Features | Essential / minimum requirements |
|---------|--------------------------|---|
| a) | Type scale | Variable linear type |
| b) | Fluid media | Water/oil |
| c) | Material body | Transparent toughened glass |
| d) | Material of float | 316 SS |
| e) | Indicator | Magnetic float |
| f) | Accessories | Flange, orifice in case of bypass rotameter (for line size above 50 mm) |
| g) | Housing protection class | IP-55 |
| h) | Accuracy | $\pm 2\%$ |

6.4.8 Specification for Process Actuated Switches

| Features | Essential / minimum requirements | | |
|--------------------|--|---|---|
| | Pressure/draft switches/ DP switches | Temperature switches | Level switches |
| a) Sensing element | Piston actuated for high pressure and diaphragm or bellows for low pressure/vacuum | Vapor pressure sensing, liquid filled bellow type with SS bulb and capillary (10 m minimum) | Capacitance types for oil and dirty medium, water, condensate application. Float type switches for applications as decided by Purchaser during detailed engineering. |



| | | | |
|------------------------------------|--|---|--|
| | | | Capacitance/ Conductivity/ Ultrasonic type for acid and alkali application. |
| | | | Radio-frequency/ ultrasonic type for ash hopper, ash slurry application. |
| b) Material | 316 SS | Bulb 316 SS/ capillary 304 SS | 316 SS |
| c) End connection | ½ inch NPT (F) | ½ inch NPT (F) | Manufacturer standard |
| d) Over range proof pressure | 150% of max. design pressure | - | 150% of max. design pressure |
| e) Repeatability | | ± 0.5% of full range | |
| f) No. of contacts | 2 NO + 2NC SPDT snap action dry contacts | | |
| g) Rating of contacts | 60 V DC, 6 VA (or more if required by DDCMIS or PLC)* | | |
| h) Elect. connection | Plug in socket | | |
| i) Set point/ dead band adjustment | Provided over full range | | |
| j) Enclosure | Weather and dust proof as per IP-55 | | |
| k) Accessories | Syphon, snubber, chemical seal, pulsation dampeners as required by process | Thermo well of 316 SS and packing glands | All mounting accessories |
| l) Mounting | Suitable for enclosure/ rack mounting or direct mounting | Suitable for rack mounting or direct mounting | - |



Note: Where the process fluids are corrosive, viscous, solid bearing or slurry type, diaphragm seals shall be provided. Parts below the diaphragm shall be removable for cleaning. The entire volume above the diaphragm shall be completely filled with an inert liquid suitable for the application.

6.4.9 Specification for Indicators, Recorders, Integrators

i) Indicators, Recorders

| Sl. No | Features | .Essential/minimum requirements | | |
|--------|-----------------------|--|---|--|
| | | Digital indicator | Vertical indicator | Recorder |
| a) | Type | 4½ digit LED seven segment display. | Permanent magnet moving, coil, (PMMC) single element with strip scale | 1 24 point strip chart, micro-processor based programmable 2 3-Pen continuous |
| b) | Input signal | 4-20 mA DC | 4-20 mA DC | 4-20 mA DC, thermo couple and RTD input |
| c) | Display character | 14 mm size decimal continuous reading | Analog linear with pointer | Linear on chart paper |
| d) | Accuracy | ± 0.1% of full scale(at 20 °C -30 °C) ± 2 LSD | ± 1% of full scale | ± 0.3% of span |
| e) | Response time | 250 m sec. | 2 sec. (full span) | 2 sec. (full span) |
| f) | Signal Connection | Screwed | Screwed | Screwed |
| g) | Power Connection | Screwed | N/A | Screwed |
| h) | Zero/span adjustment. | Shall be possible from the front of instruments. | | |



| | | | | |
|-----|--|-------------------------------------|-------------------------------------|--|
| i) | Chart speed | | | Adjustable continuously from 1-1200 mm/hr. (step of 1mm/hr.) |
| j) | Power supply | 240V AC | N/A | 240V AC |
| k) | Power supply fuse connection | Yes | N/A | Yes |
| l) | Mounting | Fully compatible to the mosaic grid | Fully compatible to the mosaic grid | Fully compatible to the mosaic grid |
| m) | Protection class | IP-20 | IP-20 | IP-20 |
| n) | Chart speed | | | Adjustable continuously from 10-600 mm/Hr |
| o) | Identification | -----Engraved Phenolic tag ----- | | |
| p) | Dimension | 96 mm (W) x 48 mm (H) | 36 mm (W) x 144 mm (H) | 144 mm (W) x 144 mm (H) |
| ii) | Integrator shall have total display 6 digit, 4mm high. Totaliser mechanism shall be as per manufacturer's standard. It shall have an accuracy of + 0.3% a span. Input shall be 4-20mA DC. | | | |

6.4.10 Electric to Pneumatic (E/P) Converters

E/P converters and associated accessories shall be furnished in accordance with the specifications given below :

| | |
|-----------------------|--|
| Air supply : | 1.5 kg/cm sq., |
| Input signal : | 4-20m A DC(as required by the design of control system), |
| Output signal : | 0.2 to 1.0 kg/cm sq., |
| Linearity : | 0.5% of span or better, |
| Hysteresis : | 0.1% of span or better, |
| Ambient temp effect : | less than 0.02% of span per deg C between -20 deg. To +60 deg C. |
| Mounting : | close to actuator (but not on the actuator), |
| Output capacity: | to suit the actuator, |
| Protection class: | IP 55. |
| Allowable drift rate | ±2% of set point/ hour maximum. |



On loss of control signal, the last set point pressure shall be maintained so that the associated control valve remains in stay put condition.

6.4.11 Displacer Type Level Transmitters

- i) Displacer type level transmitters shall be provided for level measurements of the vessel under vacuum or low pressure applications (viz. condenser hotwell, LPH-1, 2, 3 level measurements).
- ii) The displacer spring and tube material shall be K-monel. The float movement shall be transmitted to the pivot mechanism by a torque device incorporating a positive seal between float cage interior and the transmitting mechanism without the use of stuffing boxes. Level transmitters, not incorporating torque tube mechanism, shall not be acceptable.
- iii) Level transmitters shall be complete with external float chambers of cast or fabricated steel construction with 2 inch upper side and lower bottom socket weld connections unless otherwise required as per main vessel connections. Displacement float chambers shall be designed for internal access without breaking the level connection primary piping. Matching weld neck counter flanges shall be supplied alongwith the instrument.
- iv) Accuracy (including combined effect of linearity, hysteresis and repeatability) shall be $\pm 0.75\%$ of span or better.
- v) Connection details, other technical features and materials of construction shall be suitable for the intended applications and shall be subject to purchaser's approval.
- vi) The transmitters shall be provided with IP-55 protection class with durable corrosion resistant coating.
- vii) The transmitters shall be able to provide digital signals superimposed on 4-20 mA signal as per HART protocol.

6.4.12 Positive Displacement Type Flow Transmitters

- i) The bidder shall provide positive displacement type flow transmitters for fuel oil flow measurement, suitable for the fuel oil being used for the project, i.e., keeping in view the pressure, temperature and viscosity of the fuel oil.
- ii) The meter shall be a volumetric meter type consisting of two meshing oval wheels driven by the fluid. Each revolution of the oval wheels shall displace a precisely known volume of the fluid from inlet to outlet. The housing/measuring chamber and oval wheels shall be of 316 SS.
- iii) The measurement accuracy of the transmitter shall be better than $\pm 0.2\%$.



- iv) The transmitter shall provide suitable 4-20mA DC output signal for control and indication/recording. Converters if necessary shall be provided to generate the 4-20mA signal.
- v) A local indicator of fuel oil flow shall also be provided. The instrument shall be calibrated in tons/hr.
- vi) Suitable strainer shall be provided before the transmitter for the protection of oval wheel meters against foreign matter contained in the fuel oil.
- vii) The exact model no. and type of material being used, etc., shall be subject to Purchaser's approval during detailed engineering without any price repercussion to Purchaser.

6.4.13 Impact Head Type or Ultra sonic type Flow Element

Impact head type or ultra sonic type flow elements shall be provided for measurement of CW flow.

a) Impact Head Type:

- i) The impact head type element shall be tubular insert type with four impact ports facing upstream direction, located precisely for determination of average flow velocity and shall be of 316 SS.
- ii) Accuracy shall be $\pm 1.0\%$ of actual value or better. Repeatability shall be $\pm 0.01\%$ of actual value or better.
- iii) The elements shall be supplied complete with mounting hardware, end support plugs and CS valve manifold (1/2" NPT connection) for instrument connections. All pertinent data including Purchaser's instrument tag no. for the flow element shall be punched on a stainless steel plate and affixed to the element.
- iv) On line retracting facility and flushing arrangement shall be provided.

b) Ultra sonic type Flow Meter

- i) Ultrasonic Flow meter shall be dual path transit time clamp-on type.
- ii) The flow meters shall be of proven reliability, accuracy and repeatability requiring a minimum of maintenance. They shall comply with relevant international standards and shall be subject to approval.
- iii) All accessories required for mounting/erection of these instruments shall be furnished, erected and installed as necessary for completeness of the system though not specifically asked for. Also



the equipment shall include necessary cables, flexible conduits, junction boxes required for the purpose.

iv) Flow meters shall be provided with suitable environment protection devices/structures such that they shall be suitable for continuous operation in the operating environment of a coal fired utility station without any loss of function or departure from the specification requirements.

v) Technical Requirements

| | |
|---|---|
| Type | Transit time Clamp On Ultrasonic meter |
| Mounting Style | Dual path with two sets of transducers on the same pipe |
| Flow measurement | Instantaneous Flow rate as well as totalized flow |
| Power supply | 230 V AC |
| Outputs : | |
| Analog Current | Isolated 4-20mA linear outputs for each path |
| Binary | Contact relay outputs, 2 NO + 2 NC for alarm |
| Communication ports | RS 232 C digital Hand held terminal port |
| Display/Indication | Flow meter with LCD screen backlight based local display and keypad. If required, transmitter shall be suitably located away from the sensor for better access and visibility. |
| Recording / Totalizing/Logging Facilities | Yes. Should be able to compute cumulative flow over intervals selectable by owner i.e., daily, weekly, monthly etc. The data shall be stored in the memory of flow computer for access in future. |



| | |
|-----------------------|---|
| Software features | Compensation for any cross path errors Programming, configuration, shall be possible from front panel. |
| Diagnostics | False signal tolerance , power supply failure etc. |
| Protection class | IP-65 or better, Weather protection against direct sunlight, rain etc for Flow meter and suitable for Cooling water for Transducer. |
| Accuracy | +/- 1% |
| Electrical connection | Plug and socket |
| Pipe location | Underground |
| Accessories | All mounting hardware required like clamping fixtures, mechanism to remove the transducers online, interconnecting cables etc All weather canopy for protection from direct sunlight and direct rain. Material of all fittings shall be SS 316. |

- vi) The Bidder shall submit certified flow calculation and differential pressure Vs. flow curves for each element for Purchaser's approval. Sizing calculation, precise flow calculation for all the flow elements, fabrication and assembly drawings and installation drawings shall be submitted for Purchaser's approval.



6.5 STEAM AND WATER ANALYSIS SYSTEM (SWAS)

- i) The purity of the condensate, feedwater, steam etc. shall be continuously monitored through on-line analysis system. The on-line chemical analysis for pH, conductivity, hydrazine, sodium ion, silica, dissolved oxygen, etc. shall be carried out in the plant cycle at strategic points. The exact sample points, their location, type of chemical analysis to be carried out for each sample, measurement ranges etc., shall be subject to the approval of the Purchaser. The system shall be generally designed in accordance to the recommendation of ASME PTC 19.11 Part-II, water & steam in power cycle.
- ii) The bidder shall provide the chemical analysis system as a composite system including sample piping, valves, grab sample collection facility, gauges/indicators, coolers, on- line analyzers etc.

6.5.1 SWAS Panels

- i) Sample conditioning panel (wet section) shall house bulk head type fittings, removable cartridge type filters, pressure reducing elements, flow rate control, secondary coolers, grab sample valve and other sample conditioning equipments. For each sample, pressure gauge, temperature gauge, flow indicator, back pressure regulating valve, grab sample valve shall be provided on front of panel. The grab sampling facility and quick disconnect patch board facilities shall be provided on this panel.

Analyzer panel (dry section) shall house cells, analyzers, monitors etc.

- ii) The above panels shall be physically separate from each other and shall be mounted in the air-conditioned SWAS room (common for 2 units). Sample conditioning panel shall be corridor type with walkway. The analyzer panel shall be free standing and of totally enclosed construction. The panel sheet thickness shall be 2.5mm except for doors which shall be of 2.0 mm thickness. All SWAS panels shall be designed for ready access of components for easy maintenance. The layout and general arrangement of these panels shall be subject to Purchaser's approval.
- iii) Primary cooling of all samples having temperature in excess of 45 deg C shall be provided through an individual sample cooler (primary cooler) of submerged helical coil type of shell and tube design with removable shell, meeting the intent of ASTM D 1192-1977, to bring down the temperature to around 45°C. These coolers shall be rack – mounted and located at the field. The primary coolers shall use water from equipment cooling water system. The design, construction materials and technical features of the coolers shall be subject to Purchaser's approval. However, the sizing of the coolers should consider total sample flow plus 500 ml / min grab sample and a fouling factor of 0.2. All fittings, tubes & other wetted parts shall be 316 SS. All high pressure samples shall be provided with pressure reducing valves after primary cooler in the field.

Each sample stream with the required flow rate shall be finally cooled from



approximately 45°C to 25°C \pm 1°C or to a preset temperature required by the analyzer through an individual secondary cooler before passing the sample to the respective measuring cells and analyzer even in case, the corresponding analyzer is rated for higher sample temperature. The pressure of the samples shall be about 2 kg/cm² and flow rates shall be as required by the individual analysers. The secondary cooler shall use condensate quality chilled water at 20°C. All samples will be passed through cartridge type filters before being cooled in respective secondary coolers. The secondary coolers will also be of submerged helical coil type of shell and tube design meeting the intent of ASTM D 1192-1977. All tubes, fittings & wetted parts shall be 316 SS.

The chilled water for SWAS should be drawn from chiller plant of the plant A/C system, if required. The bidder shall provide two identical 100% capacity chilled water circulation pumps for the secondary cooling as detailed above. Loss in chilled water pressure, flows and rise in temperature shall be alarmed.

6.5.2 Specification of Analysers

6.5.2.1 Conductivity Analyser

- | | | |
|------|--|---|
| i) | Type: | |
| | a) Cell | Flow through type / removable type (withdrawable with sealing valve) |
| | b) Monitors | Electronic (microprocessor based) indicating type with multi range facility |
| ii) | Material: | |
| | a) Cell | Epoxy resin |
| | b) Electrode | Platinised |
| | c) Monitor body | Carbon steel |
| iii) | Monitor output: | |
| | a) 4 to 20mA DC for recorder | |
| | b) 4 to 20mA DC isolated output for DDCMIS | |
| iv) | Power supply | 240V, AC, 50Hz |
| v) | Accuracy | \pm 1 % of full scale span |
| vi) | Stability | \pm 1% of full scale per month no cumulative |



- vii) Repeatability ± 0.3 of span
- viii) Annunciation contacts for monitors
 - a) Number 2 SPDT
 - b) Type Snap action micro switch
 - c) Rating 5 Amp, 240V; 0.2Amp, 220V DC
- ix) Mounting
 - a) Cell On line/ pipe mounted (on line in sample table)
 - b) Monitors Flash panel mounting
- x) Connection:
 - a) Process $\frac{1}{4}$ inch NPT(F) screwed for on line type.
 $\frac{3}{4}$ inch NPT (M) screwed for pipe mounted
 - b) Electrical $\frac{1}{2}$ inch NPT (F) screwed
- xi) Accessories
 - a) Automatic temperature compensation in the range 0-100⁰ C.
 - b) Ammonia (NH₃) removal equipment.
 - c) Sample coolers.
 - d) Flow and pressure regulators.
 - e) SS impulse tubing and fittings
 - f) Isolation & drain valves as required.
 - g) Other accessories as required.
 - h) Adequate length of cables for connecting coils to monitors.
 - i) Sample rate set valves.
 - j) Alarm settings and Alarm indications on monitor.
- xii) Range As per sample stream .



