

		6 Nos. of recorders shall be supplied with BTG packages and the parameters shall be decided during detailed Engineering. Quantities of recorders for BOP packages shall be decided during detailed Engineering. (Simultaneous parameter display preferred)
Input Signal	:	Fully configurable multi range (Programmable) universal (input)
Recording method	:	Continuous with different colour, for each channel
Display colour	:	Selectable from 30 Colours
Bar graph facility	:	To be provided
Digital indication	:	To be provided
Accuracy	:	+/- 0.1 % for reading for DC V Input And 0.1 Deg for TC/RTD input
Programmability	:	Front key board
Data Storage	:	hard disk/ Flash Memory
Data Retrieval	:	Compact 4 GB flash Memory card and USB port with 8 GB USB drive.
Scan rate	:	≤ 20 m second for individual channel. Selection of scan time for individual channel is required.
Power Supply	:	240 VAC 1 Phase UPS
Ambient Temperature	:	0-50 Degrees
Mounting	:	Front panel mounted weather & Dust proof IP 65
Application software	:	Yes, To be provided
Internal Memory	:	400 MB or more
Screen	:	≥ 10.5" colour LCD TFT
Resolution	:	≥ 640 X 480 Pixels
Type of Display	:	i) Trends ii) Bar Graph iii) Digital display/ values
Event Sampling	:	1/2/5/10/30/60/120 sec.
Zoom & Scroll Facility	:	Required
OWS and printer connectivity port	:	Required
	:	Necessary software shall be supplied for uploading the data.
Communication	:	Additional MODBUS/PROFIBUS ports connectivity between recorder and third party systems.

3.03.45 DIGITAL INDICATOR

Type	:	Programmable electronic digital indicator with floating point decimal.
Input	:	4-20 mA DC/1-5V DC/RTD/T/C.
Number of inputs	:	One
Range	:	As per requirement/adjustable by end user

		through key pad available on the indicator.
Number of digits	:	Four plus sign
Digit height	:	20 mm or larger
Display	:	Fluorescent red
Input over range/open sensor (T/C)	:	All digits to flash
Input hold time	:	0.7 seconds max.
Accuracy	:	$\pm 0.25\%$ of span
Power supply	:	240V AC, 50Hz
Mounting	:	Flush panel, compatible for mounting on mosaic grid panel
Size	:	96x48 mm
Other Particular	:	Indicator receiving thermocouple signal shall have automatic cold junction compensation.
	:	Retransmission Output 4 -20 mA isolated required.
	:	24 V DC inbuilt power supply
	:	Alarm contact with 2 N/O/NC contact (rating 5A/230 V AC)

3.03.46 RECEIVER INDICATORS (SINGLE/DUAL CHANNEL)

Type	:	Analogue indicator
Input Signal	:	Universal input (T/C, RTD, 4-20 mA, Voltage)
Scale	:	Range fully configurable and programmable
Measurement Accuracy	:	$\pm 0.2\%$ of span ± 1 count
Resolution	:	0.5% Span
Dead band	:	$\pm 0.2\%$ of span
Repeatability	:	0.2% of span
Full scale response time	:	Less than two(2)seconds
Power Supply	:	240V AC, 50 Hz
Connection	:	Plug in type
Accessories	:	Mounting Bracket for Bins
Other Particulars	:	Indicator receiving thermocouple Signal shall have automatic cold junction compensation.
	:	Retransmission Output 4 -20 mA isolated required.

3.03.47 Temperature Scanner

Type	:	Microprocessor based Electronic Digital Scanner.
No. of channels	:	16/24 (as per the application)
Input	:	RTD /Thermocouple/4-20mA
Accuracy	:	± 0.1 of FS ± 1 count
Number of digits	:	4 digit (7 segment display with Engg. Units)
Digit height	:	12 mm or larger
Display color	:	Fluorescent red/green
Display mode for	:	

Input over range/open sensor	:	All digits to flash
Mounting	:	Panel mounting
Zero and Span	:	Adjustable by digital calibration
Serial communication communication	:	Isolated RS232/485 for modbus-RTU
Memory Capacity	:	5MB Flash
Alarm output	:	Required
Contact rating	:	2A at 220 V AC
Power supply	:	240 V AC/24 V DC
Properties	:	i. Any channel shall be configured for Data Logging ii. Channel to Channel online Isolation shall be provided iii. Real Time RTC Interface for Printer shall be provided
Operation Modes	:	Auto/manual mode, Run mode, Verify mode, Calibration Mode, Program mode.

3.03.48 **AMMETERS (AMM)**

Input	:	4-20 mA DC
Mounting	:	Flush panel, compatible for mounting on mosaic grid panel
Face Dimensions	:	96 x 96 mm
Scale/Type	:	Moving coil, circular, FSD 240 deg. With six times suppression scale
Zero adjustment	:	Screw on meter face
Accuracy	:	± 1 percent (class 1)
Indication	:	Pointer with scale
Magnetic Shield	:	Shielded Case
Quantities	:	For all HT Motors & LT motor with rating ≥ 30 KW and other critical application motors/drives.

3.03.49 **VOLTMETER:**

Input	:	4 - 20 mA DC
Mounting	:	Flush Panel, compatible for mounting on mosaic grid panel
Face Dimension	:	96x96 mm
Range	:	As per requirement
Accuracy	:	$\pm < 0.5$ %
Indication	:	Digital type 4 1/2 digit
Magnetic Shield	:	Shielded Case
Connection	:	Plug in type
Quantities	:	For 230 V AC input power supply, UPS power supply, 24 V DC interrogation voltage & 220 V DC.

