

VOLUME-II-E

**TECHNICAL SPECIFICATIONS
FOR
CONTROL AND INSTRUMENTATION**

CONTENT

SECTION- I	:	GENERAL TECHNICAL REQUIREMENTS
SECTION-II	:	SCOPE OF WORK
SECTION-III	:	CONTROL AND INSTRUMENTATION FOR STEAM GENERATING UNIT & AUXILIARIES
SECTION-IV	:	CONTROL AND INSTRUMENTATION FOR TURBINE GENERATOR, AUXILIARIES & FEED CYCLE EQUIPMENT
SECTION-V	:	NOT USED
SECTION-VI	:	TECHNICAL SPECIFICATION - CONTROL AND INSTRUMENTATION SYSTEMS
SECTION-VII	:	STEAM AND WATER ANALYSIS SYSTEM
SECTION-VIII	:	C&I LABORATORY INSTRUMENTS
SECTION-IX	:	PLANT COMMUNICATION SYSTEM
SECTION-X	:	NOT USED

SECTION-I

GENERAL TECHNICAL REQUIREMENTS

CONTENT

CLAUSE NO.	DESCRIPTION	PAGE
1.00.00	INTENT OF SPECIFICATION	1
2.00.00	GENERAL PERFORMANCE REQUIREMENT	3
3.00.00	GENERAL DESIGN REQUIREMENTS	5
4.00.00	GENERAL TECHNICAL REQUIREMENTS	6
5.00.00	CODES AND STANDARDS	12
6.00.00	DESIGN CRITERIA	17
7.00.00	METERING BASES AND CHART UNITS	29
8.00.00	PROCESS CONNECTION & INSTRUMENT HOOK UP	30
9.00.00	POWER SUPPLY SYSTEMS	30
10.00.00	ENVIRONMENTAL CONSIDERATIONS	31
11.00.00	SECURITY	32
12.00.00	ACCEPTANCE TESTS	32

SECTION-I**GENERAL TECHNICAL REQUIREMENTS****1.00.00 INTENT OF SPECIFICATION**

1.01.00 This part of the specification is intended to provide the technical guidelines for the fully coordinated Control & Instrumentation system with auxiliaries and accessories for the proposed 1x350 MW expansion unit # 4. of the Kamalanga Thermal Power Station at Dhenkanal, Orissa. The duty of services specified below and in other drawings and documents forming part of this specification are considered required for safe, reliable, trouble free and efficient operation with adequate maintenance facilities as per modern power station practice and as per terms and conditions enumerated in this specification.

1.02.00 The technical specifications that follow serve as the guide specification for the entire C&I as well as the proprietary controls like SG and its integral controls, TG set and its integral controls etc. supplied as part of equipment packages within the contract and also various standalone system controls to be supplied as part of BOP /Offsite plant sub-packages. Interfaces with other external / existing plant systems have also been addressed.

1.03.00 In conformity with the guidelines provided in the specification, the scope of works shall completely cover all the Control & Instrumentation equipment, functions, activities and documentation specified under the accompanying Technical Specifications and shall not be limited to the following:

- a) Detailed design and engineering of the manufactured equipment; system integration and system engineering.
- b) Complete manufacture including shop testing before shipment.
- c) Specifying, procurement, quality inspection of bought-out items from sub-suppliers as well as design co-ordination and integration of bought-out items.
- d) Coordination, integration & interfaces between the Bidder's C&I systems and various proprietary , plant auxiliary control systems , C&I systems for BOP/Offsite packages such as, Ash Handling, Mill reject handling system, Fire protection and detection system, Compressed air system, Heating Ventilation & Air-conditioning unit, Steam and Water Analysis System , Continuous emission monitoring System , Station Electrical system, etc., Owner's central load dispatch centre , other third party / existing unit C& I systems for co ordinated operation and centralized monitoring & limited control.
- e) Providing engineering drawings, documents, licensed copy of software and developmental tools, data, instruction, operation and maintenance manual etc. for Owner's review/ approval / record.

- f) Arranging for Owner's inspection and testing of manufactured as well as bought-out items at the respective works.
- g) Packaging and transportation of instruments, equipment, accessories and erection hardware from the manufacturer's works to the site, including transit insurance.
- h) Opening of site office at location provided by Owner.
- i) Receipt, storage, preservation of instruments, equipments and erection hardware at the site. DCS and all electronic cabinets shall be kept in the Air conditioning area.
- j) Fabrication of site-constructed items.
- k) Pre-assembly (if any), erection, testing and commissioning of all the equipment and instruments supplied, in totality.
- l) Performing availability tests and Performance and Guarantee tests.
- m) Prepare and submit approved & as-built drawings and documents in hard and soft copies.
- n) Furnishing of spares, tools and tackle and test instruments.
- o) Fulfilling post-commissioning liabilities.
- p) Arranging for the training of Owner's personnel of different categories at manufacturer's works as well as plant site.
- q) Other activities detailed in subsequent sections of the Specification.
- r) Any other activity, not mentioned explicitly, but felt essential by Bidder for successful completion of work.

1.04.00 The requirements enumerated in this specification are qualitative in nature and are based on typical configuration of the plant for the purpose of bidding. It shall be the responsibility of Bidder to offer Control & Instrumentation system to meet the actual functional requirements of the plant offered.

1.05.00 The Control and Instrumentation shall be based on state of art MaxDNA Distributed Control System (DCS) for the entire main plant covering the total functional requirements of modulating control, sequence control, interlocks & protection, monitoring, alarm, data logging, fault analysis, performance calculation & optimization, maintenance scheduling & machine monitoring & analysis etc. Complete operation and control of Steam Generator, Turbine Generator and Electrical system including metering and auxiliary systems shall be carried out from DCS from Unit # 4 Control Room (UCR).

1.06.00 The control room operator shall be provided with color-graphic displays of the power plant equipment through Large Video screens and LED monitors. In general no back up analogue Indicators or recorders are foreseen for the

operation of the main plant, other than cases where need for such back-up is strongly recommended by equipment suppliers or in cases where such requirements are clearly spelt out in the specification. However, Bidder shall provide the back up control and instruments required to bring the plant to a safe shutdown condition without any damage to any plant personnel or equipment in case of total black out condition of DCS.

Emergency trip push buttons of boiler, turbine and unit to be provided on the control desk. Other back up instruments & control devices, as required, such as start & stop PB of critical drives, ammeters of critical drives, open & close PB for critical valves & dampers, Electrically assisted safety valves to be installed on control desk or vertical back up Unit Control Panel. The List of Critical drives, Valves & Dampers to be operated from the vertical backup Unit control panel shall be detailed out by the owner at the time of detail engineering/document finalization.

- 1.07.00 New PLC / microprocessor based standalone control and monitoring systems shall be provided for some station auxiliaries & offsite packages like Air conditioning system etc. All New PLC/Microprocessor based standalone control and monitoring systems envisaged shall be connected (soft) to the New Unit#4 DCS through OPC via redundant Single Mode FO cable including all required Hardware and softwares. This shall be for Monitoring and Limited control. Moreover, all new PLC shall be time synchronised with existing Stage-II Plant Master clock system.
- 1.08.00 It is not the intent to completely specify the details of design and construction features herein. Nevertheless, the instruments / equipment and their installation shall conform to high standards of engineering design and workmanship in all respects.
- 1.09.00 In the event of conflict between requirements of any two clauses of this specification / documents or requirements of different codes / standards specified, the more stringent requirements as per the interpretation of the Owner shall apply.
- 2.00.00 GENERAL PERFORMANCE REQUIREMENT**
- 2.01.00 Control & Instrumentation equipment shall be guaranteed to meet the performance, functional and accuracy requirements enumerated in the specification.
- 2.02.00 Control & Instrumentation equipment shall be guaranteed against manufacturing defect for at least two (2) years from the date of handing over to Owner.
- 2.03.00 The guaranteed performance criteria shall be met in full during the guarantee period.
- 2.04.00 Any predictable or planned deterioration and / or obsolescence of equipment shall be clearly brought out in the Bid.