- xiii) Other particulars Cell shall be suitable for maximum pressure of 7 kg/cm² and maximum temp. of 100^oC

6.5.2.2 pH Analyser

- i) Type
- a) Cell Measuring and reference electrode combination with flow through type (polypropylene flow chambers).
- b) Monitors Electronic (microprocessor based) indicating type with adjustable range facility.
- ii) Material
- a) Measuring & reference Toughened sensitive.
- b) Electrode pH glass
- c) Monitor body Die-cast aluminum.
- iii) Monitor output
- a) 4-20m A DC for recorder
- b) 4-20 m A DC isolated output for DDCMIS
- iv) Power Supply 240V AC, 50 Hz
- v) Accuracy/repeatability. ± 0.03 pH/ + 0.02pH
- vi) Resolution ± 0.01 pH
- vii) Stability 0.02 pH per week.
- viii) Annunciation contacts for monitors.
- a) Number 2 SPDT high and low
- b) Type Snap action micro switch.
- c) Rating 5 A 240V AC, 0.2 A 220VDC.
- ix) Connection.
- a) Process 1/4 inch NPT(F) screwed
- b) Electrical 1/2 inch NPT(F) screwed



- x) Mounting
 - a) Cell Pipe Mounted.
 - b) Monitors Flush panel mounting.
- xi) Accessories
 - a) Automatic temperature compensation with fast response integral temperature sensors in the range 0-100 deg C
 - b) Co-axial cable as required
 - c) Sample coolers.
 - d) Flow and pressure regulators.
 - e) Standard pH solutions.
 - f) SS impulse tubing and fittings.
 - g) Isolation & drain valves as required.
 - h) Electrode holders.
 - i) Other accessories as required
 - j) Sample rate set valves.
 - k) Alarm settings and indications on monitor.
 - l) RF/EMI shielded, weather and corrosion proof casing.
- xii) Ranges As per sample stream .

6.5.2.3 Dissolved Oxygen Analyser.

- i) Type Electro-chemical
- ii) Material Die-cast aluminium
- iii) Output
 - a) 4-20m A DC for recorder
 - b) 4-20 m A DC isolated output for DCS.
- iv) Supply 240V AC, 50 Hz.
- v) Accuracy \pm 4% of full scale value.



- vi) Response:
 - a) Sensitivity \pm two (2) per cent overall.
 - b) Time (sensor) Less than 30 seconds for 90% step change.
- vii) Connection:
 - a) Process 1/4 inch NPT (F) SCRD.
 - b) Electrical 1/2inch NPT(F) SCRD.
- viii) Accessories
 - a) Sample cooler assembly with shut off valve at cooling water inlet, with thermometer and reducing valve at sample outlet.
 - b) Flow stabilizer.
 - c) Automatic temperature compensation.
 - d) Other accessories as required including chiller.
 - e) Calibration device.
- ix) Ranges As per sample stream
- x) Mounting Flush
- xi) Annunciation contacts
 - a) Number 2 SPDT.
 - b) Type Snap action micro switch.
 - c) Rating 5 Amp 240V AC, 0.2 amp 220V DC.

6.5.2.4 Silica Analyser (SIOX)

- i) Type Calorimetric Analyzer (with auto reagent shut off feature in case of sample loss or power loss) built in phosphate inhibition feature. Micro processor based.
- ii) Case material : Die cast aluminum
- iii) Cycle time Twelve (12) minutes maximum
- iv) Analyser out put
 - a) 4 to 20m A DC recorder
 - b) 4 to 20m A DC Isolated output for DCS



-
- | | | |
|-------|-----------------------|---|
| v) | Power supply | 240V DC, 50Hz |
| vi) | Accuracy | ± 1% of span |
| vii) | Repeatability | ± 2% of full scale |
| viii) | Sensitivity | 0.2 micrograms / liters |
| ix) | Connection | |
| | i) Process | 1/4 inch NPT(F) SCRD. |
| | ii) Electrical | 1/2 inch NPT(F) SCRD |
| x) | Ranges | As per sample stream. |
| xi) | Mounting | Flush |
| xii) | Annunciation contacts | |
| | a) Number | 2 SPDT. |
| | b) Type | Snap action micro switch. |
| | c) Rating | 5 A 240V AC, 0.2 A 220V D.C. |
| xiii) | Accessories | |
| | a) | Chilling plant (if required) |
| | b) | Automatic temperature compensation between 5 deg.to 50deg C. |
| | c) | Automatic zeroing provision. |
| | d) | SS tubing & vessels. |
| | e) | All chemical reagents for 12 months operation of the analysers. |
| | f) | Sample rate set values. |
| | g) | Comprehensive diagnostic and alarm features. |

6.5.2.5 Hydrazine Analyser

- | | | |
|------|-----------------|------------------------|
| i) | Type | Electrochemical |
| ii) | Case material | Die-cast aluminum |
| iii) | Analyser output | 4-20mA DC for Recorder |

4-20 mA DC isolated output for DDCMIS



- | | | |
|-------|-----------------------|--|
| iv) | Power supply | 240V AC, 50 Hz. |
| v) | Accuracy | $\pm 2\%$ of full scale. |
| vi) | Sensitivity | 1.0 microgram/litre. |
| vii) | Annunciation contacts | |
| | a) Number | 2 SPDT |
| | b) Type | Snap action micro switch. |
| | c) Rating | 5A 240V AC, 220V D.C. |
| viii) | Mounting | Flush mounting. |
| ix) | Accessories | |
| | a) | Flow regulator. |
| | b) | Flow gauges. |
| | c) | Other accessories as required. |
| | d) | Sample rate set valves. |
| | e) | Chemical reagents as applicable for 12 months consumption. |

6.5.2.6 Sodium Ion Analyser.

- | | | |
|-------|-----------------------|--|
| i. | Type | Continuous flow through sample type with sodium responsive electrode and reference electrode having pH adjustment facility |
| ii. | Case material | Die-cast aluminium |
| iii. | Analyser power supply | 240V AC , 50 Hz. |
| iv. | Analyser output | |
| | a) | 4-20mA DC for Recorder. |
| | b) | 4-20mA DC isolated output for DDCMIS. |
| v. | Accuracy | Better than $\pm 5\%$ of full scale. |
| vi. | Sensitivity | 0.1 ppb. |
| vii. | Annunciation contacts | |
| | a) Number | 2 SPDT |
| | b) Type | Snap action micro switch. |
| | c) Rating | 5A 240V AC, 0.2A 220V DC. |
| viii. | Mounting | Flush. |



- ix. Accessories
- a) Flow regulator.
 - b) Flow gauges.
 - c) Sample rate set valves.
 - d) Other accessories as required to Make the system complete.

6.5.2.7 Chloride Analyser

- i. Type Continuous flow through sample type
- ii. Analyser power supply 240V AC, 50 Hz
- iii. Analyser output
- a) 4-20mA DC spare output.
 - b) 4-20mA DC isolated output for DDCMIS.
- iv. Accuracy Better than + 5 microgram/litre of full scale.
- v. Sensitivity 0.1 ppm.
- vi. Annunciation contacts:.
- a) Number 2 SPDT
 - b) Type Snap action micro switch.
 - c) Rating 5A, 240V, AC, 0.2A, 220V DC.
 - d) Mounting Flush.
- vii. Terminal points All component piped & wired.
- viii. Accessories
- a) Flow regulator.
 - b) Flow gauges.
 - c) Sample rate set valves.
 - d) Other accessories as required to make the system complete

6.5.3 System and type of measurement

All analysers, cells, monitors as offered shall be from field proven of international reputed make and subject to purchaser's approval. The bidder shall provide the on line analysis system for the following samples as a minimum but not limited to:



| S.No. | System | Type of measurement |
|--------------|-------------------------------|---|
| i) | Make-up D.M. water | a) Specific conductivity b) Cation conductivity |
| ii) | Hotwell Condensate | Specific conductivity (both sides) |
| iii) | C.E.P. Discharge | a) pH b) Cation conductivity c) Sodium ion d) Dissolved Oxygen e) Specific conductivity |
| iv) | Condensate polisher outlet | a) Specific conductivity b) Sodium ion c) Silica d) Cation conductivity e) pH. |
| v) | Deaerator outlet | Dissolved oxygen |
| vi) | Feedwater at economiser inlet | a) pH b) Specific conductivity, c) Cation conductivity d) Hydrazine e) Dissolved Oxygen |
| vii) | Boiler saturated steam | a) ph b) Specific conductivity c) Cation conductivity |
| viii) | Main steam -SH outlet | a) pH b) Specific conductivity c) Cation conductivity d) Sodium |



- | | | | |
|-----|-------------------------|----|-----------------------|
| ix) | Drum | a) | pH |
| | | b) | Specific conductivity |
| | | c) | Silica |
| | | d) | Phosphate |
| | | e) | Chloride |
| x) | Condenser cooling water | a) | pH |
| | | b) | specific conductivity |

For hotwell conductivity measurement, the bidder shall provide direct insertion type/ withdrawable type conductivity cell whereas for all other samples it shall be flow-through type. Monitors for hotwell conductivity shall be suitable for field mounting.

6.5.4 Alarm Contacts

One set of alarm contacts of SPDT type shall be provided with each analyzer/monitor which shall be wired to the DDCMIS. Further, 4-20 mA signals from all analyzers shall be hooked up to DDCMIS for monitoring purposes as well as for control of hydrazine and ammonia dosing through CLCS.

6.5.5 General

Field proven monitors/analyzers based on microprocessors with LCD display and with necessary fault diagnostic features shall be employed. The type, size, capacity, material, make, model and other specification details of the rest of the SWAS system like coolers, gauges/switches, sample pipes, filter, pressure reducing elements, grab sampling arrangement valves & fittings, panels etc. shall be as decided during detailed engineering stage and shall be subject to Purchaser's approval. The power supply to all the analysers/monitors shall be supplied by the bidder from his UPS system with all necessary switches, fuses etc. for distribution to individual requirements.



6.6 UNIT CONTROL DESK, UNIT CONTROL PANEL, SYSTEM CABINETS, LOCAL PANELS & TRANSMITTERS ENCLOSURES/RACKS.

6.6.1 General

- i) All unit control desks, panels, system cabinets, local panels and local instrument enclosures, racks shall be furnished fully wired with necessary provision for convenience outlets, internal lighting, grounding, ventilation, space heating, anti-vibration pads, internal piping and accessories as per IS:5039-1969 as required for completeness of the system.
- ii) All panels, desks, cabinets shall be free standing type and have bottom entry for cables unless otherwise specified. The bottom of desks, panels, cabinets, enclosures shall be sealed with bottom plate, compression cable glands and fire proof sealing material to prevent ingress of dust and propagation of fire.
- iii) All electronic system cabinets shall be designed for 50 deg C operating under maximum ambient temperature without air conditioning system in service. Further cabinets, panels shall be so designed that temperature rise due to heat load does not exceed 10 deg. C above ambient temperature under all operating conditions. Necessary louvers, fans, limited packing density, adequate spacing between instruments, devices etc. shall be provided to maintain temperature rise within permissible limits.
- iv) Desk, panels, cabinets enclosures wiring and piping shall be arranged to enable the removal of instruments and devices without unduly disturbing them.
- v) All panels, desks, enclosures interiors shall be illuminated with rapid start fluorescent strip fixtures with door actuated switches. Door switch terminals shall be shrouded. All illuminated lights shall be provided with individual switch in parallel with door switch.
- vi) Sufficient number of power receptacles with disconnect switches shall be installed within panels, desks, enclosure and racks.
- vii) Bidder shall provide the unit control desk (UCD) and unit control panel (UCP) which will be mounted in the unit control rooms.
- viii) The local instrument enclosures/racks shall be provided locally for mounting of electronic transmitters and switches, etc.
- ix) All panels, desks, cabinets shall be properly grounded. The grounding scheme shall be as approved by the purchaser.
- x) Exterior steel surface shall be sand blasted, ground smooth, filled, primed, sanded and smooth enamel painted to give a good finish subject to minimum paint thickness of 65-75 microns for sheet thickness of 3 mm and 50 microns for sheet thickness of 2mm. Minimum 2 coats of primer and two sprays of final finish colour shall be applied to all surfaces.



- xi) The colour of the panels shall be brilliant white in the panel interior. External colour of the panels will be as RAL 7032 for UCB/ UCD, LIE/ LIR and other system cabinets, etc.
- xii) Due consideration shall be given to the ergonomics of unit control desks, unit control panels and the control room design. The design shall conform to the DIN 33414 (Ergonomical design of control room), Part-2 for cognitive factors and Part-4 for arrangement principles.

6.6.2 Control Desk and Panels

6.6.2.1 General

- i) The exact dimensions, material, construction details etc. of Control Desks, panels etc. shall be as per the actual requirement and shall be finalised during detailed engineering. The general arrangement of the desks, panels shall also be finalised during detailed engineering, subject to Purchaser's approval.
- ii) The design of all control panels shall take due regard of the actual application of various devices. It is important that controls and indications required by the operator for a particular operation should be grouped together.
- iii) The bidder must pay particular attention in the positioning of desk mounted TFT's in relation to control room lighting in order to minimise reflections.
- iv) For panels, desks mounted instruments/ devices, etc. which are to be powered from UPS, all required conversion of interface equipment, accessories to make such devices compatible with UPS supply shall be provided. All necessary hardware like input switches, fuse unit for each feeder as well as switch fuse unit for each instrument/ device on the power supply line shall be provided. From UPS, two feeders shall be provided alongwith suitably rated MCB and provision of fast auto changeover of UPS feeders. Power supply distribution scheme shall be as approved by the purchaser during detailed engineering stage.

6.6.2.2 Unit Control Desk (UCD)

Unit control desk shall be free standing table top type with doors at the back and shall be constructed of 3 mm thick CRCA steel plates. All operators TFTs & keyboards shall be mounted on this UCD. PA system hand sets, telephone sets and alarm annunciation PBs shall also be mounted. Very few auto-manual stations & PB stations and lamps may also be mounted on the control desk on mosaic grid structure if found necessary. The desk shall be arranged in an continuous arc shape. The exact profile of the desk, dimension and the radius of curvature shall also be finalised during detailed engineering stage.

To achieve durable and water resistant finish, a coat of "Polyuthesive crystal clear" on the surface of unit control desks shall be provided. Final paint finish with proper smoothing is to be ensured. Final finish of UCD should be in line with relevant International standards.



6.6.2.3 Unit Control Panel (UCP)

UCP shall be free standing vertical panel with double leaf hinged doors at the back. It shall be constructed of 3 mm thick CRCA steel plates with mosaic grid structure on front surface. The mosaic grid tiles shall be of 24 mm x 48 mm (or 25 mm x 50 mm) size, made of heat and flame retardant, self extinguishing and non-hygroscopic material with flat matt finish without glare and non reflecting type. The UCP shall also be arranged in a continuous arc shape. The profile and dimension i.e. radius of curvatures shall be decided during detailed engineering.

All conventional back up devices/instruments shall be provided on UCP. For mounting items like PB stations, miniaturised control switches, indicators, recorders, annunciation windows, on mosaic grid, the size of all these devices/instruments shall be compatible to mosaic grid on UCP.

The mosaic grid construction should be flexible enough to allow easy shifting at site of any instrument on mosaic grid (including indicators & recorders) to any other free location on the UCP without any need of cutting or special equipment/ tool.