3.03.50 **FREQUENCY METER/MW METER (DIGITAL)**

Type	:	Electronic digital 7- segment with fluorescent display
Input	:	4 - 20 mA DC
Mounting	:	Flush Panel compatible for mounting On mosaic grid panel
Number of digits	:	4 1/2 digit
Face Dimension	:	192X192 mm
Digit size	:	Approximately 40 mm
Range	:	As per requirements
Accuracy	:	± 0.2 Hz
Display	:	Red LED display.
Connection	:	Plug in type
Magnetic Shield	:	Shielded Case

3.03.51 AC CURRENT TRANSDUCERS

Input	:	0 - 1 A CT current
Output	:	Dual 4-20 mA with 500 impedance
Mounting	:	Back rail
Accuracy	:	$\pm 0.25\%$

3.03.52 DC CURRENT TRANSDUCERS

Input	:	0 - 75 mV
Output	:	Dual 4-20 mA with 500 impedance
Mounting	:	Back rail
Accuracy	:	$\pm 0.25\%$

3.03.53 AC VOLTAGE TRANSDUCERS

Input	:	0 - 110 V PT, Volts
Output	:	4-20 mA with 500 impedance
Mounting	:	Back rail
Accuracy	:	$\pm 0.25\%$

3.03.54 DC VOLT TRANSDUCERS

Input	:	System Voltage
Output	:	4-20 mA with 500 impedance
Mounting	:	Back rail
Accuracy	:	$\pm 0.25\%$

3.03.55 TRANSDUCERS FOR POWER

Input	:	CT and PT (1A) (110V)
Output	:	4-20 mA with 500 impedance
Mounting	:	Back rail
Accuracy	:	$\pm 0.25\%$

3.03.56 TRANSDUCERS FOR FREQUENCY

Input	:	110 V PT Volts
Output	:	4-20 mA with 500 impedance
Mounting	:	Back rail
Accuracy	:	$\pm 0.25\%$

3.03.57 TRANSducers FOR POWER FACTOR

Input	:	PT (110V)
Output	:	4-20 mA with 500 impedance
Mounting	:	Back rail
Accuracy	:	$\pm 0.25\%$

3.03.58 TRANSducers FOR MVAR

Input	:	CT & PT (110V/1A)
Output	:	4-20 mA with 500 impedance
Mounting	:	Back rail
Accuracy	:	$\pm 0.25\%$

3.03.59 DIFFERENTIAL FREQUENCY TRANSducers (FOR SYNCHRONIZATION)

Input	:	110 V PT
Output	:	4-20 mA with 500 impedance
Mounting	:	Back rail
Accuracy	:	$\pm 0.25\%$

3.03.60 DIFFERENTIAL VOLT TRANSducers (FOR SYNCHRONIZATION)

Input	:	System voltage
Output	:	4-20 mA with 500 impedance
Mounting	:	Back rail
Accuracy	:	$\pm 0.25\%$

3.03.61 PUSH BUTTONS (PB)/ ILPBs FOR ON/OFF, OPEN/CLOSE, START/STOP

Type	:	Momentary/Miniaturised Suitable for mosaic grid 24x48 Mm with 2 PB and 3 coloured LED.
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Contact Configuration	:	2 NO + 2 NC
Contact Material	:	Hard Silver Alloy
Contact Rating	:	500V / 10 A
Insulation Voltage	:	2 KV for 1 minute between

terminals and earth

Lamp Rating :-

a) Voltage	:	240 V AC
b) Watt	:	2 Watt (approx.)

Colour

Red	– ON/Start/Open ILPB
Green	– OFF/Stop/Close ILPB
Red	- energized, running, Start, valve open LED/Lamp
Green	- de-energized, stopped, valve closed LED/Lamp
Light yellow	- abnormal, discrepancy LED/Lamp
Red	– OFF/Stop/Close PB
Green	– ON/Start/Open PB
Red	- Emergency trip push buttons with red flap / hinged Transperent arylc cover.

3.03.62 PUSH BUTTON FOR Control DESK: **Momentary mosaic grid mounted**
24x48 mm size, single PB 18x40 mm
Colours for DESK RELEASE - Yellow,
Desk Lamp test - Blue, Desk Ack - Green

3.03.63 PUSH BUTTON FOR SEQUENCE START/RELEASE : Momentary (Miniaturised) suitable
for mosaic grid 24x48 mm
3 PB + 5 LED

3.03.64 PUSH BUTTON FOR ANNUNCIATION

Contacts

- Number & Type	:	As per requirement
- Breaking capacity	:	1 Amp, 220V DC 10 Amp, 600V AC Different colours for Accept/Ack - Green, reset Grey, Lamp test – Blue, System Test – Yellow & Audio Ack - Black.

3.03.65	<u>BELT WEIGHING SYSTEM</u>
3.03.65.1	General
	The mechanical design and constructional features for belt weigher has been described under mechanical section, hence not repeated here, Similarly motor specifications for the same has been covered under electrical specification, hence not repeated here.
	The belt weighing system shall have its own local control panel to be located in electrical equipment room. The local panel shall include: (a) Local flow rate indication (b) Integrated flow rate indications (c) System alarm annunciation (d) Local Calibration facility (e) Power on/off All these above display shall be backlit LCD type with 12mm character height. NI Cd Battery back up (60 minutes backup) shall be provided for the measurement system. (a)Application : Bulk material, Powder material (b)Drive Protection : Reverse Polarity, Communication failure

3.03.65.2	Load Sensing Cell	
	(a)Type	Strain Gauge/Compression type
	(b)Enclosure Protection	NEMA 4X (IP 66)
	(c)Load	
	(i)Nominal Load	Bidder to specify in tabular form.
	(ii)Rated Load	Bidder to specify in tabular form.
	(iii)Destructive Load	Bidder to specify in tabular form.
	(d)Supply Voltage	24V DC
	(e)Sensing	Resistance bridge
	(f)Temp. Effect on Zero & span	+/- 0.015%/10K
	(g)Basic Resistance	Manufacture's Standard
	(h)No. Of Load Sensors	Single
	(i)Mounting Type	Four idler
	(j)Accessories	Mounting plate kit, cable etc.
	(k)Accuracy	+/- 0.015% FSD
	(l)Spd Sensor	Tacho/encoder
	(m)Speed Output	Pulse train to be distributed to
		(i)Local control panel for own use
		(ii)4-20 mA DC signal to PLC
	(n)Load Sensor Output	4-20 mA DC isolated signal for PLC along with provision for serial communication link standard protocol
	(o)Computed Flow rate	
	(i)Hardware	4-20 mA DC isolated 2 numbers
	(ii)Serial Link	In Compliance with standard protocol
	(p)Protection class for measuring cell	NEMA 4X (IP 66)
	(q)Accessories	Special cables, electronics, cabinets etc. As required to make the system complete, with bar/chain.
	(r)Range	Application dependent
	(s)Range increment	0.1% of this selected range
	(t)Operating Temperature	0-70 degC
	(u)Accuracy	+/-0.25 % FS range
3.03.66	Hydrogen Gas System Instruments/Analysers	
3.03.66.01	Hydrogen Gas Hygrometer	