- 2.05.00 Control & Instrumentation equipment shall be capable of maintaining the specified performance and accuracy standard over the complete regime of operation of main equipment, taking into account the excursion of parameters during emergency or malfunction of main equipment.
- 2.06.00 Control & Instrumentation system shall not impose any limitation or constraint on the operation of the main equipment. It shall be possible to utilize any in-built over capacity in design of an equipment with complete controllability and observability.
- 2.07.00 The control system shall be designed to prevent abnormal swings due to loss of control power, instrument air, failure of any system component, open/short circuits or any other such failure or degradation in the system and shall drive the plant and equipment to fail safe condition.
- 2.08.00 All modulating devices shall be in stay put condition during any of the above failures if not otherwise asked in the control philosophy.
- 2.09.00 Mean Time Between Failure (MTBF) of the instruments shall be considerably higher than the equipment they shall cater to in order to avoid shutdown on account of instrumentation failure.
- 2.10.00 Bidder shall introduce redundant control equipment or instruments wherever it is felt that the introduction of the same may lead to reduction of downtime of plant and equipment, in addition to the cases clearly identified in the specification.
- 2.11.00 In cases where continuous monitoring of performance of equipment is envisaged, Bidder shall supply instruments of suitable accuracy class to meet the accuracy requirements of the calculation as per ASME standard.
- 2.12.00 All instruments and control equipment shall ensure high reliability, low downtime and ease of maintenance.
- 2.13.00 Protective systems and their safety features shall be guaranteed to ensure the main equipment safety in the event of tripping, maloperation and malfunction.
- 2.14.00 The performance guarantee shall be on complete system basis as well as on the basis of isolated, individual instrument or component.
- 2.15.00 Bidder shall replace all instruments failing to meet the performance stipulations of the specification at any stage of the project.
- 2.16.00 All instruments / equipment shall be capable of performing satisfactorily in continuous commercial operation conforming to all relevant codes and regulatory requirement under the specified environmental conditions.
- 2.17.00 In general, equipment located in air-conditioned environment shall be capable of operating without any degradation of performance or damage for at least twelve (12) hours to keep the plant in running condition in case failure of air

conditioning units. Bidder shall consider back-up packaged air conditioning unit/s to cater such type of emergency needs.

2.18.00 Trial Operation

The trial operation shall be conducted by Bidder as per the stipulation of this specification which shall be witnessed and signed off by Owner.

2.19.00 Performance and guarantee test

Bidder shall perform the tests for performance and guarantee as per the process requirement.

2.20.00 Total System Availability

Bidder shall guarantee the total system availability of 99.7% by selecting suitable components and by judicious incorporation of redundancies.

3.00.00 GENERAL DESIGN REQUIREMENTS

3.01.00 Equipment and system shall be designed and constructed to perform accurately and safely under the environmental and operating conditions described or implied in this specification without undue heating, vibration, wear, corrosion.

3.02.00 Equipment and systems shall be supplied from latest proven product range of reputed experienced manufacturer whose successful performance has been established by a considerable record of satisfactory operation in large capacity coal fired thermal power stations. Bidder shall obtain Owner's approval for the selected manufacturers for critical items.

3.03.00 Bidder shall indicate the year in which the offered models of the instruments and control system have been introduced and how long the commercial production of the same is expected to continue. In any case, Bidder shall ensure supply of spare parts for lifetime of the plant. In case if it is felt by Bidder that certain equipment/components is likely to become obsolete, Bidder shall clearly bring it to the notice of Owner and indicate step proposed to deal with such obsolescence like maintaining "bonded spares" with the manufacturer/s.

3.04.00 Any part/module of the C&I system which are not listed under recommended spares shall be deemed as having life expectancy not less than the expected life of the plant i.e. 30 years.

3.05.00 Bidder shall supply proven latest version of hardware and software available at the time of system designing. All software user licenses shall be valid for entire life of power plant. User should not have to pay any recurring license fee during the usage period of the system. In case of future up-gradation of software, Bidder shall remain committed to upgrade the supplied system at per with the new version within the warranty period and ensure successful integration of the system without any additional cost to owner. Beyond the

warranty period and during the remaining life of the plant, any upgradation in hardware and software shall be brought to the notice of Owner indicating whether it shall be possible to upgrade the system by partially replacing, modifying and/or patching of hardware /software.

3.06.00 All the modules of the control and monitoring system including for DCS / PLC / Proprietary control system shall be from latest product range and from same family only.

4.00.00 GENERAL TECHNICAL REQUIREMENTS

4.01.00 Control & Instrumentation system design will aim at high availability, fuel efficient performance, plant & personnel security and high level of automation with minimum deployment of operational manpower.

4.02.00 Uniformity of make and type of instruments and control components shall be followed throughout for rationalization of spares' inventory, except for certain proprietary items where this requirement can not be met. Bidder shall , however take the Owner's approval on the make and type during detailed engineering for such proprietary items .

4.03.00 Suggestive Plant Control System Overview Diagram for the DCS is schematically shown in Drawing No. 24A11-DWG-I-0001.

4.04.00 All Field Transmitters shall be SMART type and of uniform make . Each SMART equipment shall communicate in the form of analog signal 4-20 mA DC with super imposed digital signal conforming to HART Protocol to facilitate zero adjustment, calibration and diagnostic from remote location. Five nos. HART portable communicator for BTG and auxiliaries shall be supplied for this contract.

4.05.00 Power supply for Transmitters, contact interrogation, interposing relay and solenoid shall generally be ungrounded 24V DC. Power supply for contact Interrogation, interposing relay and solenoid shall be provided from separate redundant bulk power supplies in the control systems viz. DCS/PLC/Proprietary control systems.

4.06.00 When more than one device utilizes the same signal, the signal source shall meet such signal requirement and with proper isolation and without overloading. Short circuiting or grounding of one device shall not have any perceptible influence on any other consumer point nor shall change the transmitter calibration.

4.07.00 Final control device for regulating control shall have Pneumatic/motorized modulating actuators. Actuators for isolating and inching duty dampers and valves shall be, in general, electrical motor operated. Generally pneumatic actuators for ON-OFF services shall not be considered unless process requirement demand to use same. Actuators for isolating and inching duty type dampers/valves shall have limit switch. SMART positioner along with position transmitter (4 - 20 mA output) and limit switches shall be provided for

all types of control valves. SMART positioners shall be HART compatible. Hydraulic operated control valves shall also be operated from DCS in addition to the local control. All control valves shall have motorised isolation valve in the upstream and downstream line. Moreover the bypass line shall be provided.

- 4.08.00 Electronics located outside control room shall be tropicalized and enclosed in dust & weatherproof cabinets (IP-65/67) suitable for the environment.
- 4.09.00 All Local Field Instruments like Pressure/ Differential pressure/Vacuum gauge, Temperature gauge, Level gauge, Flow gauge etc. with all necessary accessories shall be provided in cases where these are required for maintenance, commissioning and recommissioning of major equipment or for calibration and setting of other instruments and for equipment safety.
- 4.10.00 In general, instruments installed outdoors and in areas where these may be exposed to Heat , Dust , splashing oil, water, steam etc. shall be mounted in closed type enclosures. For other areas (indoor), open type racks shall be used. All Open & close type Instrument racks shall be shop manufacture. Site fabricated racks are not accepted
- 4.11.00 Drain from instrument rack/enclosure shall be routed to nearby plant drainage system.
- 4.12.00 Temperature measurement shall have up scale / down scale drive to protect from process upset in case of sensor failure. Both the elements of duplex temperature sensors shall be terminated to junction boxes. For RTDs ring - tong type lugs shall be used at Junction Boxes.
- 4.13.00 In general, for temperature measurements up to 300°C, 100 ohms Platinum resistance temperature detectors (Pt-100 RTD) shall be used unless the area is prone to vibration. For temperature measurement above 300°C up to 750°C, Chromel-Alumel (K) type thermocouple shall be used. For high temperature applications, noble-metal thermocouple (TC) such as Pt Rh-Pt (R) type in inconel sheathed thermowell shall be used. For lower temperature with vibration prone areas Iron Constantan (J) / Chromel constantan (E) type thermocouples shall be used . All temperature elements shall be Duplex".
- 4.14.00 Temperature elements shall be in sheath tube and in thermowells of suitable material. Temperature elements in high abrasion resistance area like Mill outlet, flue gas path shall be enclosed in thermowell of solid sintered tungsten carbide material
- 4.15.00 Temperature elements shall be directly connected to their respective input modules through compensating cables. For Boiler Metal temperature measurement Remote I/O or for bulk data acquisition shall be provided for monitoring in DCS.
- 4.16.00 In general, temperature switching function shall be configured by use of temperature elements and software configured limit value monitors instead of using conventional field mounted temperature switch.