6.6.2.4 The repeat annunciation for locally controlled systems like service air & instrument air compressors, DM water pumps etc. shall be provided on UCP. All required miniaturised control switches, electrical meters for achieving the control of station electrical system (circuit breaker etc.) shall be provided in the UCP of different units as applicable. The exact number & location of these shall be as finalised during detailed engineering state.

6.6.3 Cabinets, Enclosures, Panels

- i) Smoke detectors shall be provided inside the system cabinets.
- ii) The cabinets, panels shall be provided with eye bolts for lifting.
- iii) Feeder failure/ healthy indication shall be provided in each cabinet and remote indication shall be hooked up to DDCMIS/ annunciation and suitably grouped.
- iv) The dimensions and load of all panels, cabinets and enclosures shall be clearly brought out during detailed engineering.
- v) Sheet steel thickness for local panels, system cabinets shall not be less than 1.6 mm unless otherwise specified.
- vi) All panels, enclosures, system cabinets, marshalling cabinets shall be provided with a minimum of 20% spare terminations and system cabinets shall be provided with spare space for 20% additional modules fully wired with connectors etc. in excess of the total requirement of the system design when the cabinets are delivered. The spare space capacity shall be distributed evenly throughout the cabinets.



6.6.4 Local Instrument Enclosure and Racks

- i) Transmitters and switches, devices, etc. mounted in the field shall be suitably grouped together and mounted in local instruments enclosures in case of open areas of the plant like boiler area, etc. and in local instrument racks in case of covered areas like A-B bay. These local instrument enclosures and racks shall be furnished as per the actual requirements finalised during detailed engineering stage. The exact grouping of instruments in a particular instrument enclosure/instrument rack shall be as finalised during detailed engineering stage subject to the purchaser's approval.
- ii) The local instrument enclosures shall be constructed of 1.6 mm sheet plate and shall be of modular construction with one or more modules and two end assemblies bolted together to form an enclosure. Vibration dampeners shall be installed for supporting each enclosure. The internal layout shall be such that the impulse piping/ blowdown lines are accessible from back doors of the enclosure and the transmitters etc. are accessible from front side for easy maintenance. Gaskets shall be used between all mating sections to achieve protection class of IP-55.
- iii) The local instrument racks shall be free standing type constructed of suitable 3 mm thick channel frame of steel and shall be provided with a canopy to protect the equipment mounted in racks from falling objects, water etc. The canopy shall not be less than 3 mm thick steel, and extended beyond the ends of the rack. Bulk heads, especially designed to provide isolation from process line vibration shall be provided. Exact fabrication details shall be as finalised during detailed engineering stage. The junction box for racks also shall conform to IP 55 protection class.
- iv) Provision for continuous purging arrangement is to be made for all air and flue gas applications.



6.7 ELECTRIC POWER SUPPLY

6.7.1 General

The requirements of electric power supply system are specified herein on system basis. The contractor shall be fully responsible for engineering and furnishing a complete and operational system fully meeting the intent and requirements of this specification and purchaser approved drawings. All equipment and accessories required for completeness of this system shall be furnished by the contractor whether these are specifically mentioned herein or not. All the equipments and sub systems offered shall be from reputed experienced manufacturers. All system cabinets, enclosures and distribution boards shall be manufactured, assembled, wired and fully tested as a complete assembly as per the requirements of this specification at the manufacturer's works.

6.7.2 Power Supply Requirements

The power supply system shall be designed to meet the electric power requirements of various C&I systems including DDCMIS and shall be configured as described below:

- i) Three sets to meet the total DC load requirement each for SG-C&I system, TG-C&I system and for BOP-C&I and miscellaneous loads shall be provided.

Each of the above set shall comprise of 2x100% 24V DC batteries, 2x100% redundant chargers, 2 x 100% DC distribution boards etc. Bidder shall clearly bring out in the proposal the redundancy features along with necessary single line diagram, data sheets etc. and this shall be finalised during detailed engineering and subject to Purchaser's approval.

In case some other DC system (e.g. 48 V) is being supplied, similar configuration as described above for 24 V DC shall be provided.

- ii) For MMIPIS portion of DDCMIS including peripherals like TFT's, printers, disks etc. and other systems such as SWAS, panel instruments, vibration monitoring system, etc., requiring stabilised AC power, the Bidder shall furnish a redundant UPS system
- iii) For other SG/TG related instruments (clause 6.3), the power supply shall be derived from either the 24V DC or UPS as per specific requirement of the equipment supplier and as approved by Purchaser during detailed engineering.

The DC power supply system and UPS system in the above mentioned configurations employing float cum boost chargers, battery banks, static inverters, static switches. AC/DC distribution boards etc. shall meet the following specification requirements as a minimum.



6.7.3 DC Power Supply System (24 V)

6.7.3.1 Float cum boost chargers

- i) Each of the redundant chargers shall be sized to meet connected load requirements and keep the connected battery fully charged (float mode). In boost mode, each of the charger shall be able to re-charge the fully discharged battery within 8 hours. The exact sizing of the chargers shall be as approved by the purchaser during detailed engineering.
- ii) The chargers shall be self regulating, solid state silicon controlled, full-wave rectifier type designed for single and parallel operation with battery and shall have automatic voltage regulators for a close voltage stability even when AC supply voltage and DC load fluctuates, effective current limiting features and filters on both input and output to minimise harmonics. The charger output regulation shall be $\pm 1\%$ from no load to full load with an input power supply variation of $\pm 10\%$ in voltage and $\pm 5\%$ in frequency. In addition to indications on charger panel, potential free contacts for alarms like charger output voltage high, battery isolated, charger failed etc., shall also be provided for use in DDCMIS. Further isolated 4-20 mA signals shall be provided for important parameters like charger voltage etc. The list of alarm output and 4-20 mA signals shall be as approved by the purchaser during detailed engineering.
- iii) A selector switch "FLOAT/BOOST" mode shall be provided for either trickle charging the battery (while supplying the load) or boost charge the battery (isolated from load) respectively. In boost charging mode, the chargers shall operate in constant current mode building up the voltage across the battery to 1.6 V/ cell.

6.7.3.2 Batteries

The batteries shall be heavy duty Nickel-cadmium (Ni-cd) type and shall be sized for an hour of full load operation during non-availability of AC supply / chargers. The Ni-Cd batteries shall conform to IS:10918. For sizing calculation, an aging factor of 0.8 and a temperature correction factor of 0.935 (based on temperature characteristics curve to be submitted by the contractor and at a temperature of 4 deg. C). Capacity factor shall be taken into consideration, if applicable and ambient temperature shall be considered as the electrolytic temperature. The sizing of the battery shall be as approved by Purchaser during detailed engineering. However, bidder will consider a voltage drop of 4V from battery room to DCDB, while sizing the battery.

6.7.3.3 DC Distribution Board (DCDB)

Each of the connected load shall be supplied by redundant DC feeders. The exact design & number of feeders of the each redundant DCDB shall be as finalised during detailed engineering and as approved by the purchaser. However, 25% spare feeder (minimum one no.) with fuses for each rating shall be provided.



6.7.4 Uninterruptible Power Supply (UPS) System

The UPS system shall have 2x100% parallel redundant chargers and inverters, 1x100% battery bank, bypass line transformers and voltage stabiliser, static switch, manual bypass switch, AC/DC distribution boards, other necessary protective devices and accessories and shall meet the following requirements as a minimum.

6.7.4.1 The kVA rating of UPS shall be as required by expected loads and include 10% spare capacity guaranteed at 50 deg. C ambient. However, for bidding purpose, a minimum capacity of 90 KVA shall be considered. If UPS KVA rating is applicable at a lower ambient temperature than specified 50 deg. C, the Bidder shall consider a derating factor of at least 1.5%/deg.C for arriving at the specified UPS capacity at 50 deg. C ambient. The UPS shall have an over load capacity of 125 % rated capacity for 10 minutes and 150 % rated capacity for 10 seconds. The inverter shall have sufficient I^2t capability to clear fault in the maximum rated branch circuit. The sizing of UPS shall be based on the power factor of the loads being fed subject to a maximum of 0.8.

6.7.4.2 Each of the two sets of 2x100% redundant chargers shall be sized to meet the 100% UPS load plus recharge the fully discharged battery within 8 hours. Other features as mentioned in clause 6.7.3.1 above shall also be applicable.

6.7.4.3 The UPS battery shall have sufficient amp-hour capacity to supply 100% full load current of UPS for 60 minutes. For this, the UPS capacity to be considered as the finally selected UPS rating, irrespective of the actual load on UPS. A drop of 4V from battery room to the inverter input will be considered for design. The battery shall meet other specification requirements as per clause 6.7.3.2 above.

6.7.4.4 The UPS system shall be capable of operating without D.C. battery in circuit under all conditions of load and the performance of various components of UPS like inverter, charger, static switch etc. shall be guaranteed without the battery in circuit.

6.7.4.5 The UPS system design shall ensure that in case of failure of mains input power supply to one of the chargers, the other charger whose mains input power supply is healthy, shall feed to one or both the inverters as the case may be as per manufacturer's standard practice & continue to charge the D.C. battery at all load conditions. The Bidder should note that this situation should not in any way lead to the discharge of the D.C. Battery.

6.7.4.6 Static Inverters

- i) The static inverter shall be solid state type using proven pulse width modulation (PWM)/quasi square wave/step wave technique. The inverter equipment shall include all necessary circuitry and devices to conform to requirements like voltage regulation, current limiting, wave shaping, transient recovery, automatic synchronization etc. The steady state voltage regulation shall be $\pm 2\%$ and transient voltage regulation (on application/removal of 100% load) shall be $\pm 20\%$. Time to recover from transient to normal voltage



shall not be more than 50 m sec. Frequency regulation for all conditions of input supplies, loads and temperature occurring simultaneously or in any combination shall be better than $\pm 0.5\%$ (automatically controlled). The total harmonic content shall be 5% maximum and content of any single harmonic shall be 3% maximum. The inverter efficiency shall be at least 85% on full load and 80% on 50% load. The synchronisation limit for maintenance of synchronisation between the inverter and standby AC source shall be 48-52Hz, field adjustable in steps of 0.5 Hz.

- ii) The inverter shall be provided with suitable HRC fuses at the input and output which will permit proper coordination with other protective devices and at the same time protect the inverter against damage due to internal faults. However, if the Bidder's system design does not use fuses then the fuse free circuit breaker may also be permitted provided it meets the specification requirements. All necessary equipment shall be provided to protect the inverter against overload, short circuit and 100% loss of load. The inverter shall be self protecting against damage if energized with full load connected.
- iii) Inverter equipment shall include all solid state circuitry and devices including stable oscillator etc. to enable inverters to operate satisfactorily in parallel sharing mode each inverter taking 50% load during normal operation. In case of failure of either inverter, 100% load shall automatically be transferred to healthy inverter without any break and degradation in the quality of UPS output and disconnecting the faulty inverter automatically.
- iv) The inverter failure shall be alarmed and the healthy inverter shall get synchronizing signal from the standby AC source and remain synchronized within the set limits. The limits for the synchronisation between healthy inverter and standby AC source shall be field adjustable.
- v) On failure of both inverters, the loads shall be transferred to standby AC power without a break if within synchronisation limits. However, such transfer shall be inhibited, during operation of inverter on its internal oscillator, to standby AC source frequency being beyond the synchronisation limits. Provision of asynchronous transfer with a break in case of inverter being out of synchronisation limits shall also be there with standby source.

6.7.4.7 **Static Switch and Manual Bypass Switch**

The static switch shall be provided to perform the function of transferring UPS loads automatically without any break from (i) faulty inverter to standby AC source in case of failure of both the inverters and (ii) from faulty inverter to standby AC source in case of failure of both the inverters.

Manual bypass switch shall be employed for isolating the UPS during maintenance.

6.7.4.8 **Step Down Transformer and Voltage Stabiliser**

The transformer shall be of low impedance type and the rating shall be such that extremely fast fault clearance is achieved even in the largest rated branch circuit.



The overload capacity of the transformer/stabilizer shall not be less than 300% for 200 ms. The stabilizer shall employ silicon solid state circuitry and the output voltage regulation shall be $\pm 2\%$. The efficiency of the stabiliser shall be 95% or better.

6.7.4.9 AC Distribution Board (ACDB)

The details of the AC distribution board, i.e. exact design, number of feeders etc of the 2x100% ACDB shall be as finalised during detailed engineering and as approved by the purchaser. However, 25% spare feeders (minimum one no.) with fuses for each rating shall be provided.

6.7.5 Auxiliary Equipments

- i) All required auxiliary equipment/materials as finalised during detailed engineering shall be furnished with each charger, inverter, battery bank and shall include as a minimum various meters such as AC/DC voltage/current, kVA, power factor, frequency meters etc., circuit breakers, selector switches, push buttons indicating lights, ground detector system, battery accessories like inter cell connectors, inter step connectors, battery racks etc.. Further, isolated 4-20 mA signals for important parameters and potential free contacts for important alarms shall be provided for use in DDCMIS.
- ii) One complete set of all accessories and devices required for maintenance and testing of batteries shall be supplied for each unit. Each set shall include at least the following :

| | | |
|----|---|--------|
| a) | Hydrometer | 5 Nos. |
| b) | Set of hydrometer syringes suitable for the vent holes in different cells | 5 Nos. |
| c) | Thermometer for measuring electrolyte temperature | 5 Nos. |
| d) | Specific gravity correction chart | 5 Nos. |
| e) | Wall mounting type holder made of teak wood for hydrometer & thermometer | 5 Nos. |
| f) | Cell testing voltmeter (3-0-3 V) | 5 Nos. |
| g) | Alkali mixing jar | 5 Nos. |
| h) | Rubber apron | 5 Nos. |
| i) | Pair of rubber gloves | 5 Nos. |
| j) | Set of spanners | 5 Nos. |



| | | |
|----|--|---------|
| k) | No smoking notice for each battery room | 2 Nos. |
| l) | Goggles (industrial) | 5 Nos. |
| m) | Instruction card | 10 Nos. |
| n) | Minimum and maximum temperature indicator for battery room | 1 set |
| o) | Cell lifting facility | 1 No. |

6.7.6 Battery Racks

Two tier battery racks made of steel and painted with anti- corrosive epoxy paint construction in accordance with applicable codes and standard shall be provided. AISC specification shall apply in the absence of another design specification.

6.7.7 Load End Power Supply Distribution

Bidder shall provide power supply distribution boxes for sub-distribution of main UPS/ DC/ Utility feeder(s). These shall include necessary change over circuitry (if applicable), switch-fuse units, MCB, terminal blocks etc. suitable for the application.

Bidder shall furnish the power supply distribution scheme, single line diagram, all calculations such as charger/inverter rating calculations, battery sizing calculation etc., for DC system as well as for UPS during detailed engineering for Purchaser's review and approval.



6.8 ELECTRICAL ACTUATORS

Electrical actuators provided for valves and dampers shall meet with following requirements.

6.8.1 Type

- i) The actuators shall have integral starters alongwith overload relays with built in SPP (single phasing preventer). A 415, 3 phase 3 wire power supply shall be given to the actuator from contractor's switch board through a switch fuse unit. Control voltage of the motor starter shall be 110 V AC / 24 V DC, derived suitably from 415V power supply.
- ii) In case supplier's standard control voltage for open/close contactors is 110V AC, the same is acceptable if suitable opto - isolation circuit is provided with coupling relays for 24 V DC command inputs.

6.8.2 Interfaces

Open/close command termination logic with position and torque limit switches, positioner circuit shall be suitably built in the PCB inside the actuator.

- (a) For binary drive, open/close command and status thereof and disturbance monitoring signal (common contact for overload, thermostat, control supply failure, L/R selector switch at local, other protections operated) shall be provided.

Interface with the control system shall be through hardwired signal only. Interposing relays provided (with coil burden 2.5 VA) in the actuator shall be energized to initiate opening and closing, by 24V DC signal from the external control system.