A	Performance	
1	Measuring Range	-80 C to 20 C
2	Response Time for 63% Step Change	<5 sec.
3	Output Resolution	0.01 mA
4	Storage Temp: Max	70°C
5	Operating Ambient Relative Humidity	<95%
6	Sensitivity	< 5 se conds for 63% s tep ch ange i n moisture content
B	Construction	
7	Measuring Principal	Thin Film Alum Oxide
8	Enclosure Protection class	intrinsically safe and explosion proof as per NEC article 500, class 1, Division 1 area I.
9	Display	3-1/2" Digit LCD
10	Mounting	In Explosion Proof Box
11	Location (Hazardous)	Hydrogen delivery after compressors.
12	Service	Measures Moisture co ntent i n t he Hydrogen Delivery
13	Code & Standard	EMC di rective 89/ 336/EEC and P ED 97/23/EC f or DN<25 - FM Standard 6320
14	Analog Output	4-20 mA, HART.
15	Type of Transmitter	4 to 20 mA loop powered 24 VDC
16	Certification	CE
17	Calibration	Required ev ery 12 m onths, C alibrator shall be supplied by bidder.
3.03.66.02	TRACE OXYGEN (O2) in Hydrogen gas Analyser	
A	Performance	
1	Nature of Fluid	Oxygen in Hydrogen
2	Response Time for 90% step change	< 10 sec.
3	Relative Humidity	0-99 %
4	Measuring Range	0-100 ppm
5	Accuracy	+ 2%
6	Repeatability	+ 0.1 ppm
7	Sensitivity	0 - 10 ppm < 45 seconds
B.	Construction	
8	Measuring Principle	Electrochemical Fuel Cell
9	Display	3-1/2" Digit LCD
10	Enclosure Protection class	intrinsically safe and explosion proof as per NEC article 500, class 1, Division 1 area I.
11	Mounting	On Panel with Sample System
12	Service	Measure t race oxy gen i n t he pr oduct hydrogen
13	Location (Hazardous)	Hydrogen delivery after compressors.
14	Code & Standard	ATEX Approved. II 1/2 G Ex ia II c T4
15	Output Current	4-20 mA, HART
16	Type of Transmitter	4 to 20 mA Loop powered 24 VDC
17	Calibration	Every 12 m onths with c alibration g as,

18	Calibration Gas	Calibrator shall be supplied by bidder. 5ppm O2 in N2, shall be provided by bidder for one year after commissioning of plant.	
3.03.66.03	Combined Gas Sensor for Hydrogen Gas System		
A	Performance		
1	Nature of Fluid	Hydrogen /Air	
2	Measuring Range	0 to 100% LEL	
3	Response 50%	<10 sec.	
4	Recovery to 10%	<30 sec.	
5	Accuracy	0-50%LEL range	51-100% LEL range
		± 1%	± 2%
6	Repeatability	± 1%	
7	Calibration frequency	180 days	
8	Output Range: 0-100 LEL	4-20 mA, HART	
9	Humidity RH	<99%	
10	Sensitivity	<12 seconds to 60% full scale	
11	Measuring Range	0-100 ppm	
B.	Construction		
12	Measuring Principle	Catalytically bead	
13	Enclosure Protection class	intrinsically safe and explosion proof as per NEC article 500, class 1, Division 1 area I.	
14	Display	3-1/2" Digit LCD	
15	Mounting	4 mtrs above respective instruments supporting Conduit	
16	Service	Monitor combustible mixture in the atmosphere of each room where hydrogen may be present.	
17	Location (Hazardous) (one in each), Any other location as finalised by owner during detailed engineering.	Roof -H2 Generation room	
		Roof - Compressor Room	
		Roof - H2 Storage Room	
18	Code & Standard	FM Standard 6320 FM Standard 3600	
19	Type of Transmitter	4 to 20 mA Loop powered 24 VDC	
20	Calibration Gas	2% H2 in N2, shall be provided by bidder for one year after commissioning of plant.	
21	Calibration	Every 6 months with calibration gas , Calibrator shall be supplied by bidder.	
3.03.66.04	Hydrogen Gas purity measurement Analyser		
A	Performance		
1	Range	80% to 100 % H2 in air	
		0 to 100 % H2 in pure gas *	
		0 to 100 % air in pure gas *	
2	Accuracy/Linerarity	± 1 % of FSD	
3	Resolution/Repeatability	± 0.5 %	
4	Response Time for 90% step change	< 5 sec.	

5	Stability/Drift	< + 1 % of FSD/month
B.	Construction	
6	Measuring Principle	Thermal Conductivity or Multi mode Oscillation type
7	Enclosure Protection class	Intrinsically safe and explosion proof as per N E C article 500, class 1, Division 1 area I.
8	Display	3-1/2" Digit LCD
9	Safety & EMC Standards	Safety Standards EN 61010-1 EMC Standard EN 61326
10	Output	2 nos. 4 – 20 mA DC, isolated from input
11	H2 Purity	99.99%
12	Calibration Gas	shall be provided by bidder for one year after commissioning of plant.
13	Calibration	Every 6 months with calibration gas , Calibrator shall be supplied by bidder.
14	Note: * Pure Gas options: CO ₂ , N ₂ , Argon	

Amplitude	: 100 mV to 20 V p-p (into open circuit) 50 mV to 10 V p-p (into 50 ohms)
Frequency accuracy	: $\pm 1\%$
Sine wave distortion	: less than 0.5%
Frequency stability	: $\leq 0.05\%$ for 10 min. $\leq 0.1\%$ for 1 hr. $\leq 0.5\%$ for 24 hrs.
Power	: 110V AC / 240V AC / 24V DC

13. Dual Beam storage type Digital Oscilloscope

Dual beam storage type oscilloscopes with color LCD display shall be supplied for the instrument shop. It shall incorporate latest state of art in design. Low watt dissipation and light weight shall be preferred. Simple direct reading controls arranged functionally shall be there in the front of the cabinet. Positive and negative triggering circuit selection shall be done easily by a selector switch. Auto range, auto set menu, automatic wave form measurement, shall be inbuilt features. Intensity/brightness shall be controlled from the front. Oscilloscope shall have a bandwidth from DC to 200 MHz (minimum). The oscilloscope shall have a minimum sensitivity of 2 mV/div.