- 4.17.00 The instruments and control equipment shall be logically grouped in electronic cabinets in functional order for convenient fault location, troubleshooting and maintenance.
- 4.18.00 Equipment and devices, which require maintenance, shall be suitably located to ensure easy accessibility.
- 4.19.00 On-line automatic periodic testing, self-checking & diagnostic facility shall be provided with fault indication for easy identification of the faulty module. The system shall continuously check health of the component elements including the stand-by ones and shall permit carrying out of the on-line checks while maintaining safe condition of the plant without endangering the safety of equipment and without influencing the process being controlled.
- 4.20.00 Failure of equipment/instrument used for alarm & trip purposes shall initiate alarm.
- 4.21.00 Automatic unadministered switchover to standby equipment (such as fan /blower /pump) is foreseen in case of either running equipment is not adequate to maintain the desired process condition or due to tripping of running equipment.
- 4.22.00 End positions of manually operated suction valves of critical pumps and all other manual operated critical isolation valves shall be monitored & interlocked.
- 4.23.00 In case of HT motors, winding temperature for each stator winding and bearing temperature of motors & driven equipment shall be monitored for abnormal rise. For monitoring of such temperature if required in a local panel where no operator station has been provided suitable electronic display device driven by output of DCS / PLC system shall be provided.
- 4.24.00 Microprocessor based Vibration monitoring system (VMS) including analysis system shall be provided for all HT drives and driven equipments .
- 4.25.00 Electrical drives rated at 30 KW or more and for critical drives including all lub oil pumps, fuel oil pumps current rated at less than 30 KW shall be monitored for current in DCS. Moreover, all current transducers shall be hooked up in DCS/PLC for remote monitoring.
- 4.26.00 Process fluids shall not be piped directly in to Unit Control Room (UCR) and Control Equipment Room (CER) areas.
- 4.27.00 Ergonomically & aesthetically designed furniture viz. control desks & chairs shall be provided for workstations, programming stations, PCs and various peripherals at control room/computer room/equipment room. Furniture shall include documentation racks, tables for laydown etc.
- 4.28.00 KKS identification system shall be adopted consistent with the plant equipment numbering system.
- 4.29.00 Steam Generator (SG) Integral Control and Monitoring

- 4.29.01 Steam Generator (SG) Integral Control shall be synthesized from the same family of hardware as the DCS (MaxDNA) through redundant controllers and shall integrate **seamlessly. SG Integral control and monitoring include:**
- i) This shall include controls namely HP bypass control, SADC, SBC etc. and other SG CLCS & OCLS controls through redundant controllers.
 - ii) This shall include interlock & Protections like FSSS/BMS, MFT through TMR (Triple Modular redundant) IO & Controllers.
 - iii) This shall include Monitoring of Separator Drum, Superheater, reheater etc. Metal Temperature through redundant controllers
- 4.29.02 Major Boiler interlock and protections like Burner Management System (BMS) / Furnace safeguard and supervisory system (FSSS) including safety related interlock and protections , Master fuel Trip (MFT) shall be of triple-modular redundant (I/Os and controllers) configurations and shall be part of DCS . Hardwares related to this system shall be housed in a distinctly separate cabinet set. All trip and interlocking inputs shall be hardwired.
- 4.29.03 HP bypass control , Secondary Air Damper Control (SADC), Soot Blower Control and other SG controls shall be implemented in the DCS through redundant controllers under SG Control.
- 4.30.00 Turbo Generator (TG) Integral Control and Monitoring
- 4.30.01 This shall include controls and protective trips functions like Electro Hydraulic Governor (EHG) control, Automatic Turbine Run up System, Automatic Turbine Testing, Turbine Stress Evaluator, Turbine Protective Trip System, Turbine supervisory Instruments, HP-LP Bypass system, Gland Seal Steam System, Condenser Air Evacuation, TG Cooling water, TG stator coil cooling water if applicable, TG Seal Oil system, and Other closed loop & Open loop controls of TG system and auxiliaries related to the integral performance and safety.
- TG integral control shall also include the following :
- 1) EHG control, ATRS, CLCS & OLCS of BFPDT.
 - 2) TSI of BFPDT
- 4.30.02 TG integral Control and Monitoring system shall be implemented in the DCS (MaxDNA) through redundant controllers . TSI can be NON-DCS with the 4-20 mA input to DCS for Monitoring, alarm and interlock. All trip and interlocking inputs shall be hardwired. Safety related interlock and protection functions shall be implemented through two out of three (Triple Modular Redundant - I/Os and controllers) configurations . TMR shall be applicable only for safety related interlock & Protection function of the Main turbine.

4.31.00 Station C&I System

4.31.01 Station C&I System shall include the control & monitoring of all other balance non-integral functions in SG area, TG area and other Balance of Plant equipment and auxiliaries such as Boiler circulation water, ID fans, FD fans, PA fans, Air preheater, Coordinated master control, Air and flue gas, Blow down, Boiler Motor Driven feed water pumps, Condensate pumps, DM make up pumps, Boiler fill pumps, Condensate transfer pumps, Pressure reducing & de-super heating system, Chemical Dosing, Service /potable, DM water distribution system etc. These shall be implemented through redundant controllers of DCS (MaxDNA). Station C&I system shall also include the following:

- 1) CW & ACW (Remote DCS node)
- 2) EDMS.
- 3) Mill & Feeder
- 4) HP & LP heater

4.31.02 Plant Auxiliaries and Off site Plants Controls

- i. Existing facilities of offsite plants (Balance of Plants) shall generally meet the requirements of unit-4.
- ii. As such no augmentation in control system is envisaged for the existing Plant Water System (PWS) catering the unit#4 requirement.
- iii. For Coal Handling Plant the additional augmentation within the mechanical system would be taken care in the existing PLC by using the spare IO's or else all the related controls shall be realised in the new PLC and the associated utility applications. However, the new PLC shall be interfaced with the existing CHP (Stage-II) PLC for data exchange as required for control and interlocking purpose.
- iv. In case of AHP, dedicated and independent PLC based control system shall be provided for unit # 4 Ash Handling Plant.
- v. Auxiliaries like Condensate Polishing Unit (CPU), CW Chlorination, CW treatment, FGD etc. of Phase-III unit#5 shall be controlled from Unit#4 DCS. Remote Nodes for the same shall be provided. CW Chlorination & CW Treatment shall be controlled from remote node installed for CW & ACW system.
- vi. A separate DCS node shall be installed for the CPU in the CPU building control room with RIO in the service area vessels.
- vii. Mill Reject Handling System (MRHS) for unit#4 shall be controlled from the unit#4 DCS.
- viii. Proprietary Systems like Debris filter, COLTCS, SCS shall be controlled from unit#4 DCS located in the Electronic equipment room.

Regarding Environmental Monitoring system, all 4-20 mA Outputs from the analysers/Transmitters shall be connected DCS.

ix. A new & separate PLC for the below BOP systems to be provided:

- 1) Fire water Pumps.
- 2) HVAC

4.31.03 FGD, CW & ACW pumping system, Fuel oil system, CPU along with regeneration system & compressed Air system shall be operated from DCS workstations in Unit #4 Control Room as well as from Local operator work stations/panels.