- (b) For modulating drive, the command to actuator shall be in form of 4-20mA signal. The necessary positioning circuit and motor protection shall be provided
- (c) Open/close command termination logic shall be suitably built inside actuator.

6.8.3 Rating

- (a) Supply voltage & frequency: 415V +/- 10%, 3- phase, 3 wire 50Hz +/-5%.
- (b) Sizing for open/close at rated speed against designed differential pressure at 90% of rated voltage.



- (c) For isolating service, three successive open-close operations or 15 mins, whichever is higher. For regulating service, 150 starts per hour or required cycles, whichever is higher.

6.8.4 **Construction**

- a) Enclosures shall be totally enclosed weatherproof minimum IP-55 degree of protection
- b) Gear Train shall be made of metal (Fibre gears are not acceptable). Self-locking feature shall be provided to prevent drift under torque switch (where ever applicable) spring pressure when motor is de-energised.
- c) Manual wheel shall disengage automatically during motor operation.

6.8.5 **Motor**

- (a) Type
Squirrel cage induction motor, direct-on-line starting with starting current limited to six times the rated current.
- (b) Enclosure
Totally enclosed, self ventilated IP-55 degree of protection.
- (c) Insulation
Class B or better. Temperature rise 70 Deg C. over 50 Deg C ambient
- (d) Bearings
Double shielded, grease lubricated antifriction.
- (e) Earth Terminals
Two
- (f) Protection
Single phasing protection, overload protection, overheating protection through thermostat and wrong phase sequence protection shall be provided over and above other protection features standard to bidder's design. Suitable means shall be provided to diagnose the type of fault locally.

- 6.8.6 Four nos. (2 each in open and close position) position limit switches and two nos. (one in open and other in close direction) torque switches each having two nos. NO and two nos. NC contacts shall be provided. A single shaft shall actuate all contacts of limit switches at each position.



- 6.8.7 It shall be possible to operate the actuator locally also. Lockable local/remote selection shall be provided on the actuator
- 6.8.8 Position Indicator shall be provided for 0 to 100% travel
- 6.8.9 Position Transmitter (for modulating/inching type) shall be provided as required it shall be suitable for stabilized 4-20 mA signal, 2 wire inductive type, 24 volts DC operated.
- 6.8.10 Space heater of suitable rating shall be provided. The supply shall be derived from the main power supply available in the actuator



6.9 PROCESS CONNECTION PIPING

The bidder shall provide, install and test all required material for completeness of impulse piping system, sample piping system and air piping system as per the requirements of this clause on as required basis for the connection of instruments and control equipment to the process and make the system complete. However, the bidder shall furnish during detailed engineering all relevant drawings, material and technical specifications of various items service wise for Purchaser's approval.

All materials supplied shall be suitable for intended service, process, operating conditions and type of instruments used and shall fully conform to the requirements of this specification. The material offered by the bidder shall be from reputed, proven manufacturer.

6.9.1 Impulse Piping, Tubing, Fittings, Valves and Valve Manifolds

- i) All impulse pipes shall be of seamless type conforming to ANSI B36.10 for schedule numbers, sizes and dimensions etc. The material of the impulse pipe shall be same as that of main process pipe. For various applications specification of impulse pipe materials and associated fittings and valves shall be as given in Table –9.1 (Process Connection Piping) given at the end of this sub-section.
- ii) Stainless steel tube shall be provided inside enclosures and racks from tee connection to valve manifold and then to instrument. For high pressure/temperature applications (piping class A,B,C &D of the Table 9.1) the material shall be ASTM A 213 TP 316H and for other applications material shall be ASTM A 213 TP 316L. The wall thickness of the tube shall be in accordance with the ANSI B31.1 standard.
- iii) All fittings shall be forged steel and shall conform to ANSI B16.11. The material of forged tube fittings for shaped application (e.g. tee, elbow etc.) shall be ASTM A182 Gr. 316 H for high pressure/ temperature applications (as defined above) and ASTM A182 Gr. 316L for other applications. The material for bar stock tube fitting (for straight application) shall be 316 SS. Metal thickness in the fittings shall be adequate to provide actual bursting strength equal to or greater than those of the impulse pipe or SS tube, with which they are to be used.
- iv) The source shut-off (primary process root valve) and blow down valve shall be of 1/2 inch size globe valve type for all applications except for air and flue gas service wherein the source shut-off valve shall be 3/4 inch size gate valve to avoid frequent chocking. The disc and seat ring materials of carbon steel and alloy steel valves shall be ASTM A-105 and ASTM A-182, Gr. F22, hard faced with stellite (minimum hardness - 350 BHN.) The surface finish of 16 RMS or greater is required in the area of stem packing. The valve design shall be such that the seats can be re-conditioned and stem and disc may be replaced without removing the valve body from the line.



- v) The valve manifolds shall be of 316 stainless steel with pressure rating suitable for intended application. 2 valve manifold and 3 valve manifold shall be used for pressure measurements using pressure transmitters/ pressure switches and differential pressure transmitters/ switches respectively. 5 valve manifold shall be used for remaining applications like DP, flow and level measurements.

For Pressure/D.P gauges in fluid application two-way globe valve on each impulse line to the instrument and in air/flue gas application two way gate valve on each impulse line to the instrument shall be provided near the instrument. These shall be in addition to the three way gauge cock provided alongwith the pressure/D.P gauges.

6.9.2 Sample Piping System

- i) This shall include pipings, fittings, valves and accessories from tapping points upto SWAS conditioning panel located in SWAS room. All sample pipings shall be 3/4" Nb seamless type of material ASTM A213 TP 316 H, conforming to ANSI B36.19. The schedule number shall be suitable for the particular application.
- ii) All fittings shall be socket welding type and of material ASTM A182 F316H conforming to ANSI B 16.11.
- iii) Single and multi tubes shall run with the minimum number of changes in direction. Suitable identification tags shall be provided for easy check up and for proper connections.
- iv) The valves to be used in sample piping shall be of globe type, forged construction and stainless steel conforming to ASTM A182. The pressure and temperature ratings shall be as per ANSI B16.34. The valve design shall be such that the seats can be re-conditioned and stem and disc can be replaced without removing valve body from the line.

6.9.3 Air Supply Piping

- i) All pneumatic piping, fittings, valves, air filter cum regulator and other accessories required for instrument air for the various pneumatic devices/ instruments shall be provided.

This will include as a minimum air supply to pneumatically operated control valves, actuators, instruments, continuous and intermittent purging requirements of Local Instrument Enclosures (LIE) etc.

- ii) For individual supply line and control signal line to control valve, 1/4 inch size light drawn tempered copper tubing conforming to ASTM B75 shall be used. The thickness of copper tubing shall not be less than 0.065 inch and shall be PVC coated. The fittings to be used with copper tubes shall be of cast brass, screwed type.



- iii) All other air supply lines of 1/2 inch to 2 inch shall be of carbon steel hot dipped galvanized inside and outside as per IS-1239, heavy duty with threaded ends. The threads shall be as per ASA B.2.1. Fittings material shall be of forged carbon steel A234 Gr. WPB galvanized inside and outside, screwed as per ASA B2.1. Dimensions of fittings shall be as per ASA B16.11 of rating 3000 lbs.
- iv) For air supply to various devices mentioned above, the bidder shall provide 2 nos., 2 inch size GI pipe header with isolation valve, one for boiler area and one for turbine area. In the boiler area the 2 inch head shall be provided upto top most elevation of boiler floor and from this 2 inch header, 1 inch sub-header shall be branched off at each floor with isolation valve. From this 1 inch sub-header, branch line of 1/2 inch, with isolation valve shall be provided upto various devices. Similar air supply piping shall be done in the turbine area also. Similar system is to be followed for service air required for intermittent purging in the Local Instrument Enclosures (LIEs) etc.
- v) Instrument air filter cum regulator set with mounting accessories shall be provided for each pneumatic device requiring air supply. The filter regulators shall be suitable for 10 kg/ sq.cm max. inlet pressure. The filter shall be of size 5 microns and of material sintered bronze. The air set shall have 2 inch size pressure gauge and built in filter housing blowdown valve. The end connection shall be as per the requirement to be finalised during detailed engineering.
- vi) All the isolation valves in the air supply line shall be gate valves as per ASTM B62 inside screw rising stem, screwed female ends as per ASA B2.1. Valve bonnet shall be union type & trim material shall be stainless steel, body rating 150 pounds ASA. The valve sizes shall be 1/2 inch to 2 inch.
- vii) **Purge Air Connection for Air and Flue Gas Applications**
 - a) The continuous purging with instrument air shall be done, for all air and flue gas measurements excepting instrument air and service air instruments, at the process source connection end. Necessary arrangements required for continuous purging shall be provided inside all the air and flue gas enclosures.
 - b) For intermittent purging with service air, necessary arrangements inside all the air and flue gas enclosures shall be provided. The SS three way valve provided in the SS tubing shall be used for isolating the transmitter and connecting the service air quick disconnect line.

6.9.4 Installation and Routing

6.9.4.1 Instrument Piping System

- i) For steam and liquid measurements, the impulse pipe should preferably slope downwards from source connection to instrument and instrument shall be installed below the source point. If due to any reason instrument is installed



above the source point, the impulse pipe should slope upwards continuously and a 'pigtail' should be provided at the instrument to assure a water seal for temperature protection. For vacuum measurements instrument shall be installed above source point and impulse pipe should slope upwards.

- ii) Impulse piping for air and flue gas shall slope upwards and instrument shall be installed above source point. If this requirement cannot be met special venting or drain provision shall be provided with vent and drain lines alongwith isolation valves and other accessories including drain pipes. This drain is to be connected to plant drain through open funnel also.
- iii) All impulse piping shall be installed to permit free movement due to thermal expansion. Wherever required expansion loops shall be provided. Expansion joints shall be provided wherever required especially for impulse piping coming in the furnace area.
- iv) Special accessories such as condensing pots/ reservoirs shall be provided and installed wherever required. In any case condensing pots shall be provided for all level measurements in steam and water services, all flow measurement in steam services and flow measurements in water services above 120°C. For drum level measurement required balancing chamber shall be provided.
- v) Colour coding of all impulse pipes shall be done by the bidder in line with the colour coding being followed for the parent pipes.

6.9.4.2 **Instrument Air & Service Air Piping/ Tubing System**

Instrument air and service air headers and their branches with all associated fittings and accessories shall be provided for giving supply to all consumers, as per the requirements. Air piping shall be installed always with a slope of over 1/100 to prevent accumulation of water within the pipe.

Single and multi tubes shall run with the minimum number of changes in direction. Suitable identification tags shall be provided for easy checkup and for connections.

6.9.5 **Piping/ Tubing Support**

Impulse piping and sample piping shall be supported at an interval not exceeding 1.5 meters. Each pipe shall be supported individually using slotted angle mounted clamps with necessary fixtures. Tubing shall run in proper perforated trays with proper cover. Tubing shall be supported inside the trays by aluminium supports. Hangers and other fixtures required for support of piping and trays shall be provided, either by welding or by bolting on walls, ceilings and structures. Hanger clamps and other fastening hardware shall be of corrosion resistant metals and hot-dip galvanized.



6.9.6 Shop and Site Tests

i) General Requirements

The equipment and work performed shall be subject to shop and site test as per Owner's approved quality assurance plan.

Hydrostatic and pneumatic tests shall be performed on all pipes, tubings and systems and shall conform to ANSI B31.1.

ii) Hydrostatic Testing

All instrument piping/ tubing shall be hydrostatically tested upon completion of erection. The test pressure shall be 1.5 times the maximum process pressure. The test shall be performed either with the testing of associated process piping or without the associated process piping (by closing the root valve. In both the cases the instrument shall be isolated by closing the shut-off valve).

iii) Air Testing

All air headers & branch pipes shall be air tested by pressure decay method as per ANSI B31.1. Flexible hoses and short signal tubing shall be tested at normal pressure for leakage. Long signal tubing shall be tested by charging each tube with air at 2 kg/ sq. cm. through a bubbler sight glass. The boiler draft and vacuum piping shall be air tested by the same method as long signal tubing.



TABLE 6.9.1 Process Connection Piping

| <u>S.No.</u> | <u>System/Line Description</u> | <u>Piping Class</u> | <u>Impulse Pipe Material</u> | <u>Schedule (Size)</u> | <u>Materials for Fitting/Valve Body</u> | <u>Valve Stem Material</u> | <u>Rating of Piping/ Fittings</u> | <u>Pr. Class of Valve</u> |
|--------------|---|---------------------|-------------------------------|------------------------|---|----------------------------|-----------------------------------|---------------------------|
| i) | Main steam/ upstream of HP bypass and auxiliary steam pressure reducing valve | A | ASTM-A335 Gr.P-91/22 (Note-2) | XXS (1/2 inch) | (Note-3) | (Note-3) | 9000 lb | 3000 SPL |
| ii) | BFP discharge/superheater attemperator/ spray to PRDS | B | ASTM-A106 Gr.C | 160 (1/2 inch) | ASTM-A105 | ASTM-A-182 Gr.F6a | 6000 lb | 2500 |
| iii) | Reheater attemperator | C | ASTM-A106 Gr.C | 160 (1/2 inch) | ASTM-A105 | -do- | 6000 lb | 1500 |
| iv) | Hot reheat/ down stream of aux. steam press. reducing valve upto desuper heater/ Flash tank drain manifold. | D | ASTM-A335 Gr.P-91/22 (Note-2) | 160 (1/2 inch) | ASTM-A182 Gr.F-22 | (Note-3) | 3000 lb | 900 |
| v) | Cold reheat upto tee-off for HP bypass / extraction steam No. 5 to HPH | E | ASTM-A335 Gr.P-22 | 80 (1/2 inch) | ASTM-A182 Gr.F-22 | ASTM-A-182 Gr.F6a | 3000 lb | 800 |
| vi) | Cold reheat down steam of tee-off (HP Bypass) | F | ASTM-A106 Gr.C | 80 (1/2 inch) | ASTM-A105 | -do- | 3000 lb | 800 |
| vii) | BFP suction/ condensate system/ extraction to LPH/ ext-4 to BFP-T, deaerator/ auxiliary steam | G | ASTM-A106 Gr.B | 80 (1/2 inch) | ASTM-A105 | -do- | 3000 lb | 800 |



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| | | | | | | | | |
|-------|-------------------------------|---|---------------------|---------------|-----------------------|------|---------|-----|
| viii) | Air/ flue gas outside furnace | M | ASTM-A106 Gr.B/C | 80 (3/4 inch) | ASTM-A105 | -do- | 3000 lb | 800 |
| | Air/ flue gas inside furnace | N | ASTM-A335 Gr.P22 | 80 (3/4 inch) | ASTM-A182 Gr. F-22 | -do- | 3000 lb | 800 |

NOTE:

- 1 Rating of piping/fittings/valves etc. is subjected to the final design pressure & temperature during the detailed engineering.
- 2 In case temperature is more than 540 deg C, the material shall be P-91 only.
- 3 Material shall be compatible with that of the impulse pipe material and design parameter.



6.10 INSTRUMENTATION CABLES

6.10.1 General Requirements

- i) The bidder shall supply, erect, terminate and test all instrumentation cables for control and instrumentation equipment/devices/systems included under bidder's scope-
- ii) Any other application where it is felt that instrumentation cables are required due to system/operating condition requirements, are also to be provided by the bidder.
- iii) Other type of cables like co-axial cables for system bus, cables for connection of peripherals etc. (under Bidder's scope) are also to be furnished by the Bidder.
- iv) Bidder shall supply all cable erection and laying hardware like cable trays, supports, flexible conduits, cable glands, lugs, pull boxes etc. on as required basis for all the systems covered under this specification.
- v) In addition to above, bidder shall supply all the cables including co-axial cables for station Wide LAN interconnecting all the common plant, main plant & control system in Bidder's scope as well as the control systems supplied by Purchaser for DM plant, coal handling plant, ash handling plant and ash water recirculation system etc. Further, the instrumentation cables for interconnecting few nos. information signals from each of the common plant packages being supplied by purchaser for all signals of CW pump package to DDCMIS are also in the scope of bidder.