Time Base

Sweep rate	: 5 nano seconds/div.
Raise time	: 3.5 nano seconds
Accuracy	: $\pm 5\%$ or better
Power supply	: 240V, 1 pH, 50 Hz

Horizontal Amplifier

Input impedance	: 1 M ohms (min.)
Band width	: DC to 200 MHz
Operating Station	: 8 x 10 cm, P31 phosphor operating station with 0.45 cm/division
Display modes	: Coloured display with Nonstore, bistable, variable persistence, fast bistable, Fast variable persistence
Calibration	: Rectangular wave for calibration and probe adjustment
Accessories	: a. One trolley with one lower rack is Envisaged for Carrying the OPERATING STATION from one point to other. b. High voltage grade, probe with suitable screening etc. Software & hardware for interfacing.

14. Tachometer

Digital Tachometer with contact and optical measurement facility in single instrument shall be supplied. Tachometer shall have measurement unit selection facility for rotational and linear velocity measurement and the same shall also be displayed. This instrument shall be offered with contact and non-contact pickup tips.

Following requirements as a minimum shall be fulfilled:

- a) Range:
 - i) Optical mode : 10 to 99,999 rpm
 - ii) Contact mode : 10 to 20,000 rpm
 - iii) Linear mode : 1 cm/sec. to 1000 m/min.
- b) Accuracy : $\pm 0.01\%$ of indicated reading for optical mode & $\pm 0.05\%$ of indicated reading for contact & linear mode
- c) Display : 5 digit LCD for measurement+ Measuring unit
- d) Sampling rate : 0.5/1.0 second
- e) Operational Mode : Sample
 - Hold
 - Lock
- f) Operating temp. : 0-50°C range
- g) Power supply : Built in 9.0 volts Rechargeable battery
- h) Accessories : Carrying case
 - One set of spare battery with
 - Chargers Tripod & adopter
 - Contact adapter, surface-speed wheel, convex and concave tips, reflective tapes, battery carrying case, etc.

15. **Soldering iron**

Use & performance : Electronic soldering iron specially engineered for long Lasting heavy duty and production line use fast heat up and quick recovery timing efficient heat transfer assure steady tip temperature and superior performance. All micro-electronics soldering application. Low current leakage and infinite heat insulation of element eliminates risk and damage to transistor integrated ckt and other electronic components and assure the safety of the operator.

Wattage & Qty. : 10 Watts - 1
25 Watts - 1
40 Watts - 1

- Suitable pressure generating unit (external) shall be provided for higher pressures.
- Measurement, generation and indication of current and voltage (mV, V and mA) signals.
 - Digital read-out of electrical as well as pressure signals.
 - Selection facility for reading pressure in five engineering units.
 - Generation of DC supply voltage to electronic transmitters.
 - Over pressure protection
- The instrument shall have re-chargeable battery as power back-up and shall be complete with all accessories viz. Battery Charger etc

39. Portable Analogue & Digital Vibration Meter

This instrument shall measure vibration of machinery in terms of displacement, velocity and acceleration. Power supply shall be by self contained replaceable batteries.

Displacement Range : 0 to 3000 microns peak to peak.
 Velocity range : 0 to 3000 mm/sec.
 Acceleration range : 0 to 100 g's.

The instrument shall be furnished complete with vibration pick-up, straight probe. Carrying case and one meter cord for connecting pick-up to meter. Vibration Meter shall be of digital and analogue type separately. One extra cable of 10 meter long connecting the sensor & Electronic unit to take vibration measurements of vertical pumps to be supplied.

Note: Analogue meter is used to find out any vibration due to electrical problem in the motor by measuring the transient vibration.

40. VIBRATION/ SHOCK PULSE ANALYSER cum Data Collector cum Balancer

Frequency Range : DC and 21 cpm (0.36 Hz) to 1,500,000 cpm (25K Hz)
 Acceleration Input : 21 to 1,500,000 cpm
 120 to 1,500,000 cpm
 Velocity Input : 21 to 1,500,000 cpm
 120 to 1,500,000 cpm
 Displacement Input : 21 to 1,500,000 cpm
 1500 to 1,500,000 cpm
 120 to 1,500,000 cpm
 Voltage Input : 30 V DC (Aux. 2 I/P)
 5 V DC (Aux. 1 I/P)
 Power : 6 volt, 2.4 A hr rechargeable battery
 Min. operating time - 6.5 hrs.
 Environment : Operating temp. Range -18°C to 60°C
 Relative Humidity : 0-95% non condensing
 Splash: Resistant, sealed case
 Output : RS 232 C port with HART for communication to 115,200 baud.

Accessories : As required with complete software.
 Application : Analyzing bearing condition, measuring machine vibration & checking of rotational speed.
 Type of Measurement : Acceleration, Velocity, Displacement, Phase, FFT, CPB, HFD spectrum, Temperature, Thrust, Axial position etc. with auto ranging in RMS, peak to peak, bearing fault analysis feature, balancing kit for in situ dynamic balancing and required software for 1 plane, 2 plane balancing, route generation and maintenance facility with off route data collection and analysis.
 Averaging Type : Linear, Exponential, Peak Hold

41. **Decade Resistance Box**

This should be three nos. analog type decade resistance box with resistance range of 1 ohm to 1.2M ohm, $\pm 1\%$ accuracy, all resistors rated to 0.75W, and shall use stable metal film resistors with complete electrostatic screening. This shall be supplied with certificate traceable to National /International Standards.

This shall be two nos. digital type decade resistance box with resistance range of 1 ohm to 1.2M ohm, $\pm 0.05\%$ accuracy.

One no. digital type variable Decade resistance Box, shall be provided as an accurate resistance source for calibration of RTD elements and receiver devices. The range shall be 0-100 ohm with increments of 0.001 ohm. Accuracy shall be $\pm 0.05\%$ or better.

42. **LAN/ Coaxial Cable Meter/ Tester**

This portable unit is used to check the quality of cable and test and troubleshoot coaxial and twisted pair cable in Local Area Network (LAN) installations. It shall be powered by standard AA alkaline battery allowing minimum 8 hour of operation. The cable meter shall meet the following requirement as minimum.