4.31.04 CW treatment system shall be operated from Local operator work stations.

4.31.05 Debris filter, SCS & COLTCS system shall be operated from LCP (local control panels).

4.32.00 Rotating Machine Condition Monitoring System (RMCMS) including analysis system.

Continuous monitoring and analysis of the mechanical health of rotating equipment viz, Turbine, Generator & Exciter, BFP drive turbine & pump and all HT motors & their driven equipment shall be performed by proven and state of the art microprocessor based RMCMS . RMCMS for TG and HT motor & their driven equipment shall be same and of same family of hardware of Turbine Supervisory Instruments (TSI) / systems and HT drives Vibration Monitoring System. The RMCMS shall be considered as a standalone system. However, provision shall be there for hardware and software connectivity of the entire TSI/ HT drive's VMS to the nearby DCS.

4.33.00 C&I Laboratory

One state of the art C&I laboratory with necessary testing /calibration/ maintenance equipments shall be provided for the day-to-day maintenance / testing and calibration of the C&I equipment of the plant

4.34.00 Erection Hardware

Standard and good engineering practice of international standard shall be adopted throughout. All materials supplied shall be suitable for tropical, dust laden, humid power plant environment and shall be from reputed manufacture.

4.35.00 C&I Cabling

Instrumentation cables shall be copper, overall screened for binary signals and individual pair and overall screened for analog signals. All cables shall be FRLSH type (inner and outer sheath) and armored. Short run cables may be unarmored. Unarmored cables shall run through conduits.

Fibre Optic cables in the field shall be laid through HDPE conduits for buried section and through dedicated encased perforated GI trays for over-ground section.

- 1) DI & DO signal cannot be routed through the same cable.

- 2) AI & AO signal cannot be routed through the same cable.
- 3) Single pair or Single TRIAD cable is not acceptable. Minimum of 2 Pairs or 2 triad cable shall be used.
- 4) Each multi-pair or Multi-Triad cable shall have 20% or minimum 1 pair / 1 triad cable which ever is maximum as spare
- 5) Cable laying of C&I cable on perforated cable trays shall not exceed three (3) vertical layers.

The screen shall be grounded at the electronic equipment room /control room end only. Adequate separation shall be maintained from electrical cables carrying 240 V AC or higher voltage levels to avoid electrical interference.

Two pair or Two triad signal cables as well as multi-pair or multi-triad signal cables shall not have individual conductor cross section less than 0.5 mm². For solenoid valves, depending on pick-up VA, individual conductor cross section shall not be less than be 2.5 mm². For interposing relay drive connection, individual conductor cross section shall be 1.5 mm².

5.00.00 CODES AND STANDARDS

The design, manufacture, inspection, testing, site calibration and installation of all C&I equipment and systems covered under this specification shall conform to the latest editions of applicable codes and standards eg. ANSI, ASME, IEEE, ISO, IEC, IGCI, AWS, NFPA, AISC, IGS, SAMA, UBC, UL, NESC, NEMA, ISA, DIN, VDE , IS etc. Generally, the following latest edition of codes and standards prevailing at the time of award of contract shall be applicable.

- 1) Temperature Measurement
 - a) Instrument and apparatus for temperature measurement - ASME PTC 19.3 (1974).
 - b) Temperature Measurement - Thermocouples - ANSI - MC 96.1 - 1982.
 - c) Temperature Measurement by electrical resistance thermometers - IS: 2806
 - d) Thermometer-element-Platinum resistance - IS: 2848 / DIN 43760.
- 2) Pressure Measurement
 - a) Instrument and apparatus for pressure measurement - ASME PTC 19.2 (1964).
 - b) Bourdon tube pressure and vacuum gauges - IS: 3624/1996.

- 3) Flow Measurement
 - a) Instruments and apparatus for flow measurement - ASME PTC 19.5 (1972) Interim supplement, Part-II
 - b) Measurements of fluid flow in closed conduit - BS 1042.
- 4) Electronic Measuring Instruments and Control Hardware
 - a) Automatic null balancing electrical measuring instruments - ANSI C 39.4 (Rev. 1973), IS 9319
 - b) Safety requirements for electrical and electronic measuring and controlling instrumentation - ANSI C 39.5 / 1974.
 - c) Compatibility of analog signals for electronic industrial process instruments - ISA-S 50.1: ANSI MC 12.1 / 1975.
 - d) Dynamic response testing of process control instrumentation - ANSI MC 4.1 (1975) - ISA -S26 (1968).
 - e) Surge withstand capability (SWC) tests - ANSI C 37.90A (1989), IEC-255.4.
 - f) Printed circuit boards - IPC TM-650, IEC 326C.
 - g) General requirements and tests for printed wiring boards - IS-7405 (Part-I)/1973.
 - h) Edge socket connectors - IEC 130-11.
 - i) Requirements and methods of testing of wire wrap terminations--DIN 41611 Part-2.
 - j) Dimensions of attachment plugs and receptacles- ANSI C73-1973.(Supplement ANSI C73a – 1980)
 - k) Direct Acting Electrical Indicating Instruments - IS - 1248 - 1968
- 5) Instrument Switches and Contacts
 - a) Contact Rating - AC services NEMA ICS Part-2 125, A-600
 - b) Contact Rating - DC services NEMA ICS Part-2 125, N-600
- 6) Enclosures
 - a) Enclosures for Industrial Controls and Systems--NEMA ICS-6-110.15 through 110.22
 - b) Racks, panels and associated equipment -EIA: RS-310-B-

1983 (ANSI C83.9 - 1972) / IEC 60947 / IEC 60529

- c) Protection Class for Enclosures , Cabinets Control Panels and Desks - IS 2147 1962
- 7) Apparatus, Enclosures and Installation Practices in Hazardous Area
 - a) Classification of hazardous area - NEMA Article 500, Volume-6, 1978./ NFPA Article 500 , Vol.70-1984
 - b) Electrical Instruments in hazardous dust locations - ISA-RP 12.11.
 - c) Intrinsically safe apparatus - NFPA Article 493 Volume-4 1978.
 - d) Purged and pressurized enclosure for electrical equipment in hazardous location - NFPA Article 496 Volume-4, 1982.
- 8) Sampling System
 - a) Stainless Steel material of tubing and valves, for sampling system - ASTM A 269-79 GRTO-316.
 - b) Submerged helical coil heat exchangers for sample coolers -- ASTM D11-98.
 - c) Steam and water sampling ,conditioning and analysis in the power cycle - ASME PTC - 19.11
 - d) Standard methods of sampling system - ASTM D 1066-69
- 9) Annunciators
 - a) Specifications and guides for the use of general-purpose annunciators - ISA RP 18.1.
 - b) Surge withstand capability tests -ANSI C37.90 a -1971 and IEEE Standard 472-1974.
- 10) Interlocks, Protections
 - a) Relays and relay system associated with electric power apparatus - IEEE Standards 3.13.
 - b) Surge withstand capability tests - ANSI C37.90 a - 1971 and IEEE Standard 472-1974.
 - c) General requirements and tests for switching devices for control and auxiliary circuits including contactor relays - IS-6875 (Part-I)/1973.