6.10.2 Instrumentation Cable Specifications

- 6.10.2.1 All the instrumentation cables i.e. twisted and shielded multipair cables, compensating cables, pre fabricated cables etc. shall be flame retardant low smoke (FRLS) type. The Cables shall be provided in non returnable drums. The drum length shall be 1000m (+/-5%) up to & including 8 pairs and 500 m (+/- 5%) above 8 pairs.
- 6.10.2.2 Voltage grade of the instrumentation cables shall be 225V (peak value).
- 6.10.2.3 All instrumentation cables covered in this specification shall comply with VDE 0815, VDE 0207, Part 4, Part 5, Part 6, VDE 0816, VDE 0472, SEN 4241475, ANSI MC 96.1, IS-8784, IS-10810 (latest editions) and its amendments read alongwith this specification.
- 6.10.2.4 The conductor shall be of minimum 0.5 sq.mm size, high conductivity, multi-stranded copper for all types of instrumentation cables .
- 6.10.2.5 The insulation of individual conductor shall be extruded PVC meeting the requirements of VDE 0207 Part 4 compound Y I3. The outer sheath of instrumentation cables shall be extruded PVC (compound YM1) as per VDE



0207 Part 5 and shall be of flame retardant low smoke (FRLS) type. The cable shall be provided with marking including manufacturer's name, insulation material, conductor size, no of pairs, voltage ratings, type of cable etc. Progressive sequential marking of the length of the cable at every one meter & progressive markings to read 'FRLS' at every 5 meters shall be provided on the outer sheath of all instrumentation cables. Pairs of Cables shall be identified by colour coding & colour banding. The colour of outer sheath shall be sky blue so that C&I cables are easily distinguished from other cables.

Fillers in multiple conductor cables shall be flame retardant and moisture resistant. Cable accessories such as harnessing components, markers, bedding, cable jointer, binding tape etc. shall also have flame retardant quality.

6.10.2.6 All instrumentation cables shall be provided with overall shielding. However multipair cables carrying analog signals shall be provided with individual pair shielding in addition to overall shielding. Shielding shall be of Aluminium-Mylar tape with 100% coverage and with atleast 20% overlapping. The thickness of individual pair shield shall be 28 micron (minimum) and that of overall shield shall be 55 microns (minimum). Separate drain wires for individual pair shield (wherever applicable) as well as overall shield shall be provided. Drain wire shall be of seven (7) strand 20 AWG (0.51 sq. mm) tin coated copper conductor. Maximum lay of individual twisted pair shall be 50 mm. Bidder to ensure that individual core diameter shall be suitable for maxi-termi connection. Insulation thickness of individual core shall be between 0.28 and 0.35 mm for 0.5 mm² cables and 0.35 to 0.45 mm for 1.31 mm² cables.

6.10.2.7 The outer sheath of the instrumentation cables shall meet the following minimum requirements:

- (i) An oxygen index of not less than 29% and a temperature index of not less than 250 deg. C as per ASTM D-2863.
- (ii) Maximum acid gas generation by weight as per IEC-754-I shall not be more than 20%.
- (iii) Smoke density rating shall not be more than 60% during smoke density test as per ASTM D-2843. The results of smoke density test shall be plotted on a curve indicating light absorption v/s time as per ASTM D 2843. The average area under the curve (smoke density rating) shall not be more than 60%.
- (iv) Complete cable assembly shall pass Swedish Chimney test as per SEN-4241475 and flammability test as per IEEE-383.

The thickness of outer sheath shall be as per the guidelines given in VDE 0816. Thickness of outer sheath shall not be less than 1.8 mm in any case. Allowable tolerance of overall diameter of the cables shall be +/-2 mm max.



over the declared value in technical data sheets. The variation in diameter and the ovality at any cross section shall not be more than 0.1 mm.

- 6.10.2.8 All instrumentation cables shall be suitable for continuous operation at 70 deg. C, except for high temperature resistant teflon insulated cables which shall be suitable for continuous operation at 205 deg. C. The cables shall be suitable for laying in wet or dry locations in trays, conduits, ducts, trenches and under ground buried installations.
- 6.10.2.9 The thermocouple extension cables shall be of single/multi pair, twisted & shielded, PVC insulated, FRLS PVC sheathed and compatible for the type of thermocouples employed. The material of conductor shall be as per ANSI MC-96.1.
- 6.10.2.10 All cables near high temperature zone like burner front devices, metal temperature thermo-couples on main steam & turbine casing etc. shall be high temp cables, which shall be terminated at a junction box in normal temperature zone. Thermocouple extension cables and copper conductor cables for high temperature applications shall be with insulation of individual conductor and outer sheath of extruded FEP (i.e., Teflon) as per VDE 0207 Part 6 and ASTM D 2116. The thickness of insulation shall be 0.5 mm nominal (i.e., 0.4 mm minimum). These cables shall be single/ multipair, twisted & shielded.
- 6.10.2.11 Cable parameters such as mutual capacitance between conductors, conductor resistance, insulation resistance, characteristic impedance, cross talk and attenuation figures at 20 deg. C (± 3 deg. C) for various types of cables as applicable shall be as specified under table 10.1.
- 6.10.2.12 Identification of the cores & pairs shall be done with suitable colour coding & band marking as well as by numbering of cores/pairs as per VDE: 0815. The details of colour coding etc. shall be as approved by Purchaser during detailed stage. Also refer table 10.2 for description of various type of cables.
- 6.10.2.13 The bidder shall furnish all documentary evidence including cross-sectional drawings, test certificates to substantiate the suitability of cables offered for different applications. The bidder shall also clearly bring out the application wise details for each type of cable offered.
- 6.10.2.14 All prefabricated cables shall have 10% spare cores which will not be connected to pin connectors.



TABLE- 6.10.1: CABLE PARAMETERS

| Conductor Size | | 0.5 sq.mm | | | |
|----------------|--|--|--------------------|--------------------|--------------|
| Parameter/Type | Type E,F | Type-G, I | Type A,B&C | | |
| (a) | Mutual capacitance at 0.8 kHz (max.) | 120 nF/Km. | 100 nF/Km. | 120 nF/Km. | 200nF/ Km. |
| (b) | Conductor Resistance (max.) | 73.4 ohm/km (loop) For Type F, 13.3 ohm/km (loop) for Type E | 73.4 ohm/km (loop) | 73.4 ohm/km (loop) | -- |
| (c) | Insulation Resistance (min.) | 100 M ohm/km | 100 M ohm/km | 100 M ohm/km | 100 M ohm/km |
| (d) | Cross-talk figure at 0.8 kHz (min.) | 60 dB | 60 dB | 60 dB | 60 dB |
| (e) | Characteristic impedance (max.) at 1 kHz | 320 ohm | 340 ohm | 320 ohm | -- |
| (f) | Attenuation at 1 kHz (max.) | 1.2 dB/Km for Type F 0.8 dN/Km For Type E | 1.2 dB/Km | 1.2 dB/Km | -- |



TABLE- 6.10.2

DESCRIPTION OF VARIOUS TYPES OF CABLES

| Type | Conductor size in sq. mm | Remark |
|-------------|--|--|
| A | 0.5 | Two pair shielded and twisted pair thermo-couple, extension cable, ANSI type KX, solid alloy conductor. |
| B | 0.5 | Two pair shielded & twisted thermo-couple, extension cable ANSI type SX, solid alloy conductor. |
| C | 0.5 | Two pair shielded & twisted heat resistant teflon insulation & outersheath thermo-couple extension cable ANSI type KX, solid alloy conductor. |
| E | 0.5 | Two pair individual pair and overall shielded twisted pair instrumentation cable for both analog and digital signal to be used from field mounted instruments to local junction box. |
| F | 0.5 | Multipair individual pair & overall shielded twisted pair instrumentation cable (4/8/12/ 36/48 pair) for analog signals with stranded copper conductor. |
| G | 0.5 | Multipair overall shielded & twisted pair instrumentation cable (4/8/12/ 24/48/64 pair) for binary signals with stranded copper conductor. |
| I | 0.5 | Type F cable/type G cable with heat resistant teflon insulation & outersheath for high temperature application. |
| S | As per specific standard/ requirement for each application | Multicore/ multipair shielded cable for system specific cables like conductivity type level, switches, system bus cable, flame scanner etc. as applicable. |

6.10.3 Instrumentation Cable Interconnection and Termination Philosophy

6.10.3.1 The cable interconnection philosophy to be adopted shall be such that extensive grouping of signals by large scale use of field mounted Group JB's



at strategic locations (where large concentration of signals are available, e.g. switchgear) is done and consequently cable with higher number of pairs are extensively used. JB's to be furnished under this specification shall be of 6/12/24/36/48/64/72/96/128/256 way. The material dimension and interior/ exterior colour of JB's shall be subject to Purchaser's approval. The details of termination to be followed is mentioned in the following table

TABLE- 6.10.3 :- CABLE TERMINATION TO BE FOLLOWED

| S.N. | APPLICATION | | TYPE OF TERMINATION | | TYPE OF CABLE |
|------|--|--|---|---|---------------|
| | FROM (A) | TO (B) | END A | END B | |
| 1 | Valves/dampers drives (Integral Junction box) | Marshalling cubicle/local group JB/ termination/ control cabinets/ system cabinets | Plug in connector | Post mounted Maxi termi/ cage clamp type. | G |
| 2 | Transmitters, Process actuated switches to be mounted in LIE/LIR | Integral Junction box of LIE/LIR | Plug in connector | Maxi termi/ cage clamp (Rail mounted) type. | F,G |
| 3 | RTD heads | Local junction box | Plug in connector | Maxitermi/ cage clamp (Rail mounted) type. | F |
| 4 | Thermocouples | CJC box | Manufacture 's | Screwed/cage clamp Type | A,B,C* |
| 5 | Local Junction box, CJC box, int. Junction box of LIE/ LIR/Group JB/ MCC/Swgr. | Marshalling cubicle/local group JB/termination/ control cabinets/system cabinets | Maxitermi/ cage clamp (Rail mounted) type. | Post moun ted Maxi termi/cage clamp type. | F,G |
| 6 | Local Junction box, MCC/swgr. | Group JB | Maxitermi/ cage clamp (Rail moun ted) type. | Maxitermi/ cage clamp (Rail moun ted) type. | F,G |
| 7 | Field mounted Instrument | Group JB | Maxitermi/ cage clamp (Rail moun ted) type. | Maxitermi/ca ge clamp (Rail moun ted) type. | F,G |



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| | | | | | | |
|----|--|---|--|--|---|---------------------------------|
| 8 | Marshalling cubicle/ termination cabinet | Electronic system cabinet | | Post mounted Maxi termi/cage clamp type. | Post mounted Maxi termi/cage clamp type. | F,G |
| 9 | UCP mounted equipments | Post mounted Maxi termi/cage clamp type | | Post mounted Maxi termi/cage clamp type. | Plug in connector/Cage clamp type (rail mounted). | F,G (with connector at one end) |
| 10 | DDCMIS/PLC cabinets | PC, Printers etc. | | Plug in connector | Plug in connector | Manufacturer Standard |
| | | | | | | |

Notes:

1. For Sl. No. 5, 6, 7 & 8, normally 10% spare core shall be provided
2. For analog signals individual pair shielding & overall shielding & for binary signals only overall shielding of instrumentation cables shall be provided.
3. *For high temperature application only.



6.10.4 Internal Panels/Cabinets/System Cabinets Wiring

- i) Internal panel/cabinet wiring shall be of multistranded copper conductor with FRLS PVC insulation without shield and outer sheath meeting the requirements of VDE 0815.
- ii) Wiring to door mounted devices shall be done by 19 strand copper wire provided with adequate loop lengths of hinge wire so that multiple door opening shall not cause fatigue breaking of the conductor.
- iii) All internal wires shall be provided with tag and identification nos. etched on tightly fitted ferrules at both ends in purchaser's approved format. All wires directly connected to trip devices shall be distinguished by one additional red colour ferrule.
- iv) All external connections shall be made with one wire per termination point. Wires shall not be tapped or spliced between terminal points.
- v) All floor slots of desk/panels/cabinets used for cable entrance shall be provided with removable gasketed gland plates and sealing material. Split type grommets shall be used for prefabricated cables.
- vi) All the special tools as may be required for solderless connections shall be provided by Bidder.
- vii) Wire sizes to be utilised for internal wiring.
 - (a) Current (4-20 mA) : 0.5 sq.mm.
low voltage signals (48V)
 - (b) Ammeter/voltmeter circuit, : 1.5 sq.mm.
control switches etc. for
electrical system.
 - (c) Power supply and internal : 2.5 sq.mm.
minimum illumination
(shall be as per load
requirement.)

6.10.5 Cable Installation and Routing

- i) All cables assigned to a particular duct/conduit shall be grouped and pulled in simultaneously using cable grips and suitable lubricants. Cables removed from one duct/conduit shall not be reused without approval of Purchaser.
- ii) Cables shall be segregated as per IEEE Std.-422. In vertically stacked trays, the higher voltage cable shall be in higher position and instrumentation cable shall be in bottom tier of the tray stack. The distance between instrumentation cables and those of other systems shall be as follows :



- a) from 11 kV/6.6 kV/3.3 kV tray system - 914 mm
 - b) from 415V tray system - 610 mm
 - c) from control cable tray system - 305 mm
- iii) Cables shall terminate in the enclosure through cable glands. All cable glands shall be properly gasketed. Fire proof sealing to prevent dust entry and propagation of fire shall be provided for all floor slots used for cable entrance.
- iv) All cables shall be identified by tag nos. provided in Purchaser's approved format at both the ends as well as at an interval of 5 meters.
- v) Line voltage drop due to high resistance splices, terminal contacts, insulation resistance at terminal block, very long transmission line etc. shall be reduced as far as practicable.
- vi) The cables emanating from redundant equipment/devices shall be routed through different routes.

6.10.6 Cable Accessories and Fittings

- i) Bidder shall supply and install all cable accessories and fittings like cable glands, grommets, lugs, termination kits etc. on as required basis.
- ii) Bidder shall furnish two completely new sets of cable termination kits like crimping tools, maxi-termi/wire-wrap tools etc. which are required for maintenance of the system.

6.10.7 Field Mounted Local Junction Boxes

- i) No. of ways 12/24/36/48/64/72/96/128 with 20% spare terminals.
- ii) Material and Thickness 4mm thick fibre glass reinforced polyester.
- iii) Type Screwed at all four corners for door. Door handle shall be of SS. Self locking with common key. Door gasket shall be of synthetic rubber.
- iv) Mounting clamps and accessories Suitable for mounting on walls, columns, structures etc. The brackets, bolts, nuts, screws, glands and lugs required for erection shall be of brass, included in Bidders scope of supply.
- v) Type of terminal Rail mounted maxi termi or cage-clamp type



- blocks suitable for conductor size upto 2.5 mm². A M6 earthing stud shall be provided.
- (vi) Protection Class IP:55 minimum

6.10.8 Conduits

All rigid conduits, couplings and elbows shall be hot dipped galvanised rigid mild steel in accordance with IS:9357 Part-I (1980) and Part-II (1981). The conduit interior and exterior surfaces shall have a continuous zinc coating with an overcoat of transparent enamel lacaner or zinc chromate. Flexible conduit shall be heat resistant lead coated steel, water leak, fire and rust proof. The temperature rating of flexible conduit shall be suitable for actual application.