- (a) Display : Backlit LCD Display for observing result in sheet dark environment and emit audible tone to assist in pass/fail indication.
- (b) Test Standard : IEEE-802 & EIA/TIA 568
- (c) Range : For unshielded twisted pair (UTP) - 6 to 600 m
 For shielded twisted pair (STP) - 6 to 600 m

CHAPTER-9

ERECTION HARDWARE

9.00.00 PROCESS CONNECTION AND PIPING

9.00.01 General Requirements

This section covers the material requirement for instrument connection to process, instrument process, piping, tubing, supports, Instrumentation cables, control cables and power cables for connecting UPS, 24/48 V DC, unregulated power supply for cubicle illumination, compensating cables/Extension cables, transmitter racks and main accessories to be furnished under this specification and the requirements of installation and routing. Impulse lines, fittings and other accessories required for the erection of complete Instrumentation and Control System supplied under various packages of this specification shall be supplied on "as required" basis. Bidder shall offer all necessary items for this section based on his experience on similar plants, plant layout diagrams, installation drawings and other applicable sections of this specification. Based on the good engineering practices Bidder shall furnish installation drawings during the engineering of the system for Owner's review and approval. The installation of the drawings shall be suitable for his installation of his range of instrumentation.

The Bidder shall furnish and test all required erection hardware, which is necessary for proper installation and interconnection of the equipment/systems furnished by the Bidder and their integration with main equipment/systems as per the enclosed installation drawings and other applicable clause. The Bidder shall furnish all hardware and accessories to ensure that the equipment/systems furnished form a complete and operational system meeting the intent and requirement of this specification.

All materials, furnished shall conform to the latest editions of America National Standard Code for Pressure piping, Power piping, ANSI B311.1, ANSI B16.11, ASME Boiler and Pressure Vessel Codes, IBR and other applicable ASME, ANSI and Indian Standards. Schedule numbers, sizes and dimensions of all carbon steel, stainless steel and alloy seamless steel pipe shall confirm to ANSI B.36.10 and of stainless steel pipe shall confirm to ANSI B 36.19 unless otherwise specified.

All materials supplied under this section 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 Bidder is responsible for the performance of the equipment furnished on system basis any shortfall in erection material observed during erection stage shall be compensated by the Bidder at no extra cost. (Installation drawings # 114-04-0000, 0100 to 0113 shall also be referred by bidder).

9.01.00 GUIDLINE FOR INSTALLATION AND ROUTING OF INSTRUMENT PIPING

9.01.01 General Requirements

The following general erection guidelines have been enumerated here to enable the Bidder to estimate the requirement of instrument piping in plant:-

- i) All instrument piping shall be in accordance with good engineering practice. It shall be finalized during engineering stage. Instrument piping shall be complete with fittings, valves and other required accessories.
- ii) Instrument piping shall not be routed:-
 - a) Across equipment removal areas
 - b) Below mono-rails and cranes
 - c) Above or below removable gratings
 - d) Above or below cable trays.
- iii) Primary Impulse Piping System:
 - a) The primary impulse piping system shall include the instrument piping and all required accessories from process tap off point (root valves onwards) up to the respective instruments. From the same source, Tee off for instruments are not allowed. Separate tapping shall be provided for each instrument. The Bidder shall provide the necessary fittings and accessories along with impulse pipes for completeness and arrangements as per the finalized Instrument Installation Diagrams. Special accessories such as reservoirs and other devices shall be installed as required for flow primary element connection as required by the design of instruments, in accordance with the instructions of the instrument manufacturer.
 - b) The Bidder shall prepare impulse pipe routing drawings.
 - c) Impulse piping shall include a blow-down line and shut-off valve adequate for the duty requirements and for withstanding continuous design pressure and temperature of process medium. For process pressure above 40 Kg/Cm²g, double valves shall be used before connecting to the blow-down header (This arrangement shall be provided for installation for the new transmitter if the existing transmitter has the same arrangement.)
 - d) To assure a constant static head the connections from low pressure steam and low pressure liquid filled lines should preferably slope downward continuously towards the instrument as the instrument is mounted below the source point. If downward slope is not feasible or the instrument is mounted above the source point, the line should slope upward continuously and a "pigtail" installed at the instrument to assure a water seal for temperature protection. Upward sloping liquid lines should be used only if the process pressure is sufficient to assure a head of liquid at the instrument. Horizontal runs should have a slope of not less than 40 mm per meter and must be adequately supported to maintain a constant slope. Vacuum connections to the condenser should always slope upward to the instrument.
 - e) Primary process piping for steam flow, liquid flow and manometric level measurement systems should preferably slope downward from the primary element connections to the instrument. Primary piping for flue gas and air flow measurement systems should preferably slope upward from

the primary element connections to the instrument. If these requirements cannot be met, special venting or drain provisions will be required. Horizontal runs must have a slope of not less than 40 millimeters per meter and must be adequately supported to maintain a constant slope.

- f) Primary process piping from the field which enters the instrument enclosure from the bottom shall extend into the enclosure approximately 150 millimeters and be equipped with a socket weld to flare less tubing coupling of stainless steel. This coupling shall be used to connect the field primary process line to the enclosure process line. The field primary process line shall be anchored to the enclosure angle with U-bolts. Holes for supporting U-bolts shall be field or drilled.
- g) All impulse piping shall be supported rigidly at an interval not exceeding 1.5 meters so as to prevent excessive sag in piping. Process piping shall not be used for supporting impulse piping.
- h) Impulse lines subject to severe sonic pulsations such as boiler feed pump discharge, shall be of sufficient length and of suitable configuration to scatter harmful sonic wave energy before it reaches the instrument.
- i) Impulse piping shall be installed to permit thermal expansion without placing excessive stress on the piping and without affecting the gradient of slope. Long continuous straight runs of piping shall always be avoided. If required, expansion loops shall be provided at least every 2.5 meters to break the continuity.
- j) All welded and screwed fittings shall conform to ANSI B16.11. Threads of piping components shall be taper pipe thread in accordance with ANSI B2.1. All threads shall be clean machine cut with all burrs and chips removed. Lubricants shall be of dry film type. Any one of the following compounds may be used as a pipe thread sealer. Bidder shall supply adequate amount of his preferred sealer for erection purpose.
 - a) Permatex
 - b) Molycote
 - c) Neolube(Teflon tape shall not be used as a pipe thread sealer).