- d) Turbine water damage prevention - ASME-TDP-1-1980.
- e) Boiler safety interlocks - NFPA Section 85B, 85D, 85E, 85F, 85G.
- f) Installation and operation of Pulverized fuel system - ANSI / NFPA 8503
- g) Functional diagramming of Instrument and control systems - SAMA PMS 22.1
- h) Digital interface for programmable instrumentation - ANSI / IEEE 488
- 11) Control Valves
 - a) Control valve sizing (Incompressible fluids) - ISA-S39.2 / 1972.
 - b) Control valve sizing (Compressible fluids) - ISA-S39.4 / 1972.
 - c) Control Valve seat leakage – ANSI / FCI 70.2
 - d) Face to face dimensions of Control Valves - ANSI B16.10
 - e) Control Valve Capacity Test Procedure – ISA – S75.02
- 12) Process connection Piping and Tubing
 - a) Seamless Carbon Steel Pipe - ASTM-A-106.
 - b) Forged carbon steel fittings - ASTM-A-105.
 - c) Dimensions of fittings - ANSI-B16.11.
 - d) Code for pressure piping, welding, hydrostatic testing - ANSI-B 31.1.
 - e) Nomenclature for instrument tube fittings - ISA-RP 42.1 / 1982.
 - f) Seamless Stainless Steel Tube ASTM A-213 TP 316 / ASTM A-269 TP 316
 - g) Seamless Alloy Steel Pipe ASTM A 335 P22
 - h) Seamless Stainless Steel Pipe ASTM A-312 TP 316
 - i) Forged and Rolled alloy steel pipe flanges , forged fittings , valves and parts ASTM A - 182
 - j) Pipe fittings of wrought carbon steel and ally steel - ASTM A - 234

- k) Composition bronze metal castings ASTM B - 62
- l) Seamless copper tube , bright annealed ASTM B- 168
- m) Valves flanged and butt welding ends ANSI B 16.34
- 13) Cables
 - a) Thermocouple extension wires / cables - ANSI MC96.1.
 - b) Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy-IPCEA S-61-402
 - c) Guide for design and installation of cable system in power generating station (insulation, jacket materials) -IEEE Standard 422.
 - d) Requirements of vertical tray flame test - IEEE 383
 - e) Standard specification for tinned soft or annealed copper wire for electrical purpose - ASTM B33.
- 14) Electronic Cards, Subassemblies and Components
 - a) Unpackaged
 - i) Vibration : IEC-68.2.6
 - ii) Shock : IEC-68.2.27
 - iii) Drop & Topple : IEC-68.2.31
 - b) Packaged
 - Vibration, Drop & Static Compression - NSTA.
 - c) Electromagnetic Compatibility
 - i) Electrical Fast Transient : IEC-801.4
 - ii) Surge Withstand : IEC-255.4
 - iii) Radiated Electromagnetic Field: IEC-801.3
 - iv) Electrostatic Discharge : IEC-801.2
 - v) Electromagnetic Emissions : VDE 0871, Class-B
- 15) Cable Trays, Conduits
 - a) Guide for the design and installation of cable system in power generating station (cable trays, support systems, conduits)- IEEE Standard 422, NEMA VE-1, NEC-1981. Test Standards

NEMA VE-1-1979.

- b) Galvanizing of carbon steel cable trays - ASTM A-386.

Codes and standards as described in different sub-sections of this specification shall also be followed .

Items such as thermowells, control valves, flow elements and other in line devices in high and medium pressure steam, feed water and similar services, which fall under the purview of Indian Boiler Regulation Act shall be either certified by IBR or shall be certified by authorities acceptable to IBR. It shall be responsibility of Bidder to obtain the necessary approval of the concerned Authority / Chief Inspector of Boilers for the design and design calculations, manufacturing and erection procedure as called for under the IBR Act for all items requiring such certification.

6.00.00 DESIGN CRITERIA

This section lays down the general design criteria to be adapted in designing the Control & Instrumentation system of the plant.

6.01.00 General Requirements

6.02.00 Instrumentation, control and automation devices and accessories shall be designed with the following considerations:

- a) Stable in spite of temperature fluctuations.
- b) Able to withstand high humidity.
- c) Weather proof.
- d) Dust proof.
- e) Corrosion resistant.
- f) Erosion resistant.
- g) Able to withstand high vibration.
- h) Easily accessible for operation & maintenance.

6.03.00 Parts subject to high pressure, temperature or other severe duty shall be of materials and construction suitable for the service conditions and long operating life.

6.04.00 Components of instruments, control devices, accessories, piping etc. which contact steam, condensate or boiler feed water shall be manufactured from copper-free materials.

6.05.00 Instrument Accuracy, Standard Scales and Ranges

6.05.01 Instrument Accuracy

Instruments shall meet the following general requirements.

- a) Pressure measurement shall be linear with respect to the measured pressure.
- b) Flow meter shall meet the specified accuracy criteria when operating between 25 and 100 % of full-scale flow. The accuracy shall include the effect of errors in the differential head measuring device, square root converter and signal generator.
- c) Level measurement shall be linear with respect to the measured level based on a water specific gravity of 1.00.
- d) Wherever the measured parameter is influenced by process pressure & temperature, required compressibility correction shall be introduced.

6.05.02 Instrument Scale Displays

- a) All displays shall be in engineering units. Instrument scales displayed on screen will have graduations with scale divisions based on multiples of 10. The smallest division shall preferably be a whole number approximately 1% of the scale range if not otherwise impracticable.
- b) Pressure instrument shall have the unit suffixed with 'a' or 'g' to indicate absolute or gauge pressure, respectively.
- c) Scales and charts of all instruments shall have linear graduations

6.05.03 Instrument Ranges

Instrument range shall be selected to have the normal reading, preferably between 50% and 70% of full scale for linear parameters and 70% to 80% for flow measurements. Deviation indicators shall have the null position at mid scale. The normal operating parameter shall be identified with a clear green mark.

6.06.00 Operability & Maintainability

6.06.01 The system shall be designed such that any 'single-failure' shall not lead to loss of availability of the plant, alteration in operating routine or degradation of performance. This shall be achieved by judicious introduction of redundancy at all critical levels. The plant operator remains totally transparent to 'single-failures'.

6.06.02 The system and operator interfaces / consoles shall be designed for the operation of the unit with minimum operational manpower deployment .

Bidder shall ensure proper operability and also take into account protections to achieve no accidental maloperations .

- 6.06.03 The choice of hardware shall take into account sound maintainability principles and techniques and shall not be limited to the following:
- a) Standardization of parts.
 - b) Minimum use for special tools.
 - c) Modular and hot replacement.
 - d) Logical grouping of functions.
 - e) Separate and non-interactive adjustability.
 - f) Malfunction identification facility through self-diagnostics.
 - g) Easy removal, replacement and repair.
 - h) Easy assembly and disassembly.
 - i) Fool-proof design to preclude improper mounting and installation.
 - j) Redundancy of critical parts.
 - k) Unique process equipment vis a vis hardware identifiability by assigning sub-racks / sub-rack sections to specific plant areas.
- 6.06.04 Intercommunications in between sub-racks and system termination cabinets and in between sub racks and other panels shall be made by prefabricated connectors and cables with mechanical latch.
- 6.06.05 Adequate test facility shall be incorporated in the design.
- 6.07.00 Established Reliability & Availability
- 6.07.01 The minimum target reliability of each component/module shall be established by taking into consideration its Mean time between failure (MTBF) and Mean time to repair (MTTR), so that availability of the complete system is assured for 99.7%.
- 6.07.02 In order to establish the target reliability Bidder shall perform necessary availability tests and burn-in tests for major systems. Surge protection for solid state systems, selection of proper materials, manufacturing processes, quality controlled components and parts, adequate derating of electronic components and parts shall be ensured to meet the reliability and life expectancy goals.
- 6.07.03 Continuous self-checking features shall be incorporated in system design with automatic transfer to healthy/redundant circuits to enhance the reliability of the complete system.

6.08.00 Security and Failure Philosophy

6.08.01 General

It is essential that interlock, protection, supervision and automatic control systems shall have high integrity. Control & Instrumentation system shall meet the following requirements:

- a) No single failure shall cause failure of the control.
- b) No single fault shall cause the protection system to operate spuriously or cause the protection system to become inoperative.
- c) Grouping of the control functions into system blocks shall be such that failure of any one block will only partly degrade the overall system.
- d) Control system shall be structured with redundancy so that no single failure within the control system can cause the failure of plant on duty and at the same time cause the standby plant to be unavailable.
- e) Due to control system failure if a final control element or plant item does not respond then the control element shall go into a fail safe status.
- f) Field wiring for contact interrogation or device control shall be protected such that a fault on the cable does not cause loss of more than a minimum tolerable functionality of the system.

6.08.02 Measurement & Channel Redundancy

To meet the failure and self checking criteria for the control system, measurement redundancy shall be provided for all the critical parameters. Throughout the control system, the security and validity of signals are to be ensured based on the following design principles.