6.11 MAINTENANCE AND CALIBRATION EQUIPMENT

- i) Maintenance and calibration equipment of proven type, as specified under this sub-section, shall be provided as a minimum by the Bidder. However any other equipment deemed necessary by the Bidder for maintenance and calibration of C&I devices/systems shall be included in Bidder's quoted price. The Bidder shall be responsible for supplying any necessary additions of tools as required for proper maintenance and calibration of the installed C&I devices/systems.
- ii) Electrical power supply requirement of the instruments offered under this sub-section shall be 240 V AC, 50 Hertz nominal, single phase, unless specified otherwise.
- iii) Microprocessor based instruments shall be offered wherever specified. The make, model, range and other technical features of the maintenance and calibration equipments shall be as finalised during detailed engineering. The Bidder shall be responsible for erection and commissioning of maintenance and calibration equipments and for setting up of the electronic & pneumatic C&I laboratory including provision of necessary furniture necessary for mounting of all equipment & working space, tables, chairs, trolleys etc. as finalised during detailed engineering. The laboratory shall be modular in design, enabling easy change of arrangement wherever applicable.
- iv) All the microprocessor based maintenance and calibration units should also have the provision for data logging facility for keeping calibration/maintenance records with proper communication facility for download these data on the laboratory PC.
- v) All required accessories for the maintenance and calibration equipments shall be included whether specifically indicated herein or not.
- vi) The following maintenance and calibration equipments as specified in this section shall be furnished common for both the units.

6.11.1 Test Bench

- i) Electronic Test Bench

One number electronic self contained test bench made of anodized aluminum for testing and repair of electronic instruments and gadgets shall be furnished. It shall be modular in design, enabling easy change of arrangement. The test bench shall be complete with power packs (AC and DC) receptacles, (AC/DC) meters digital multi meter etc. The various voltage levels, shall be finalized during detailed engineering. However, the minimum are indicated below:

- a) 0-260V, 1phase, 50 Hz, 10Amp for one socket.



- b) 240 V, 1phase, 50 Hz, 3 KVA stabilized having six sockets.
- c) ± 48 V D.C, 3A for 2 sockets.
- d) ± 24 V D.C, 6A for 2 sockets.
- e) ± 12 V D.C, 10A for 2 sockets.
- f) 0-60 VDC $\pm 0.02\%$, 1A for one socket.

ii) **Pneumatic Test Bench**

One number pneumatic test bench made of anodized aluminium, modular in design, enabling easy change of arrangement/layout as and when required, shall be provided for testing/calibration of pneumatic instruments/devices. The test bench shall be complete with valves, pressure gauges, filter regulators, overload protection feature etc.

6.11.2 Mechanical Items

i) **Dead Weight Tester:** one number

Dual range dead weight pressure gauge tester with all required accessories shall be provided for testing of pressure gauges. The measuring range shall be 1 - 600 kg/cm² with an accuracy not less than 0.03% other requirement shall be as per detailed engineering.

ii) **Vacuum Tester:** one number

Air operated dead weight type vacuum tester along with electrically operated vacuum pump and all required accessories shall be furnished. It shall have a measuring range of 15-1000 mm bar and an accuracy of $\pm 0.03\%$ or better.

iii) **Hydraulic Pressure Gauge Tester:** one number

A hydraulic pressure gauge tester comprising of primary pump using light hydraulic mineral oil shall be furnished to compare the gauge under test with a standard test gauge for pressures up to 1200 kg/cm². The accuracy shall be $\pm 0.05\%$ of full scale. Gauge connection shall be 1/2", 1/4" & 1/8" NPT. All required accessories are to be supplied.

iv) **Portable Hydraulic Pressure Generator:** one number

Portable hydraulic pressure generator comprising of two stage pump using light hydraulic oil shall be provided to generate pressure of approx. 15 bar (1st stage) and 700 bar (second stage). Provision for mounting standard pressure gauge and five volume adjustment shall be there with the unit.



v) **Portable Pressure Calibrator:** two numbers

It shall be microprocessor based and operated by rechargeable battery and by 240 AC, single phase, 50 Hz. Accuracy shall be $\pm 0.05\%$. Overpressure protection & indication shall be provided. Tentative pressure range shall be (-)1.06 bar to 1000 bar (subject to finalisation during detailed engineering). All required accessories to be provided.

vi) **Manometers**

a. Test Manometers (Mercury well type): two numbers

It shall have 1500 mm extended transparent plastic tube. Scale shall be compensated for liquid level changes and shall be graduated in mm of Hg and kg/cm². Body shall be made of steel. Test pr. to be 17.5 kg/cm². All accessories to be provided.

b. U-Tube Manometers (Mercury filled) : two numbers

Manometer shall be clear plastic U tube/ Borosilicate glass tube. The scale range shall be (-) 1000-0-1000 mm having 1mm smallest division and zero adjustment facility. All wetted parts shall be 304SS. All required accessories to be provided.

vii) **Secondary Standard Quality Pressure Gauges:**

The bidder shall provide 2 sets of secondary standard quality pressure gauges of each range as required for comparing different gauges in the Bidder's scope. Accuracy shall be $\pm 0.25\%$ of full scale or better.

viii) **Air Sets :** 4 numbers

Input - 6 - 7 kg/cm² as per Instrument Air system.

Output - As required by Instrument/drive

Filter - 5 micron.

ix) **Portable Electro-Pneumatic Calibrators:** two numbers

The electro-pneumatic calibrator shall be microprocessor based and used for calibration of electronic and pneumatic instrumentation as supplied by the Bidder. These shall have accuracy of $\pm 0.05\%$ & shall be complete with all adapters & accessories. 4 - 20 mA DC output to be provided for E/P converter and E/P converter output should also be measured by it. Power supply shall be (i) rechargeable battery and (ii) 240 V, 1 phase, 50 Hz.



- x) **Fluidized Temperature Bath** : one number
- The temperature bath shall be microprocessor based and shall have fully controlled temperature range of 100 to 600 deg. C. Temperature stability shall be ± 0.2 deg.C or better over whole range.
- xi) **Thermocouple Test Furnace** : one number
- This furnace shall be microprocessor based and used for precise comparison of upto 6 test thermocouples with a checking thermocouple upto a maximum temperature of 1200 deg.C. It shall be suitable to make temperature checks with least uncertainty of about ± 1 deg. C over the full range.
- xii) **Barometers** : two numbers
- The Bidder shall furnish precision aneroid barometers, accurate to $\pm 0.3\%$ of full scale or better. Dial size shall be 150 mm. Graduation shall be 0.5 mm and range shall be as per detailed engineering.
- xiii) **Mercury Thermometers** : two sets of approximately 12 nos. each
- These shall cover a temperature range of -10 deg.C to 600 deg.C. Various split ranges shall be as per detailed engineering.
- xiv) **Flowmeter Calibrators** : three numbers
- One each for the ranges 0-1000mm WCL, 0-6000mm WCL & 0-30,000mm WCL. Type shall be finalized during detailed engineering. and will be subject to Purchaser approval.
- xv) **Portable Tachometer**: one number
- It should be latest proven non contact type suitable upto 6000 RPM.
- xvi) **Coil Winding Machine** : one number
- It shall be single phase motor driven with all accessories to wind wires of dia 0.001" to 0.036".
- xvii) **Stop Watches** : three numbers
- It shall have provision of Analog & Digital display.
- xviii) Precision instrument radial drilling machine with all standard tools.(1 no.)
- xix) Jewelers lathe, with provision for screw cutting, precision cutting and other related mechanical work, with all necessary accessories & CAD/CAM software. (1 no.)



- xx) Standard tool box for instrument maintenance work. (2 sets)
- It shall comprise of multi purpose screw drivers, Ratchet screw drivers, star screw drivers, spanners, cutters, pliers, allen keys (all type), Nose plier, Rough & smooth files, slide & pipe wrench etc.
- xxi) **Wet & dry bulb hygrometer:** Two numbers
Measuring range shall be 20% - 100% with digital indication. Accuracy shall be $\pm 0.2\%$.
- xxii) **Soldering/ desoldering station:** Two numbers
- Precision type with built in temperature controller. All required accessories shall be provided.
- xxiii) **Vacuum pump :** One number complete with vacuum gauge (0-760 mmHg) shall be able to provide vacuum of 3×10^{-2} mbar or better. It should be provided with all accessories.
- xxiv) **Solder sucker** - Three numbers.
- xxv) **Motor & Hand operated wire wrap tools** - 1 number of each type with all accessories and suitable for various pin size used.
- xxvi) **Maxitermi Guns** :- 3 nos. electrically operated + 3 nos. hand operated. It should be suitable for various sizes of maxitermi type connection specification such as length, width and shall be as finalised during detailed engineering.

6.11.3 Electrical Items

- i) **Digital Multimeters**
- Quantity : 3½ digit handheld - 10 nos, 4½ digit handheld - 4 nos. and 4½, 5½, 6½ Desk top model - 2 nos. each.
- Type, signal & ranges shall be as per detail engineering. subject to Purchaser approval. Input resistance shall be 10 M ohm , ambient temp. shall be 0-50°C.
- ii) **Portable Current Calibrator** : five numbers
- This instrument shall be microprocessor based and provide an accurate and reliable measurement of milliamp signals and shall generate milliamp signals for use in calibrating receiver type instrumentation. Accuracy shall be $\pm 0.05\%$ of selected span or better. CMRR (DC to 50 Hz) of 0.1 micro Amp/ volt and ambient temp. errors of 0.0005% per °C. The instrument should be powered by (i) 240 V, 1 phase, 50 Hz & (ii) by self contained rechargeable battery. The selectable input & output range shall be 0-10/ 0 - 100 mA DC with built in auto overload protection.



- iii) **Portable Millivolt Calibrator** : five numbers
- This instrument shall be microprocessor based and provide an accurate and reliable measurement of millivolt/ thermocouple signals and shall generate millivolt signals for calibration of receiver type instrumentation. Accuracy shall be $\pm 0.02\%$ of selected span or better. The instrument should be powered by (i) 240 V, 1 phase, 50 Hz and (ii) by self contained rechargeable battery. The selectable input & output range shall be 0-10 mv/ 0-100 mv/ 0-1000 mvDC. CMRR (DC to 50 Hz) shall be 120 db and ambient temp. error shall be $\pm 0.005\%$ per 1°C .
- iv) **Resistance Thermometer Bridge** : two numbers
- This instrument shall provide measurement of resistance values for verification of RTD elements and receiver instrumentation. The resolution and accuracy shall be 0.001 ohms and $\pm 0.005\text{ohm}$ or better respectively. The range shall be 0-1000ohms.
- v) **Decade Resistance Box** : two numbers
- This variable resistance device shall provide an accurate resistance source for calibration of RTD elements and receiver devices. Accuracy shall be $\pm 0.05\%$ or better. Resistance range shall be 0-100 K ohm and increments shall be 0.1 ohm.
- vi) **Variac**: One number
- Light weight variac, providing variable voltage upto 500 V shall be provided. Input shall be 415V, 3 phase, 50 Hz.
- vii) **Rheostat/Potentiometer** : Ten numbers
- Two nos. each of following ratings :
- 18 Amps, 1 Ohm; 15 Amps, 1.4 Ohms; 12 Amps, 3 Ohms; 8.5 Amps, 6.5 Ohms; 5 Amps, 18 Ohms. They shall be wire wound continuously variable type. The insulation resistance shall be more than 5 M ohms at 500 VDC between terminal & case.
- viii) **Test Resistance Temperature Detectors** Two numbers
- The resolution be 0.001°C and range shall be 0 to 1000°C .
- ix) **Portable Thermocouple/RTD calibrator/simulator** : One number
- This microprocessor based instrument shall be used for calibration/ simulation of thermocouples /RTDs as supplied by the Bidder. The linearisation accuracy shall be ± 0.01 of reading or better and calibration accuracy shall be $\pm 0.05\%$ or better. Range shall be as per detailed engineering. it should be suitable for 240V, 1phase, 50 Hz power supply and (ii) rechargeable type batteries. All accessories to be provided.



x) **Portable Multi-Function Counter** : One number

The Bidder shall furnish microprocessor based and crystal-controlled oscillator based, dual channel multi-function counter to measure frequency, period, frequency ratio, time interval and unit count. The accuracy for frequency shall be ± 1 count \pm time base error.

xi) **Digital Storage Oscilloscope** : One number

Latest proven two channel, digital storage oscilloscope will be supplied for the instrument shop. All required accessories including probes shall be provided.

xii) **Power Pack** : Two numbers

Two numbers of highly stabilized, solid state, power supply packs with over voltage/current limiting output protections shall be provided for output range of 0-60 VDC regulation shall be 0.01% or better.

xiii) **Portable Vibration Meter**: One number

This instrument shall be of latest & proven design capable of measuring vibration of machinery in terms of displacement, velocity and acceleration. Power supply shall be (i) 240V, 1 ohm, 50 Hz and (ii) rechargeable batteries. All required accessories shall be provided. The displacement, velocity & acceleration ranges shall be 0-3000 microns, 0-300 mm/sec and 0-100 mm/sec² respectively.

xiv) **Portable Vibration Analyzer/Dynamic Balancer** : One number

This instrument shall be of latest & proven design and will be powered by a self contained rechargeable battery pack and shall be designed to operate also from a 240V AC, 50 Hz , 1 phase power supply with the battery pack removed.

This shall have frequency range of 50 to 500000 cpm and vibration range in terms of displacement/velocity/acceleration shall be 0-3000 microns/0-3000 mm/sec/0-1000gs respectively. All required accessories shall be provided. Outputs shall be in terms of built in XY plotter, diagnostic & message printout, analog amplitude & frequency meter.

xv) **RCL Bridge** : One number

Microprocessor based RCL bridge shall be provided. The measurement accuracy shall be $\pm 0.5\%$ of reading or better. R,C,L range shall be as per detailed engineering.



- xvi) **pH Simulator** : One number
- Range: 0 -14 pH in steps of 1 pH, Accuracy: +/-0.01 pH. Power supply shall be (i) 240 VAC, 1 phase, 50 Hz and (ii) rechargeable battery. All accessories to be provided.
- xvii) **Multi-channel Simulation Unit (Analog)** : Three number
- Number of channels: 20, Accuracy : +/- 0.1% of span. Output voltage shall be as per detailed engineering. The channel shall have in individual potentiometer to set the output at desired magnitude and shall also have vernier settings to set the output in millivolt.
- xviii) **Digital Channel Simulator** : Three number
- Number of channels : 40, Status selection by toggle switches. It shall produce digital output of 0 to 5 V provision for free output contacts for on/off status to be also provided.
- xix) **Logic Probe, Quantity** : four numbers
- It should test all digital circuits based on CMOS, TTL, DTL etc. other specification shall be as per detailed engineering.
- xx) **Function Generator**: one number
- a) Waveforms - Sine, square, triangle, pulse and ramp with variable symmetry.
 - b). Symmetry- 10% to 90%, 1% step, +/- 2% accuracy
 - c) Frequency- Range : 0.002 Hz to 20 MHz Accuracy : (a) Continuous mode - +/-0.1%; (b) Trigger, gate, burst modes - +/- 0.1% (for freq. less than or equal to 200 Hz) & +/- 5.0% (For freq. more than 200 Hz)
 - d) Resolution : Continuous mode - 4 digits.
 - e) Amplitude range : 20 mv to 20 Vp-p (open ckt).
: 10 mv to 10 Vp-p (50 ohm load).
- xxi) **Logic Analyzer**
- Two numbers microprocessor based latest proven type of portable logic analyzers, which are highly flexible, (so that they can be connected to many different circuit points easily and also to provide a clear visual display for the user), shall be furnished. Specification shall be as per detail engineering. All required accessories to be provided.