9.01.02 Impulse Piping System

Impulse piping system consists of primary impulse pipes/tubes, valves, fittings, valve manifolds and other accessories between the source connection point (source shut-off valve onwards) and all instruments/devices. Impulse pipe span for supporting clamp shall be 1.5 mtr. This will also include all piping and valves etc. required for instrument drain and vent connections. The Bidder shall furnish and test all items required for completeness of this specification.

9.01.03 AIR SUPPLY PIPING

The piping for air supply shall be as specified below (However the Bidder shall supply the materials as required basis to complete the system in all respect)

i) Individual Supply Lines and Control Signal Lines:-

Air lines shall be ¼ inch size, connected by brass/SS316 flare less tubing fittings. Copper/SS316 tubing shall be light drawn tempered tubing conforming to ATM B75 except copper tubing in tubing cables shall be annealed soft temper tubing conforming to ASTM B68 or B75. Fittings on the branch line to facilitate connections to the individual supply line shall be cast brass screwed type.

ii) Flexible Hoses:-

Flexible hoses shall be ¼ inch SS flexible hose pipe and with Buna-N liner steel wire braid reinforcement complete with ¼ inch brass/SS316 fittings and shall have swivel male pipe threads. Each hose shall be done meter in length.

iii) Pipe Material Specification:-

The piping material shall be carbon steel hot-dipped galvanized inside and outside as per IS-1239 or the equivalent of these standard heavy quality with screwed ends. The piping threads shall be as per ASA B.2.1.

iv) Isolating Valves:-

Gate valves as per ASTM B62 inside screw rising stem screwed female ends as per ASA B.2.1 valve bonnet shall be union type and trim shall be stainless steel body rating 150 pounds ASA. Valves sizes shall be ½ inch to 2 inch.

v) Fittings:-

Forged cast steel A234 Gr. WPM galvanized inside and outside; screwed as per ASA B2.1 dimensions as per ASA B16.11, rating 2000 pounds, elbows and soft seats. The size of the fittings shall be ½ inch through 2 inch.

vi) Air Filter Regulator Set:-

An instrument Air Filter Regulator Set with mounting assemblies shall be provided for each pneumatic device requiring air supply.

vii) Instrument Air Piping System:-

a) Instrument Air shall be made available by the bidder at 3.5 to 7.0 Kg/cm² pressure. The instrument air may be arranged as under:-

11. For the control valves and power cylinders in owner's scope but controlled by bidder's control system, the instrument air requirement for E/P converter shall be tapped from the nearby instrument air header laid by bidder / already laid existing piping with accessories available near the control valves or damper.

Complete hardware required for interfacing with Owner system shall be in bidder scope.

- b) Air supply piping shall be installed at site always with a slope of over 1/100 to prevent accumulation of condensed water within the pipe.
- c) All joints in the instrument air sub-header shall be of screwed type.
- d) Instrument air line shall be separate for each individual instrument, equipment & drive with own isolation valve and other required hardware. Tee off of instrument line for two or more same/similar services instrument, equipment & drive are not acceptable.
- e) Instrument air flushing/purging lines shall be provided for Bowl Mill DP, secondary air flow measurement instrument and other all flue gas services instruments etc.

viii) Signal / Control Air Tubing System:-

Necessary tubes with fittings and accessories for output signal from pneumatic instruments mounted in the field and control signals to final control elements shall be covered under this tubing system.

9.02.00 **SPECIFICATION FOR ERECTION HARDWARE**

The erection hardware shall meet the following specifications:-

	<u>Item</u>	<u>Specification</u>
9.02.01	Impulse Piping	
i)	High pressure and high temperature services (Medium: Steam & Water and furnace region)	Seamless Alloy Steel piping to ASTM A335 GR.P91/22 (schedule XXS/160 for high pressure & high temperature)
ii)	Low pressure and low temperature services (Medium: Steam & Water)	Seamless carbon steel piping to STM A106, Gr.C
iii)	Low pressure and low temperature services (Air, Flue gas)	ERW carbon steel piping to IS 1239:1973 Heavy class System)
iv)	Steam and water analysis system	Seamless stainless steel piping to ASTM A312 GR. TP-321
v)	Seamless copper tubing	ASTM B-75

9.02.02 Fittings Double compression type

- | | | |
|------|--|---|
| i) | Material for socket weld fittings | ASTM A105
ASTM A182,
Gr. F22
6000/3000 lbs |
| ii) | Dimensions of fittings | ANSI B16.11 |
| iii) | Fittings for steam and water analysis. | Gr. F-321 |

9.02.03 Valves

- | | | |
|------|----------------------------|--|
| i) | 3 – way valves | SS body/forged CS
body stellited internals and SW ends
as per requirement for 2500 lb/800 lb
ASA ratings. |
| ii) | 5- valve manifolds | FAS body/FCS body
316SS stellited internals with NPT(F)
SCRD ends for 3000/2500 lb/1500
lb/800 lb ASA ratings. Construction –
Single block (Bar stock) |
| iii) | 3-valve manifolds | FAS body/FCS body
316SS stellited internals with NPT(F)
SCRD ends for 3000/2500 lb/1500
lb/800 lb ASA ratings. Construction –
Single block (Bar stock) |
| iv) | 2-valve manifolds | FCS body, 316SS
stellited internals, NPT(F) SCRD
ends. Construction – Single block
(Bar stock) |
| v) | Isolation and drain valves | Globe valves with
FAS body/FCS body, 316SS stellited
internals SW ends for 3000/2500
lb/1500 lb/800 ASA ratings. |

9.02.04	Condensation vessels	FAS/FCS body with NPT (F) SCRD connection and vent plugs for 3000/2500/1500/800 lb ASA ratings.
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9.02.05	Racks and Associated Equipment	ANSI C83.9-1972
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9.02.06	Code for pressure piping, welding and Hydrostatic testing	ANSI B-31.1
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- 9.02.07** Flexible conduits with fittings Lead coated, paper insulated, heat resistant flexible metallic conduits with necessary fittings.
- 9.02.08 3 Valve manifold shall be used, wherever Diff Pressure transmitter/switch have been used for pressure measurement.
- 9.02.09 5 Valve manifold shall be used for Diff. Pressure & Flow measurement Transmitters/Switches.
- 9.02.10 In addition to above, table # 9.1 shall also be followed for selection of specific erection hard ware as per process requirements.