- a) Where a plant measurement is to be duplicated or triplicated such signals shall be separately fed to the different input modules.
- b) Signals, after due security and validity checking by means of voting, averaging, median, difference monitoring or similar technique shall be used for control functions.
- c) Where duplex measurements are used, provision shall be there for selecting any one as the duty signal. Continuous monitoring of Deviation between the signals shall be made in the system.
- d) For binary and analog inputs required for protection of SG , TG and major auxiliaries whose non availability may result in loss of generation triple sensing devices shall be provided . Binary and analog inputs , which are required for protection of more than one equipment as well as protection signals for important auxiliaries and HT drives etc. triple sensing devices shall be provided .Also other

binary and analog inputs required for CLCS dual sensing devices shall be provided. However, for those binary and analog inputs which are also required for protection in addition to CLCS, triple sensing devices shall be provided.

- e) Measurement system, CLCS and OLCS shall all be configured with redundancy at processor modules, communication modules, data bus and power supply modules. Triple redundancy shall be followed as described elsewhere in the specification. All servers shall be dual redundant.
- f) Both CLCS & OLCS shall be configured with Redundant I/O channels for each sensor/signals. Where redundant sensors are provided redundant I/O channels shall be provided for each sensors/signals.
- g) Redundant sensors shall be provided for all control applications. For all major closed loop controls (CLCS) triple redundant sensors shall be provided. For other CLCS loops dual redundant sensors shall be provided.
- h) Similarly for critical protection logic requirements triple redundant sensors for 2 out of 3 logic shall also be provided to avoid spurious tripping. For all other control application dual redundant sensors shall be provided. Dual and Triple redundant sensors shall also be provided as described elsewhere in the specification.
- i) Signals shall be verified against cable failure / non coincidence monitoring for critical trip signals.

6.08.03 Redundancy in input / output modules

- 1. Redundancy
 - a) Redundancy in input / output modules for close loop control systems, open loop control system, protection, interlocking and sequential control shall be provided as follows:
 - i) Wherever redundant sensors are employed each sensor shall be wired to a separate input module so that even if one input module fails, the parameter will be available from the other input module.
 - ii) Redundancy in output module shall be provided for all HT (11KV & 3.3 KV) drives, critical LT drives and all modulating control drives so that any single failure of the output module shall not lead to the failure/disturbance of process. critical LT drives will be finalized by the owner at the time of Detail engineering.
 - iii) For BMS / FSSS and Turbine Trip system relevant sections elsewhere shall be referred. Refer clause nos. 4.29.02 and 4.30.01 of section -I for FSSS and Turbine trip redundancy.
 - iv) In addition to above, 20% wired input/output spare channel shall be

provided for each I/O module.

2. Bidder to note that all I/O, Processor, network interface, communication modules etc., shall be sourced from their Original Principial's works.
3. The system shall be provided with extensive diagnostic features so that a system failure can be diagnosed down to the module level giving location and nature of fault. Ease of maintenance and trouble shooting shall be a primary consideration in equipment selection.
4. The system shall provide inherently safe operation under all plant disturbances and component failures so that under no circumstances safety of the plant personnel nor equipment is zeopardized.. The DCS hardware shall be suitably sized to ensure that the implemented scheme meets the desired requirements. The Bidder through detailed calculations shall establish the adequacy of the system selected and demonstrate the same during shop testing and site testing.

6.08.04 Data highway Redundancy

There shall be Redundancy in the system for high reliability of communication. The redundant buses shall work continuously. All communication modules, bus couplers, bus interfaces etc. shall also be hot redundant.

Communication between the operator station and the functional groups of control microprocessors shall be by means of hot redundant data highways. Redundancy failure shall also be indicated in operating station.

All soft links amongst DCS and various PLC / proprietary control systems shall be redundant bidirectional OPC link.

6.08.05 Redundancy for Power supply unit

All power supply feeders from UPS (in parallel mode having 50% load sharing) or 24 V DC system (in parallel mode having 50% load sharing) shall be redundant with auto changeover in each ACDB/DCDB panel. Any kind of bulk power supplies if used shall be redundant.

6.08.06 Redundancy in Operaotr Console

Operators' Consoles shall have fall back feature so that in case of failure of any console , its functions can be taken up in an adjacent console and LVS.

6.08.07 Design Of Enclosures

- i) Design of outdoor enclosures shall be weather proof, dust-tight, drip-proof and shall take into account the environmental conditions.
- ii) Enclosures shall be adequately sized so that the maximum permissible temperature shall not exceed 10 Deg.C above the ambient temperature of 50 Deg.C.
- iii) Enclosures design shall also take into account greatest possible personnel safety.

6.09.00 Electrical Noise Control

6.09.01 Equipment furnished by Bidder shall incorporate necessary techniques to eliminate problems caused by electrical noise interferences and power line borne surges encountered in power plant environment. Equipment, which are vulnerable to electrical noise interference or surge shall be suitably immunized to eliminate possible problems.

6.09.02 Bidder shall be responsible for implementation of the shielding, input balancing, ripple filtration and grounding for field inputs to achieve installation with minimum noise coupling.

6.09.03 Radiated immunity test shall be in accordance to IEC 801.3.

6.10.00 Surge-Protection For Solid State Equipment

6.10.01 All solid-state equipment shall be able to withstand the surges inherent in a powerhouse environment. Equipment shall be designed to successfully withstand surges without damage to components and/or wiring on application of surge wave whose shape and characteristics are defined in ANSI publication C37.90-a (IEEE-472-1974) entitled "Guide for Surge Withstand Capability (SWC) Tests".

6.10.02 To immunize the system against surge, coupling free wheeling diodes, surge suppressors, opto / galvanic isolators shall be used as required.

6.11.00 Burn-In And Elevated Temperature Test

Solid-state equipment / system shall be certified to be tested for a minimum period of 168 hours continuously under power. Solid-state logic systems shall be subject to the elevated temperature test and burn-in test as complete assemblies.

6.12.00 Elevated Temperature Test

- a) During the first 48 hours the ambient temperature shall be maintained at 50° C and the equipment shall be made to repeatedly perform operations it will be expected to perform in service with loads on various components being equal to those which will be experienced in actual service.
- b) The 48 hours test period shall be continuous but shall be divided into

four 12-hour segments. The power supply voltage during each 12 hours segment shall be nominal voltage for 11 hours; followed by 110 percent of nominal voltage for 30 minutes; followed by 90 percent of nominal voltage for 30 minutes.

- c) During the elevated temperature test the cubicle doors shall be kept closed and inside temperature in the zone of highest heat dissipating

component /module shall be monitored. Temperature rise inside the cubicle shall not exceed 10 Deg.C above the ambient temperature of 50 Deg.C.

6.13.00 Burn in Test

The 48 hours elevated temperature test shall be followed by 168 hours of burn in test at normal operating temperature. This test shall also be conducted as per above procedure.

6.14.00 Panels, Cubicles and Enclosures

6.14.01 General

- a) All panels, cubicles and enclosures shall be furnished complete with integral piping, internal wiring, convenience outlets, internal lighting, grounding, ventilation, space heating, vibration isolating pads and other accessories.
- b) Unless otherwise specified cable entry for panels / desks / cabinets shall be through bottom via glanding plate. Fireproof seal shall be used to seal the bottom to prevent entry of dust.
- c) Panels and cabinets shall be constructed from steel sheet reinforced as required to provide true surface and adequate support for devices mounted thereon. Thickness of the CRCA steel for UCP / backup panel and other panels/cabinets shall be as described in Section VII of this volume of the specification. Panels and cabinets shall be of adequate strength to support mounted components during shipment and to support a concentrated load of 100 Kilograms on their top after erection.
- d) Panel /cabinet shall have eyebolt on top for lifting.
- e) Mounting , wiring , powering of all items to be mounted / installed on desks irrespective of the source of procurement shall fall in the scope of erection of Bidder ,this shall include freeissue items furnished by Owner.

6.14.02 Surface Preparation and Painting

Sheet metal exterior steel surfaces shall be sand blasted, ground smooth and painted as specified below:

- a) Suitable filler shall be applied to all pits, blemishes and voids in the

surface. The filler shall be sanded so that surfaces are level and flat; corners are smooth and even. Exposed raw metal edges shall be ground burr-free. The entire surface shall be blast clean to remove rust and scale. Oil, grease and salts etc. shall be removed from by one or more solvent cleaning methods prior to blasting.