- xxii) **Portable infrared thermometer** : One number
- Range shall be from 900 to 1600 deg C with resolution of 1deg C. Accuracy shall be $\pm 1\%$ of full scale. Power supply shall be (1) 240V, 1 phase, 50 Hz & (2) chargeable battery. all required accessories to be provided.
- xxiii) **Clip on AC power meter** : One number
- Range shall be 20-600 vrms, 0.2-20A rms, 0.2-20 KW and accuracy shall be $\pm 1\%$ of rdg $+0.5\%$ of range. Display shall be 3 1/2 digit LCD. All accessories to be provided.
- xxiv) **Portable gas analyzer**: one number
- It shall be latest proven type. various measurements such as O₂, CO, NO_X, SO₂, opacity etc. shall be as per detailed engineering. only.
- xxv) DDCMIS Modules Testing kit for complete diagnostic testing of DDCMIS modules in addition to built in diagnostics present in DDCMIS. The facilities shall include functional processor test, working memory test, communication controller test, I/O modules test as a minimum.
- xxvi) **Digital insulation tester** : two numbers
- It should measure upto 100 M ohm at 500 V.
- xxvii) **EPROM Programmer** : one number
- Latest proven universal type PC based EPROM programmer with necessary software & hardware. It shall be possible to burn & reprogram all types of chips used in various microprocessor based system : All required accessories to be provided.
- xxviii) **Laboratory PC** : one no.
- The laboratory PC shall be with latest configuration.. In addition, suitable connectors and associated software(s) for downloading of logged data from various maintenance & calibration instruments shall also be provided.

6.11.4 Other Items for the Laboratory

- | | | | |
|----|--|---|-------|
| a) | Engraving Machine | : | 1 no. |
| b) | Photocopying Machine, light duty light duty with facility for A3/A4 size enlarging/ reduction, autofeed & multicopying | : | 1 no. |
| c) | Drawing Laminator | : | 1 no. |



6.12 PLC BASED MISCELLANEOUS CONTROL SYSTEMS

6.12.1 General Requirements

- i) Contractor shall provide complete and independent PLC based Control and Instrumentation system with all accessories, auxiliaries and associated equipments and cables for the safe, efficient and reliable operation of the following plant auxiliary systems mentioned below.

- a) Turbine Lube Oil Purification System
- b) Central Lube Oil Purification System
- c) Condensate Polishing System
- d) Any other such standalone system

- ii) Bidder shall include in his proposal all instruments and devices, which are needed for the completeness of the system. Same shall be subject to approval of the purchaser during detailed engineering.

All instruments and control equipments like primary and secondary instruments etc. shall meet the requirements specified in sub-section on Measuring Instruments. In addition, all electrical instrument devices like switches/transmitters/ controllers/ analysers/ solenoid valves which are located in the field/hazardous locations shall be provided with explosion proof enclosure suitable for hazardous areas described in National Electric Code (USA), Article 500, Class-I, Division-I. All field wiring should be through conduits. All fittings, cable glands etc. shall be strictly as per NEC recommendation article, 500 to 503.

ON/OFF control, indication, annunciation of incomers and bus-coupler are also to be performed from contractor's control system for each of the above system as applicable.

The control system shall be able to operate in non-air conditioned area and shall meet the minimum requirements as specified below.

6.12.2 Programmable Logic Based Control System

- i) PLC Processor

The processor unit shall be capable of executing the following functions:-

- a) Receiving binary and analog signals from the field and operator initiated commands from OWS/ control panel.
- b) Implementing all logic functions for control, protection and annunciation of the equipment and systems.
- c) Implementing modulating control function for certain application as specified elsewhere in the specification.



- d) Issuing control commands.
 - e) Providing supervisory information for alarm, various types of displays, status information, trending, historical storage of data etc.
 - f) Performing self-monitoring and diagnostic functions.
-
- ii) The controller shall provide all basic functions for binary gating operations, modulating controls, storage, counting, timing, logging, transfer operations and comparison functions. The Contractor in his bid shall submit full details regarding various functions alongwith expansion capability.
 - iii) The programmable system shall be delivered completely programmed for the complete and reliable operation of the plant.
 - iv) Each PLC unit shall be provided with two processors (Main processing unit and memories) one for normal operation and one as hot standby. In case of failure of working processor, there shall be an appropriate alarm and simultaneously the hot standby processor shall take over the complete plant operation automatically. The transfer from main processor to standby processor shall be totally bumpless and shall not cause any plant disturbance whatsoever. In the event of both processors failing, the system shall revert to fail safe mode. It shall be possible to keep any of the processors as master and other as standby. The standby processor shall be updated in line with the changes made in working processor.
 - v) The memory shall be field expandable. The memory capacity shall be sufficient for the complete system operation and have a capability for at least 20% expansion in future. Programmed operating sequences and criteria shall be stored in non volatile semi conductor memories like EPROM. All dynamic memories shall be provided with buffer battery back up which shall be for at least 360 hours. The batteries shall be lithium or Ni-Cd type.
 - vi) The PLC system shall be provided with necessary interface hardware and software for dual fibre optic connectivity & interconnection with station wide LAN for two - way transfer of signals for the purpose of information sharing. The plant information shall be made available through an OPC compliant Ethernet link following TCP/IP standard. The exact data structure shall be as decided during detailed engineering. All required plant data shall be transferred to/from through this ensuring complete security. The exact number of points to be transferred through the above communication link and the format of the data shall be finalised during detailed engineering.
 - vii) Two (2) nos latest version of PC based Operator Work Stations (OWS) each with 19" color TFT's and key boards shall be provided for control & monitoring and programming function. One no. number heavy duty A3 size color inkjet printer shall be provided along with operator work station.

PC based OWS shall perform control, monitoring and operation of all auxiliaries/ drives interacting with PLC based control system. It shall be possible to use the same as programming station of the PLC. It shall basically perform the following functions.



In case the PC based OWS can not be used as programming station of the PLC, then a separate PC based programming station shall be provided.

- a) Operator interface for PLC based control system. Operator functions shall as minimum include local/ remote selection, A/M selection, open/ close operation, sequence auto, start/ stop selection, ON/OFF, bypassing criteria etc.
- b) Supervisory functions like:-
Mimic displays, which shall depict the process in graphical form and shall cover all the process areas being monitored.

Alarm monitoring/reporting, generation of logs, calculations, printing of logs & reports etc.

- c) Suitable Interface with stations wide LAN (In Purchaser's Scope) for two-way transfer of data.
- viii) Programming station shall have access to the processor of the control system for programming. Programming shall not require special computer skills. On the programming console, it shall be possible to do the programming, self-diagnostics, testing of sequence, simulation and any sequence modification.

Programming shall be possible in any of the following formats :

- a) Flow-chart or block logic representing the instructions graphically.
- b) Ladder diagrams.

A forcing facility shall be provided for changing the states of inputs and outputs, timers and flags to facilitate fault finding and other testing requirements. It shall be possible to display the signal flow during operation of the program. Programming shall be possible OFF line.

A NORMAL / TEST / PROGRAM / OFF lockable selector switch shall be provided. In case of test mode of operation, all outputs should be blocked.

- ix) Provision shall be made for erasing and duplicating the user program and long term storage facilities shall be provided with the help of mag. Tape cartridge or EPROM.
- x) Manual intervention shall be possible at any stage of operation. Protection commands shall have priority over manual commands and manual commands shall prevail over auto commands.
- xi) In PLC controller, memory should exist as to where the sequence was aborted due to power supply failure so that further operation from that point can restart after power supply restoration. This restart after recovery of the power supply shall be through operator intervention so as to enable verification of readiness of other related equipments.



- xii) All necessary software required for implementation of control logic, operator station displays / logs, storage & retrieval and other functional requirement shall be provided. The programs shall include high level languages as far as possible. The contractor shall provide sufficient documentation and program listing so that it is possible for the Purchaser to carry out modification at a later date.
- xiii) The Contractor shall provide all software required by the system for meeting the intent and functional/parametric requirements of the specification.
 - a) Industry standard operating system like UNIX/WINDOWS NT etc. to ensure openness and connectivity with other system in industry standard protocols (TCP-IP/ OPC etc.) shall be provided. The system shall have user oriented programming language & graphic user interface.
 - b) All system related software including Real Time Operating System, File management software, screen editor, database management software. On line diagnostics/debug software, peripheral drivers software and latest versions of standard PC-based software and latest WINDOWS based packages etc. and any other standard language offered shall be furnished as a minimum.
 - c) All application software for PLC system functioning like input scanning, acquisition, conditioning processing, control and communication and software for operator interface of monitors, displays, trends, curves, bar charts etc. Historical storage and retrieval utility, and alarm functions shall be provided.
 - d) The Contractor shall provide software locks and passwords to Purchaser's engineers at site for all operating & application software so that Purchaser's engineers can take backup of these software and are able to do modifications at site.

6.12.3 Input/Output Modules

- i) The PLC system should be designed according to the location of the input/output cabinets as specified.
- ii) Input Output modules, as required in the Control System for all type of field input signals (4-20 mA, RTD, Thermocouple, non change over/change over type of contact inputs etc.) and outputs from the control system (non change over/change over type of contact, 24/48 VDC output signals for energising interface relays,4-20 mA output etc.) are to be provided by the Contractor.
- iii) Electrical isolation of 1.5KV with optical couplers between the plant input/output and controller shall be provided on the I/O cards. The isolation shall ensure that any inadvertent voltage or voltage spikes (as may be encountered in a plant of this nature) shall not damage or mal-operate the internal processing equipment.
- iv) The Input/output system shall facilitate modular expansion in fixed stages. The individual input/output cards shall incorporate indications on the module front panels for displaying individual signal status.



- v) Individually fused output circuits with the blower fuse indicator shall be provided. All input/output points shall be provided with status indicator. Input circuits shall be provided with fuses preferably for each input, alternatively suitable combination of inputs shall be done and provided with fuses such that for any fault, fuse failure shall affect the particular drive system only without affecting other systems.
- vi) All input/output cards shall have quick disconnect terminations allowing for card replacement without disconnection of external wiring and without switching of power supply.
- vii) The Contractor shall provide the following monitoring features:
 - a) Power supply monitoring.
 - b) Contact bounce filtering.
 - c) Optical isolation between input and output signals with the internal circuits.
 - d) In case of power supply failure or hardware fault, the critical outputs shall be automatically switched to the fail-safe mode. The fail-safe mode shall be intimated to the successful Contractor during detailed engineering.
- viii) Further, keying-in of individual wire connectors shall be provided to ensure that only the correct card is plugged on the I/O module. It shall be possible to remove I/O module without disconnecting wiring from field inputs or outputs. There shall be atleast 20% spare capacity available on input, output and memory modules, over and above the system requirement.
- ix) Binary Output modules shall be rated to switch ON/OFF coupling relays of approx. 3 VA at 24 VDC. Analog output modules shall be able to drive an load impedance of 500 Ohms minimum.
- x) Output module shall be capable of switching ON/OFF inductive loads like solenoid valves, auxiliary relays etc. without any extra hardware.
- xi) Only one changeover contact shall be provided in MCC for control and interlock requirement. Further multiplication, if required, shall be done by the contractor in PLC system.
- xii) All input field interrogation voltage shall be 24V DC or 48 V DC.
- xiii) In case of loss of I/O communication link with the main processing unit, the I/O shall be able to go to predetermined fail safe mode (to be decided during detailed engineering) with proper annunciation.
- xiv) Contractor shall provide for 20% spare I/O modules in each system cabinet to take care of any further addition.



6.12.4 Printer

One number A3 size color inkjet printer per PLC shall be provided as a part of the supervisory system. It shall print out all alarm/trip conditions and event changes in plant status along with date and time of occurrence. The time least count for event recording shall not be more than 100 milliseconds.

6.12.5 Data Communication System (DCS)

The DCS shall include a redundant System Bus with hot back-up and other applicable bus systems like cubicle bus, local bus, I/O bus etc.

The DCS shall have the following minimum features :

- a) Redundant communication controllers shall be provided to handle the communication between I/O Modules (including remote I/O) and PLCs and between PLCs and operator work station.
- b) The design shall be such as to minimise interruption of signals. It shall ensure that a single failure anywhere in the media shall cause no more than a single message to be disrupted and that message shall automatically be retransmitted. Any failure or physical removal of any station/module connected to the system bus shall not result in loss of any communication function to and from any other station/module.
- c) If the system bus requires a master bus controller philosophy, it shall employ redundant master bus controller with automatic switchover facility.
- d) Built-in diagnostics shall be provided for easy fault detection. Communication error detection and correction facility shall be provided at all levels of communication. Failure of one bus and changeover to the standby system bus shall be automatic and completely bumpless and the same shall be suitably alarmed/ logged.
- e) The design and installation of the system bus shall take care of the environmental conditions as applicable.
- f) Data transmitting speed shall be sufficient to meet the responses of the system in terms of displays, control etc. plus 25% spare capacity shall be available for future expansion.
- g) Passive coaxial cables or fibre optic cables shall be employed.

The Contractor shall furnish details regarding the communication system like communication protocol, bus utilisation calculations etc.



6.12.6 System Reaction Time

The reaction time of the programmable control system from input signals at the input cards to output of the associated signals or commands of the output card inclusive of programmed logic processing, comprising a mixture of logic gates, arithmetic operations and other internal operations shall be less than 250 milli seconds under the most arduous control system operating conditions. However, for specific applications, it shall be less than 100 milli seconds.

6.12.7 Operator Interface Displays/Logs

Suitable displays and reports for control operation & monitoring shall be provided. The details shall be finalised during detailed engineering stage.

6.12.8 Control & Power Supply Scheme

- i) For PLC system, redundant 24 V DC power supply shall be provided by the contractor. Necessary redundant transformers and redundant chargers with 24 V DC battery back-up shall be provided by the Contractor to derive power supply from 415 V, 3-phase redundant incomers to be provided by Purchaser at the input terminals of Power supply cabinets. The Contractor shall, however, furnish all required hardware/ equipment/ cubicles for conversion and/or stabilisation of the power source provided by the Purchaser to all other levels which may be necessary for meeting the individual requirements of equipments/ systems furnished by him within the Contractor's quoted lumpsum price.

For separately mounted I/O racks, separate power supplies shall be provided. Power supply module shall be of ample capacity to supply all modules. In addition 20% spare capacity for future shall be provided. All the drives shall be switched ON/OFF through 24V DC coupling relays to be provided in HT/LT SWGR panels. Power supply distribution from Contractor's power supply cabinets shall be in the scope of Contractor. The exact power supply scheme shall be as approved by Purchaser during detailed Engineering stage.

- ii) Each set of PC along with TFT shall be provided with smart type line interactive UPS with software & hardware for remote management along with features of surge suppression & AVR facility by the Contractor. The UPS shall be of sufficient capacity of at least 30 minute at machine load.
- iii) The battery shall be sealed maintenance free Ni-Cd type or Plante type Lead Acid batteries with long life and shall be able to provide a back-up for one hour at full load requirement of the complete control system.

6.12.9 Control Cabinets / Panels / Desks

- i) The cabinets shall be IP-22 protection class. The Contractor shall ensure that the packaging density of equipment in these cabinets is not excessive and abnormal temperature rise, above the cabinet temperature during normal operation or air-conditioning failure, is prevented by careful design. This shall be demonstrated to the Purchaser during the factory testing of the system. The Contractor shall ensure that the temperature rise is limited to 10 deg. C above ambient and is well within the safe limits for system



components even under the worst condition as specified in Sub-section-basic Design criteria and specification requirements for remote I/O cabinets.

Ventilation blowers shall be furnished as required by the equipment design and shall be sound proof to the maximum feasible extent. If blowers are required for satisfactory system operation, dual blowers with blower failure alarm shall be provided in each cabinet with proper enclosure and details shall be furnished with proposal. Suitable louvers with wire mesh shall be provided on the cabinet.