9.03.00 TRANSMITTER & SWITCHES ENCLOSURES

In general, BTG process transmitters & switches installed at outdoor location and in areas where they are subjected to splashing oil, water, steam etc., shall be mounted in closed type transmitter rack. For other areas (indoor), open type racks may be used for installation of transmitters and process switches. However the actual requirement shall be finalized during detailed Engineering considering following:-

- i) Transmitter/Switches enclosures shall be free standing, enclosed type offering protection against dust, moisture and vermin. Enclosures shall be suitable for outdoor installations, in thermal power plants.
- ii) The enclosures shall comprise of Galvanized Sheet mounting plate internally. Also external-mounting brackets in Polyamide or Stainless Steel shall be available. Alternatively transmitter enclosures can be glass Fiber Reinforced Polyester (GRP) compression moulded and shall be weather proof.
- iii) Instrument piping inside the enclosure shall conform to the specification and in line with typical installation drawings enclosed with the specification.
- iv) Blow down header shall be provided inside the enclosure as called for.
- v) Bulk head connection shall be provided to receive and terminate the impulse pipes from root valves.
- vi) Instrument tubing, fittings and isolation, drain valves shall be to ANSI code for pressure piping. Piping/tubing shall be subject to hydrostatic tests at 1.5 times maximum system pressure.
- vii) Support angles shall be provided for valve manifolds, wiring trays etc. Enclosures shall be complete with necessary bulk head fittings, junction boxes, drain header and other accessories as needed on the basis of approved hook up drawings.
- viii) Sufficient spacing among adjacent transmitters shall be maintained to offer easy accessibility and operational convenience. The enclosure shall be designed with sizes to suit the grouping and to completely include all the hardware for hooking up

the transmitters to the process on the basis of approved installation diagrams. A maximum of five (5) transmitters are envisaged to be grouped in one enclosure.

- x) A minimum of twenty (20) percent spare terminals shall be provided. Only one wire per terminal shall be used on the outgoing side of these blocks (for cable panel). Any common connections required shall be provided on the panel side of the block. All incoming power terminals are to be clearly identified in a manner distinctly different from all other terminals and grouped in a logical pattern.
- xi) Chapter no. 6 of this volume shall also be referred for designing of Transmitter/Switches enclosures.

9.04.00

LOCAL INSTRUMENTS, LOCAL BOARDS AND TAPPING POINTS

- i) All local gauges as well as sensors, Transmitters and switches any other instruments for parameters like pressure, temperature, level, flow etc for safe and efficient operation of equipment under the scope of specification, shall be provided by bidder as approved by Owner. Such equipment shall be listed by the Bidder detailing the items with the respective functions in service. All field mounted instruments shall be mounted in such a way as not to be affected by vibration & environmental conditions. Racks to mount these instruments shall be furnished by bidder complete with requisite erection hardware, tubings and junction boxes with all terminals of the instruments duly wired complete with cable glands. Groupings of instruments, actual number of racks for instruments and its construction shall be to Owners approval.
- ii) Transmitters & Switches provided shall be mounted in transmitter/Switches enclosures to owner's approval. The junction box for electrical connections shall be outside the transmitter enclosures.
- iii) All erection hardware required for complete installation/ implementation of entire instrumentation specified is included in bidders scope. Any change in size, type, rating or in quantity deemed necessary during engineering shall be supplied within package price with no additional financial implication to owner.
- iv) Bidders scope includes providing counter flanges on pipe lines/ vessels to suit owner arranged flanged devices. Counter flanges shall be complete with gaskets, nuts, bolts and other requisite accessories for proper installation.
- v) Separate and independent tapping on equipment/associated piping shall be provided to suit the philosophy of redundant primary sensors. Separate sensors for control and monitoring etc are as decided by Owner. This shall include application such as first stage pressure. Wherever the process value being measured needs to be compensated for temp, pressure variations, the tapping points for such compensating elements shall be provided in requisite number along with the tapping for the process value.
- vi) Wherever transmitters & switches are provided, in addition Local gauges shall also be provided by bidder for local field monitoring.

- vii) Local instruments and remote sensors & transmitters to be furnished with the equipment shall generally be as indicated herein and as per redundancy criteria indicated elsewhere but not be limited to the following: -

1. Pressure Measurement

i. Pressure Gauge for:

- a) Shell pressures of all Deaerator, HP and LP heaters and other vessels.
- b) Mercury manometers shall be provided during air outlet flows measurement.
- c) Bleed steam pressure at extraction point for all turbine extractions and for pressure on drain lines.
- d) Pressure gauges at inlets and outlets of condensate extraction pumps, main oil pump, each auxiliary oil pump, AC standby oil pump, DC Emergency oil pump, jacking oil pumps, DM makeup pumps, DMCW pumps, BFP, or any other pumps etc.
Pressure Gauge at outlet of each type of Fan.
- e) Lube oil pressure before and after oil coolers, HPT & IPT front seal chamber leak off pressure.
- f) MS pressure downstream of ESV, after HPT control valves and after HPT first stage, HRH steams pressure after IV, Gland steam header pressure, HPT exhaust etc.
- g) Condensate pressure in condensate pump discharge header, and feed water pressure at inlet and outlet of each LP & HP heaters.
- h) LP turbine exhaust pressure and condenser pressure
- i) Relay/Lube/Control oil pressure, Drain oil lines pressure.
- j) Pressure gauges for vacuum pumps and each pump discharge.
- k) Pressure gauge at Instrument and service air header in compressor room and in the field at the main location of instrument/service air header, the pressure gauges shall be provided.
- l) Pressure gauges at inlet and outlet of each heat exchanger and cooler.
- m) Frame mounted Pressure Gauges (FMG) shall be provided for Main steam Pressure, Feed water pressure to economizer, CRH Steam Pressure, HRH Steam Pressure etc.
- n) For condensate storage tank the pressure gauge in terms of 0-10000 mm wc or suitable range having **dial size of 300 mm or bigger size** shall be provided.
- o) **U tube manometer with Hg filled for direct measurement of condenser vacuum** shall be provided in the fixed with isolation valve for local indications.
- p) Above are the minimum requirements, actual quantities shall be as decided during detailed engineering by owner.
- q) Pressure gauge for all BoP packages as decided during detailed engineering by owner.

ii. Pressure Switches

- a) Pressure switches at condensate Extraction Pump Discharge header, Boiler feed pump, seal water line or any other pumps for alarm (high & low) and interlock purpose.