- b) Two spray coats of epoxy primer surface shall be applied to all exterior and interior surfaces, each coat of primer surface shall be of dry film thickness of 1.5 mil. A minimum of two spray coats of final finish color (Catalyzed epoxy or polyurethane) shall be applied to all surface of dry film thickness 2.0 Mil. The Min. Paint shade thickness at exterior & Interior shall be 80 to 100 Microns. The finish colors for exterior and interior surfaces shall conform to the following shades:
 - i) Exterior : RAL 7032
 - ii) Interior – Brilliant White (Preferred) / RAL 7032.
- c) Paint films, which show sags, cheeks, blisters, teardrops, fat edges or other painting imperfections shall not be acceptable.

6.14.03 Wiring

Wiring within the panels shall conform to NEC standards and shall be factory installed and tested at the works. All interior wiring shall be installed neatly. Features shall not be limited to the following :

- a) All spare contacts of relays, switches and push buttons shall be wired up to the terminal blocks.
- b) Each wire shall be identified at both ends with wire designation as per approved wiring diagram. Heat shrinkable type ferrules with indelible computerized print shall be used with cross- identification.
- c) Wire termination shall be made with insulated sleeve and crimping type lugs. All external connections shall be made with one wire per terminal. Wire shall not be spliced or tapped between terminals. Open-ended terminal lugs shall not be used.
- d) Internal wiring shall be terminated uniformly on one side of the terminal block leaving the other side available for termination of outgoing cables.
- e) Thermocouple lead wires, analyzer measuring lead wires, or any other lead wires carrying measuring signal of the order of low mili volt or micro volt shall be electrically and physically isolated from other AC and DC wiring.
- f) All low-level signal cables shall be separately bundled from control cable.
- g) Wires shall be dressed and run in troughs with clamp-on type covers. Wirings shall be neatly bunched in groups by non-metallic cleats or

bands. Each group shall be adequately supported along its run to prevent sagging or strain on termination.

- h) Shield wires shall be terminated on separately.
- i) Common connections shall be limited to two wires per terminal. Looping of wires for power distribution in the panel to be avoided. Busbars to be provided for Power distribution".
- j) Wiring to door mounted devices shall be provided with multi-strand wires of (49 strands minimum) adequate loop lengths of hinge-wire so that multiple door openings will not cause fatigue to the conductor.
- k) Wiring shall be arranged to enable instruments or devices to be removed and/or serviced without disturbing the wiring. No wire shall be routed across the face or rear of any device in a manner, which will impede the opening of covers or obstruct access to leads, terminals or devices.
- l) Panel internal wiring shall follow distinct color-coding to segregate different voltage levels viz. 24V DC, 48V, 110V AC, 240V AC, 220V DC etc.
- m) Panels /cabinets /desks shall be provided with removable gasketed cable gland plates and cable glands. Split type grommets shall be used for prefab cables.
- n) Wire shall be multistranded annealed flexible high purity copper conductor with heat resistant FRLS PVC insulation and shall pass vertical flame test per IPCEAS-1981.
- o) Wire sizes used for internal wiring shall not be lower than the followings :
 - Control wiring (switches, pushbuttons etc.) : 1.5 Sq.mm
 - Power supply /receptacle : 2.5 sq. mm or higher as per load
 - illumination wiring
 - 4-20mA DC current and low voltage signal upto 48V DC : 0.5 Sq. mm
- p) Identification of conductors shall be done by insulation color-coding identified on drawings or by printed wiring lists.

6.14.04

Grounding

- a) System cabinet AC and DC ground shall be electrically isolated from each other and also electrically isolated from the Instrumentation signal ground. All the above ground shall be individually connected to

the single point on the ground pit. Dedicated redundant earth pit shall be provided which shall be away from the HV equipment. This earth pit shall not be shared with other electrical equipment ground and shall also be insulated from other electrical system ground to ensure single point grounding of the system. Grounding resistance shall be better than 1.0 ohm. IEEE guideline shall be followed while designing the grounding system.

- b) Panels and cabinets shall be provided with a continuous tinned copper ground bus bar of minimum 25 mm x 6 mm cross section, extending along the entire length of the panel / desk / cabinet assembly. The ground bus shall be bolted to the panel structure and effectively ground the entire structure.
- c) The panel /desk /enclosure /JB ground shall have two (2) bolt drilling with GI bolts and nuts at each end to connect to GI/ copper flat ground riser by means of insulated copper ground cable of required cross section with lug.
- d) Circuits requiring grounding shall be individually and directly connected to the panel ground bus.
- e) For electronic system cabinets, the electronic system ground bus shall be similar but insulated from the cabinet and shall be separately connected to the system ground. Signal cable shields shall be grounded at the panel end only and shall not be left open. The ground in between panels of a shipping section shall be firmly looped.
- f) Electrical meters, relays, transmitters and switching devices, operating at a voltage less than 50V may be grounded through the steel structure.

6.15.00 Panel / Cabinet/ Desk/ Enclosures / junction boxes & instruments
Environmental Protections

- a) Panels, cabinets, desks, distribution boxes, racks ,junction boxes, terminal boxes , instruments and all other field mounted equipment / enclosures shall suit the environmental condition of the area and shall not be inferior than the requirement indicated in the following table.

SL. NO.	LOCATION	ENCLOSURE TYPE
1.	Indoor type non- ventilated enclosure in non-hazardous area	IP-54
2.	Indoor type ventilated enclosure in non-hazardous area	IP -42

SL. NO.	LOCATION	ENCLOSURE TYPE
3.	Enclosure in Air conditioned area	IP-32 with suitable canopy at top to prevent ingress of dripping water.
4.	Outdoor type in non-hazardous areas	IP-65 with anticorrosion coating.
5.	Outdoor in hazardous areas	As per requirements of the NEC Code for the location

- b) The construction of electrical enclosures located in areas subject to conditions classified in the National Electrical Code (NEC) as hazardous shall be of a type designated suitable for the environment in which they are located.

6.16.00 Terminal Blocks

- a) Terminals shall be chromated galvanized DIN rail mounted screwless cage clamp type or maxi termi type. Terminals shall have screwed connection for conductor cross-section above 2.5 mm². Terminal blocks shall conform to IEC 947-7-1.
- b) The **characteristics** of the terminal blocks shall be as follows.
- High contact force, independent of conductor cross-section and large contact surface area.
 - Integrated self-loosening protection to avoid shifting of contact surface that may allow contamination of connection point.
 - Inspection and maintenance free (resistant to thermal aging and vibration)
 - Low and constant voltage drop
- c) Material of the clamping yoke of screwed terminals shall be electroplated, chromated, case hardened steel with high strength clamping screw. For screwless terminals, the tension spring shall be made of high quality, non-rusting, acid-resistant steel. The current bar shall be of tin-lead plated copper or brass.
- d) Terminals shall be of non flammable suitable thermoplastic material such as polyamide.
- e) Terminal blocks shall be mounted vertically in panels and cubicles with clearance for at least 100 mm between two sets and between wall and terminal block.

- f) Terminal blocks shall be provided with white marking strips / self-adhesive marker cards. Power terminals shall have protection covers.
- g) At least 20 percent spare unwired terminals shall be provided for all panels /cabinets /desks /junction box etc... This shall be in addition to 20% spare wired terminals of spare IO channels.
- h) Bottom of the terminal block shall be at least 200 mm above the cable gland plate for bottom entry type panels.
- i) For extending 24 V DC supply to panels, the size of the terminals shall be decided based on voltage drop and not based on current.
- j) Other requirements of the terminal blocks are as follows:
 - i) The last terminal in a rail-mounted assembly shall be closed with an end plate and end bracket.
 - ii) For visual and electrical separation of terminal groups, partition plates shall be provided, which can be push fitted after forming an assembly.
 - iii) Design shall permit testing of incoming and outgoing signals by using suitable test plug and socket without disconnecting the cable connections.
 - iv) It shall be possible to use jumper plugs through the above test plug socket to connect adjacent terminals. Adequate number of short circuit jumper plugs shall be provided for the purpose.
 - v) Where more than one connection to a terminal block is required, two tier terminals shall be used.
 - vi) The terminal blocks for Power, control and signal cable terminal block shall be separate with separate colour coding for ease in recognition..