- ii) The cabinets shall be designed for front access to system modules and rear access to wiring and shall be designed for bottom entry of the cables.
- iii) The cabinets shall be totally enclosed, free standing type and shall be constructed with minimum 2 mm thick steel plate frame and 1.6 mm thick CRCA steel sheet or as per supplier's standard practice for similar applications, preferred height of the cabinet is 2200 mm. The cabinets shall be equipped with full height front and rear doors. The floor mounting arrangement for other cabinets shall be as required by the Purchaser and shall be furnished by the Contractor during detailed engineering.
- iv) Cabinet doors shall be hinged and shall have turned back edges and additional bracing where required ensuring rigidity. Hinges shall be of concealed type. Door latches shall be of three-point type to assure tight closing. Detachable lifting eyes or angles shall be furnished at the top of each separately shipped section and all necessary provisions shall be made to facilitate handling without damage. Front and rear doors shall be provided with locking arrangements with a master key for all cabinets. If width of a cabinet is more than 800 mm, double doors shall be provided.
- v) Two spray coats of inhibitive epoxy primer-surface shall be applied to all exterior and interior surfaces. A minimum of 2 spray coats of final finish colour shall be applied to all surfaces. The final finished thickness of paint film on steel shall not be less than 65-75 micron for sheet thickness of 2 mm and 50 microns for sheet thickness of 1.6 mm. The finish colors for exterior and interior surfaces shall conform to following shades:

Exterior:- As per RAL 7032 or as finalised and specified during detailed engineering.

Interior:- Same as above.

Paint films which show sags, checks or other imperfections shall not be acceptable.

- vi) Cabinets shall be designed for a grounded installation on the building structure. Any isolation from the building ground which is required by equipment design shall be provided internal to the cabinet.



- vii) The mimic shall be configured on the OWS/ TFTs and it shall be possible to control, monitor and operate the plant from the same.
- viii) Ammeters will be provided on control panel for all motors rated 30KW and above. Further, HT/LT switchgear voltmeters shall be provided on control desk for HT/LT feeders. Ammeters and voltmeters shall be suitable for 4-20 mA DC signals derived from Analog Output cards of PLC.
- ix) Mosaic based control desk type for mounting push buttons/meters etc. with door at the rear shall be provided by the contractor. The mosaic grid tiles shall be of 24mmx48mm (or 25mmx50mm) size, made of heat and flame retardant, self extinguishing and non hygroscopic material with flat-matt finish without glare and non reflecting type. PC based OWS(operator Work Station) of PLC shall be mounted on table type control desk to house PC/ keyboards/ mouse etc. The profile and dimension shall be decided during detailed engineering and shall be subject to Owner's approval.
- x) The technical specification covering panel fabrication details, wiring and termination details etc. shall be as described under Instrumentation Cables of this volume.

6.12.10 Annunciation System

- i) Contractor shall provide annunciation system as integral part of PLC system. Field contacts shall be acquired through PLC only. The annunciation sequence logics shall be implemented as a part of PLC controllers. The annunciation window lamps mounted on control panel shall be driven through contact output modules of PLC. It shall be preferable to have each window as mosaic compatible. The lamp box shall have removable impact polystyrene window shall be 50 mm x 50 mm or 48mm x 48mm with 5 mm size inscription in black lettering on white background. Each annunciation window shall be backlighted with two long life LED lamps The changing of lamps shall be conveniently done from the front by single removal of window. Redundant audible devices for alarms shall be cone type or metallic horn type and shall be driven by electronic tone generator of adjustable width and sound level. The trip alarm audible & ring back audible shall be differentiated from other alarms.
- ii) The annunciator sequence shall conform to ISA sequence ISA-2A. The number of annunciation facia windows and the provision for original input will be on as required basis. However, the minimum number of facia windows, signal input to the annunciation system shall be 25 nos.

6.12.11 Software Documentation and Software Listings

- i) All technical manuals, reference manuals, user's guide etc., in English required for modification/editing/addition/deletion of features in the software of the PLC System shall be furnished. The Contractor shall furnish a comprehensive list of all system/application software documentation after system finalisation for Purchaser's review and approval.



ii) All The software listings including Source code for application software, All special-to-project data files etc. shall be submitted by the Contractor:

iii) Software Licences

The Contractor shall provide software license for all software being used in DDCMIS. The software licenses shall be provided for the project (e.g. organisation or site license) and shall not be hardware/machine-specific. That is, if any hardware/machine is upgraded or changed, the same license shall hold good and it shall not be necessary for Purchaser to seek a new license/renew license due to upgradation/change of hardware/machine in DDCMIS at site. All licenses shall be valid for the continuous service life of the plant.

iv) Software Upgrades

As a customer support, the Contractor shall periodically inform the designated officer of the Purchaser about the software upgrades/new releases that would be taking place after the system is commissioned so that if required, same can be procured & implemented at site.



6.13 TYPE TEST REQUIREMENTS

6.13.1 General Requirements

- i) The contractor shall furnish the type test reports of all type tests as per relevant standards and codes as well as other specific tests indicated in this specification. A list of such tests are given for various equipment in table titled 'Type Test Requirement for C&I Systems' at the end of this sub-section. For the balance equipment instrument, type tests may be conducted as per manufactures standard or if required by relevant standard.
- ii)
 - (a) Out of the tests listed, the bidder/ sub-vendor/ manufacturer is required to conduct certain type tests specifically for this contract (and witnessed by Purchaser or his authorized representative) even if the same had been conducted earlier, as clearly indicated subsequently against such tests.
 - (b) For the rest, submission of type test results and certificate shall be acceptable provided.
 - i. The same has been carried out by the bidder/ sub-vendor on exactly the same model /rating of equipment.
 - ii There has been no change in the components from the offered equipment & tested equipment.
 - iii. The test has been carried out as per the latest standards alongwith amendments as on the date of bid opening.
 - (c) In case the approved equipment is different from the one on which the type test had been conducted earlier or any of the above grounds, then the tests have to be repeated and the cost of such tests shall be borne by the bidder within the quoted price and no extra cost will be payable by the purchaser on this account.
 - iii) As mentioned against certain items, the test certificates for some of the items shall be reviewed and approved by the bidder or his authorized representative and the balance have to be approved by the purchaser.
 - iv) The schedule of conduction of type tests/ submission of reports shall be submitted and finalized during pre-award discussion.
 - v) For the type tests to be conducted, contractor shall submit detailed test procedure for approval by purchaser. This shall clearly specify test setup, instruments to be used, procedure, acceptance norms (wherever applicable), recording of different parameters, interval of recording precautions to be taken etc. for the tests to be carried out.
 - vi) The bidder, shall indicate in his bid, the cost of the type test for each items only for which type tests are to be conducted specifically for this project.



6.13.2 Special Requirement for Solid State Equipments/ Systems

The minimum type tests reports, over and above the requirements of above clause which are to be submitted for each of the major C&I systems like SG-C&I system, TG- C&I system, BOP- C&I system, Flame monitoring system, Coal feeders control and instrumentation system, Boiler flame analysis system, Electronic remote drum level monitoring system, Turbine supervisory system, BFP Turbine supervisory instruments, Analyzer instruments, Vibration monitoring systems, etc. shall be as indicated below:

i) Surge Protections for Solid State Equipments/ Systems

All solid state systems/ equipments shall be able to withstand the electrical noise and surges as encountered in actual service conditions and inherent in a power plant. All the solid state systems/ equipments shall be provided with all required protections that needs the surge withstand capability as defined in ANSI 37.90a/ IEEE-472. Hence, all front end cards which receive external signals like analog input & output modules, binary input & output modules etc. including power supply, data highway, data links shall be provided with protections that meets the surge withstand capability as defined in ANSI 37.90a/ IEEE-472. Complete details of the features incorporated in electronics systems to meet this requirement, the relevant tests carried out, the test certificates etc. shall be submitted alongwith the proposal. As an alternative to above, suitable class of IEC-255-4 which is equivalent to ANSI 37.90a/ IEEE-472 may also be adopted for SWC test.

- ii) Dry heat test as per IEC-68-2-2.
- iii) Damp heat test as per IEC-68-3.
- iv) Vibration test as per IEC-68-2-6.
- v) Electrostatic discharge tests as per IEC 801-2 or equivalent.
- vi) Radio frequency immunity test as per IEC 801-6 or equivalent.
- vii) Electromagnetic immunity as per IEC 801-3 or equivalent.

Test listed at item no. v), vi), vii) above are applicable for front end cards only as defined under item i) above.



6.13.3 Type Test Requirement for C&I Systems

| <u>Sl No</u> | <u>Item</u> | <u>Test Requirement</u> | <u>Standard</u> | <u>Test To Be Specifically Conducted</u> | <u>Approval Req. on Test Certificate</u> | <u>Remarks</u> |
|--------------|---|---|-------------------------------|--|--|----------------|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| i) | Narrow chart recorder | As per standard (col 4) | IS9319 | No | No | |
| ii) | Multi point recorder | As per standard (col 4) | IS9319 | No | No | |
| iii) | Vertical indicators | As per standard (col 4) | IS9319 | No | No | |
| iv) | Elect. Metering instruments | As per standard (col 4) | IS-1248 | No | Yes | |
| v) | Transducers | As per standard (col 4) | IEC-688,IS1278 4 | No | Yes | |
| vi) | Thermocouple | Degree of protection test | IS-2147 | No | No | |
| vii) | RTD | As per standard (col 4) | IEC-751 | No | No | |
| viii) | C.J.C.BOX | Degree of protection test Ambient Temp. effect | IS-2147 Approved procedure | No No | Yes Yes | |
| ix) | Electronic transmitter | As per standard (col 4) | BS-6447 / IEC-770 | No | Yes | |
| x) | E/P converter | As per standard (col 4) | Mfr. Standard | No | Yes | |
| xi) | Dust emission monitor | Degree of protection test | IS-2147 | No | Yes | |
| xii) | Instrumentation Cables Twisted & Shielded | | | Yes | Yes | |



Section 6 (Control and Instrumentation Works)

| | | | | |
|----|--------------|--|---|--|
| a) | Conductor | <ul style="list-style-type: none">○ Resistance test○ Diameter test○ Tin Coating test (drain wire) | VDE-0815 IS-10810 | |
| b) | Insulation | <ul style="list-style-type: none">○ Loss of mass○ Aging in air ovens○ Tensile strength and elongation○ Heat shock○ Hot deformation○ Shrinkage○ Bleeding & blooming | VDE 0472 VDE 0472** VDE 0472** VDE 0472** VDE 0472 VDE 0472 IS-5831 | ** As per VDE 0207 for teflon insulated cables |
| c) | Inner sheath | <ul style="list-style-type: none">○ Loss of mass○ Heat shock○ Cold bend/ cold impact test○ Hot deformation○ Shrinkage | VDE 0472 VDE 0472** IS-5831 VDE 0472 VDE 0472 | |
| d) | Outer sheath | <ul style="list-style-type: none">○ Loss of mass○ Aging in air ovens○ Tensile strength and elongation test before and after ageing○ Heat shock○ Hot deformation○ Shrinkage | VDE 0472 VDE 0472** VDE 0472** VDE 0472** VDE 0472 VDE 0472 | |



Section 6 (Control and Instrumentation Works)

| | | | | | |
|-------|-----------------|-------------------------------|-------------------|----|----|
| | | ○ Bleeding & blooming | IS-5831 | | |
| | | ○ Colour fastness to water | IS-5831 | | |
| | | ○ Cold bend/ cold impact test | IS-5831 | | |
| | | ○ Oxygen index test | ASTMD-2863 | | |
| | | ○ Smoke density test | ASTMD-2843 | | |
| | | ○ Acid gas generation test | IEC-754-1 | | |
| e) | fillers | ○ Oxygen index test | ASTMD-2863 | | |
| | | ○ Smoke density test | ASTMD-2843 | | |
| | | ○ Acid gas generation test | IEC-754-1 | | |
| f) | AL-MYLAR shield | ○ Continuity test | | | |
| | | ○ Shield thickness | | | |
| | | ○ Overlap test | | | |
| | | ○ Noise interference | IEEE Transactions | | |
| g) | Over all cable | ○ Flammability | IEEE 383 | | |
| | | ○ Noise interference | | | |
| | | ○ Dimensional checks | IS 10810 | | |
| | | ○ Cross talk | | | |
| | | ○ Mutual capacitance | VDE-0472 | | |
| | | ○ HV test | VDE-0472 | | |
| | | ○ Drain wire continuity | | | |
| xiii) | Pressure gauge | ○ Degree of protection test | IS-2147 | No | No |



Section 6 (Control and Instrumentation Works)

| | | | | | |
|--------|---|--|--------------------------------------|-----|-----|
| | | ○ Temp interference test | IS -3624 | No | No |
| xiv) | Temperature gauge | Degree of protection test | IS-2147 | No | No |
| xv) | Pressure & DP switch | ○Degree of protection test | IS-2147 | No | No |
| | | ○As per standard (col 4) | BS 6134 | No | No |
| xvi) | Level switch | Degree of protection test | IS-2147 | No | No |
| xvii) | Conductivity level switch | Degree of protection test | IS-2147 | No | Yes |
| xviii) | Battery charger (Including chargers of UPS) | ○Degree of protection test | IS-2147 | No | Yes |
| | | ○Short circuit current capability | IEC-146-2 | No | Yes |
| | | ○Temp rise test without redundant fans | Approved procedure, IEC 146-2 | Yes | Yes |
| | | ○SWC test | Approved procedure, IEC-146-2,IEC146 | No | Yes |
| | | ○Efficiency / PF | IEC-146-2,IEC146 | Yes | Yes |
| | | ○Audible noise test | IEC 146-2 | No | Yes |
| | | ○Fuse clearing capability | Approved procedure | No | Yes |
| | | ○Relative harmonic content | Approved procedure | No | Yes |
| | | ○Radio interference | IEC 146-4 | No | Yes |
| | | ○Over Load test on inverter & charger. | Approved procedure | No | Yes |



Section 6 (Control and Instrumentation Works)

| | | | | | |
|--------|------------------------------|---|--|-----|-----|
| | | ○ Restart test | IEC 146-2 | No | Yes |
| | | ○ Output voltage tolerance | Approved procedure | No | Yes |
| | | ○ Output voltage harmonic content | Approved procedure | No | Yes |
| | | ○ Insulation test | IEC 146 | No | Yes |
| | | ○ Load tests | Approved procedure | Yes | Yes |
| | | ○ Preliminary light load test | IEC 146 | No | Yes |
| | | ○ Current division/ voltage division | IEC 146-2 | No | Yes |
| xix) | Battery | As per standard (col 4) | IEC-623 / IS-10918 for Ni-Cd IS-1652 for Plate Lead Acid IS-1651 for Lead Acid | No | Yes |
| xx) | Control valves | CV Test | ISA 75.02 | Yes | No |
| xxi) | Voltage stabilisers | ○ Over load test | Approved procedure | No | Yes |
| | | ○ Temp rise test without redundant fans | Approved procedure | No | Yes |
| | | ○ Input voltage variation test | Approved procedure | No | Yes |
| xxii) | Flow Nozzles & Orifice plate | Calibration | ASME PTC , BS 1042 | Yes | No |
| xxiii) | PLCs | All tests as per IEC-1131 | IEC-1131 | | |



Section 6 (Control and Instrumentation Works)

| | | | | | |
|---------|--------------------------|---------------------------|----------------------------|-----|-----|
| xxiv) | DDCMIS | | | | |
| | a)I/O modules | CMRR & NMRR verification | Mfr standard | No | Yes |
| | b) Other modules | CMRR & NMRR verification | Mfr standard | No | Yes |
| | c)CLCS Systems | Model test | Approved procedure | Yes | Yes |
| xxv) | LIE / LIR / Junction Box | Degree of protection test | IS-2147 | Yes | Yes |
| xxvi) | Flue gas O2 Analyser | Degree of protection test | IS-2147 | No | Yes |
| xxvii) | Flue gas CO Analyser | Degree of protection test | IS-2147 | No | Yes |
| xxviii) | Flue gas SO2 Analyser | Degree of protection test | IS-2147 | No | Yes |
| xxix) | Flue gas NOX Analyser | Degree of protection test | IS-2147 | No | Yes |
| xxx) | Master Slave Clock | Current/ Power efficiency | Approved Procedure IEC 146 | No | Yes |