7.00.00 METERING BASES AND CHART UNITS

The following system of units shall be followed for various displays and scales unless otherwise mentioned:

- i) Pressure : Kg/cm²
Differential Pressure : mm of H₂O column / Kg/cm²
- ii) Draught : mm of H₂O column
- iii) Vacuum : Kg/cm² (abs)/mm of Hg column (This may change based on requirement during detailed engineering.)

iv)	Temperature	: Degree Celsius ($^{\circ}$ C)
v)	Flow (Steam, Water)	: Tonnes / hr, M ³ /Hr
vi)	Flow (Oil)	: M ³ / Hr, Liter/Hr
vii)	Flow Air	: Tonnes / hr / M ³ / Hr.
viii)	Density	: gms / c.c.
ix)	Level	: mm /%
x)	Conductivity	: Micro Siemens / cm
xi)	Gas Analyzer	: Percentage by weight or as specified in respective case.
xii)	Dissolved Oxygen / Silica / Sodium	: ppm /ppb

8.00.00 PROCESS CONNECTION & INSTRUMENT HOOK UP

- 8.01.00 Instrument connection to the process system (piping, vessel etc.) shall be according to the process & piping specification upto and including the root valves. Root valves shall be installed as close as possible to the piping or vessel.
- 8.02.00 Each instrument shall have its own independent connection to the process except for instruments located on standpipe. Each instrument shall be connected independently to the standpipe through isolation valve.
- 8.03.00 Process connection for instruments lines and vessels shall be in accordance to standards such as ASME or other recognized international standards.

9.00.00 POWER SUPPLY SYSTEMS

- 9.01.00 Instrumentation power supply system shall include all conditioning equipment required to accommodate normal variations in the electrical supply. All panels and cabinets shall accept redundant power feeds from two different sources.
- 9.02.00 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:

DCS shall be powered by two independent 24V DC power supply sources in redundant mode for each unit. 240V AC redundant UPS shall be provided in the Unit Control Room to feed the Network components of the DCS, all system peripherals such as operator work stations(OWS), engineering stations, servers, printers,etc., LVS and other systems/equipments like CCTV, CEMS, SWAS etc. requiring UPS power.

24 VDC redundant power supply modules with diode 'O' ring shall be used separately for each application, based on system requirements. However, the 230 VAC input to each power supply module shall be provided from a redundant source via the Plant UPS. Bidder shall clearly bring out in his proposal the redundancy features along with necessary single line diagram, data sheets etc. and this shall be finalised during detailed engineering and subject to Owner's approval.

PLC / proprietary control and monitoring system for package Systems. Shall be provided with independent redundant UPS systems.

Refer Electrical Specification Volume IIF/2 Sections X-A1, X-A2 & X-B

10.00.00 ENVIRONMENTAL CONSIDERATIONS

C&I components shall operate properly with no degradation in expected lifetime or in operation parameter in the normal power plant environment. C&I system shall be designed considering all the operating conditions which may be encountered during installation and operation.

10.01.00 Temperature

10.01.01 Where the environmental extreme exceeds the capabilities of the selected system, Bidder shall take appropriate steps to control the environment.

10.02.00 Humidity

10.02.01 C&I system shall be designed to withstand the humidity limits specified for the project. Condensation shall not be allowed to form in the cabinets nor shall water be allowed to be admitted through conduit entering the cabinets from top or sides.

10.03.00 Atmospheric Contamination

10.03.01 Particulate contamination from fly ash and coal dust and gaseous contaminants such as SO₂ and other flue gas constituents in the coal fired plant are foreseen. This hazard shall be taken into design considerations.

10.04.00 Vibration

10.04.01 Design of the systems shall include features such as locking devices, anti vibration pads etc, to withstand vibration. In general, C&I equipment shall be installed away from the vibration zone.

10.05.00 Lightning

10.05.01 Protection against lightning shall be considered by providing proper grounding, metal oxide varistors, spark gap lightning arrestor, optical isolator and isolation transformer.

11.00.00 SECURITY

- 11.01.00 IP Door lock shall be provided in all Panels, Cabinets and Enclosures.
- 11.02.00 System mode key switch or password to prevent tampering of system program.
- 11.03.00 Redundant elements of the system shall not be exposed to the common hazards. For example routing of the redundant network cable through separate cable raceway, using separate cabinet / separate rack for redundant controller and redundant IO modules.

12.00.00 ACCEPTANCE TESTS

The Bidder shall be required, as part of his Bid, to fully integrate and test all the equipment, included in his Bid and respective Control packages at site and at the manufacturer's works. Owner / Consultants shall witness these tests.

The Bidder shall consider in his Bid the following minimum tests:

(a) Factory Acceptance Test (FAT)

After completion of manufacture of all control and monitoring systems like DCS , PLC, BOP network PLC , Proprietary control systems , RMCMS , , Alarm annunciation system , CEMS, CCTV , Plant telephone System , SWAS , etc. and prior to delivery to site, the manufacturer shall functionally test the assembled system. The integrated test shall be carried out with all input / output cubicles, control processors, data highway, operator's consoles, Engineer's console and peripheral devices connected in the specified configuration. The fully configured software shall also be loaded and tested at the same time.

The FAT shall include , as a minimum , the following activities:

- Complete hardware and software inspection;
- Heat cycle run test as per the prevailing standards;
- Functional test of a 100 % of all configured points, logic routines, control functions, graphic displays, reports and logs;
- Demonstration of special calculations (e.g. efficiency calculation, performance calculations etc.);
- Testing of redundancy facilities to demonstrate automatic change over to standby data highway, power supply and control processor etc.;
- Demonstration of displays , logs and system diagnostic facilities;
- Demonstration of spare capacity

- Demonstration of third party interface

The FAT shall be witnessed by the Owner / Engineer who shall be notified at least three (3) weeks before the commencement of the tests. The system shall have been fully pre-tested by the manufacturer at his works prior to notifying the Owner / Engineer to ensure any component, equipment or system fault have been identified and cleared. The test procedure for the FAT shall be issued to the Owner and agreed prior to notification. All documents / drawings and test equipment shall be available at the manufacturer's works during the FAT.

The FAT shall include a 72 hour continuous operational run, any equipment fault or failure during this time shall make this part of the test null and void and the test run shall be re-started after rectification of the fault. A test certificate, accompanied by the relevant test results, shall be issued after successful completion of the tests.

(b) Site Acceptance Test (SAT)

After installation, connection, integration with other systems and all pre-commissioning checks have been carried out on the complete system, the SAT shall be performed and witnessed by the Owner. The SAT shall include the following as a minimum:

- i. Complete hardware , software and installation inspection;
- ii. Testing of redundancy facilities by simulating data highway, power supplies and control processor failures. All such units shall be tested to demonstrate of the automatic operation of the standby units and initiation of the relevant system alarms;
- iii. Demonstration of system diagnostic facilities; by the simulation of the appropriate fault conditions. The system fault reporting techniques shall also be demonstrated;
- iv. Testing of data highway integrity using continuity test equipment based on signal injection / reflection techniques;
- v. Demonstration of data logging, displays, sequence of events trending system operation.
- vi. Pre-commissioning checks shall include the following as a minimum :
 - Calibration of all field instruments, analyzers and equipment, in the scope of supply of this package, at site;
 - Loop checking, for all open and close loops, between source and destination with manual signal injection as well as from Operating Consoles for entire DCS / PLC/ Proprietary control systems I/Os;
 - Logic sequence check with the manual signal injection at signal source as well as checking of feed back signals.

- vii. All individual configured data points, logic routines, control functions, graphic displays and reporting facilities shall be verified as part of the loop tests.
- viii. The Owner shall be notified at least 2 weeks before the commencement of the test. The procedures shall be issued and agreed before notification.
- ix. A test certificate accompanied by the relevant test results shall be issued after successful completion of the calibration and test.