- b) Pressure switches for steam supply to LP/HP heaters.
- c) Pressure switches for initiation of turning gear.
- d) Pressure switches for control oil, jacking oil and lube oil pressure for all required alarms and interlocks.
- e) Steam pressure downstream of ESV, steam pressure after first stage of HPT, gland steam header pressure and suction line from turbine glands to Gland cooler.
- f) Pressure switches for condenser vacuum low, very low alarms & interlocks.
- g) Condenser water box pressure for alarm interlocks.
- h) Pressure switches (low & high) for individual pumps/blowers suction/discharge and discharge header – alarms, interlocks and protection
- i) At the main location of instrument air header the pressure low switches shall be provided for alarms in DDCMIS
- j) Pressure switches/any other process switch etc. for OLCS / Alarms / Interlocks / Protection. Pressure switches at inlet, outlet of individual pumps and discharge header of pumps for protection and auto start / stop & alarms.
- k) Above are the minimum requirements, actual quantities shall be as decided during detailed engineering as per redundancy criteria by owner.
- l) Pressure switches for all BoP packages as decided during detailed engineering. by owner.

iii. Differential Pressure Transmitters, Diff Pressure Switches & Diff. Pressure Gauges

- a) Pressure across strainers and filters.
- b) Diff. Pressure Transmitters/switches/Gauges for all BoP packages as decided during detailed engineering by owner.
- c) Diff. Pressure Transmitter across condenser on CW lines, Air pre heaters on air & flue gas lines, on PA lines, CEP suction strainers, Feed control station etc.
- d) Above are the minimum requirements, actual quantities shall be as decided during detailed engineering as per redundancy criteria by owner.

iv. Pressure Transmitters

- a) For all services as mentioned for Pressure gauges & Pressure Switches.
- b) Pressure Transmitters at condensate Extraction Pump individual Discharge and discharge header, Boiler feed pump individual Discharge and discharge header, seal water line or any other pumps/fans/HT/LT unidirectional drive for alarm (high & low) and interlock purpose.
- c) Pressure transmitter for wind box (Left/Right) & pulverizer seal air fans discharge pressure.
- d) Pressure Transmitters as on required basis for monitoring, interlocks & controls as per redundancy criteria and approved by owner.
- e) Above are the minimum requirements, actual quantities shall be as decided during detailed engineering as per redundancy criteria and approved by owner.
- f) Pressure Transmitters for all BoP packages as decided during detailed engineering by owner.

2. Temperature Measurements:-

The Bidder shall furnish all temperature sensing elements to be installed in their piping. The scope of supply shall include, but not limited to the following: -

- i) Duplex RTDs for all bearing, drain oil from bearings, LPT exhaust steam, 3 no's of duplex RTDs each on left and right CW outlet of condenser etc.
- ii) 6 no. duplex or 12 no. simplex Embedded temperature detectors for various motor stator windings and duplex RTDs for Motor/Pump bearing temp.
- iii) Chromel-alumel surface/other thermocouples for turbine casings, ESV, IV bodies, superheated steam, hot reheat steam piping, steam of first stage HPT, inlet bowl of IPT, steam exhaust of HPT, down stream of ESV and IV, steam in ESVs and IVs, steam admission pipes metal temperatures, HPC, IPC flange metal temperature etc.
- iv) For all HP heaters remote monitoring with redundant independent sensors of inlet/outlet temperatures of feed water and extraction steam shall be provided in addition to local gauges.
- v) For all LP heaters remote monitoring with redundant independent sensors of inlet/outlet temperatures of feed water and extraction steam shall be provided in addition to local gauges.
- iv) Temperature sensors for HP-LP bypass system for measurement as well as for control.
- v) Adequate number of temperature Elements shall be furnished to provide initiating contacts for temperature interlocking and trip circuits. The temperature elements shall be provided, but not limited to the following: -

Steam temperature of HPT exhaust, steam temperature after ESV (L&R), IV (L&R), LPT exhaust hood steam, drain oil temperature of all journal bearings and thrust bearing & lube oil header temperatures, thrust bearing of each condensate extraction pump and vacuum pump protection, interlocks.

- vi) Metal Temp measurement and steam temp measurement at each super heater & Reheater location.
- vii) Temp. Element & Temp gauges at Feed water line to economizer inlet, economizer to steam separator, spray water lines to desuperheaters, Soot blower steam, Soot blower steam drain lines, steam drain lines, Flue gas & air lines etc
- viii) Temp. Measurements (Local & remote) for all BoP packages as decided during detailed engineering.
- ix) Thermocouples for Temp. above 200 deg C shall be provided by bidder.
- x) For plate heat exchangers, spare thermowell provision shall be made at inlet & outlet of ACW & DMCW lines in addition to local & remote temperature monitoring points.
- xi) Each ESP Hopper shall be provided with RTDs to control the temperature of ash through Hopper heater.

xii) Temperature gauges.

- a) For bearing temperatures AC and DC lube oil pumps, LPT exhaust hood etc.
- b) For condensate and feed water at inlet and outlet of HP heaters, Vacuum pumps, LP heaters etc.

- c) Steam & water inlet/outlet of LP and HP heaters, steam and air mixture inlet to vacuum pumps, and drain lines etc.
- d) Journal/thrust bearing drain oil, lube oil at inlet/outlet of oil coolers, cooling water at inlet and outlet of oil coolers etc.
- e) Thrust bearing of each condensate extraction pump.
- f) Temp. Gauges at inlet and outlet of each heat exchanger and cooler.
- g) Frame mounted Temperature Gauges (FMG) shall be provided for Main steam Temperature, Feed water Temperature to economizer, CRH Steam Temperature, HRH Steam Temperature etc
- xiii) Above are the min. requirements, actual quantities shall be as decided during detailed engineering by owner.

3. Level Measurement

- i) Level gauges - level gauges for boiler separator, HP heaters, LP heaters, deaerator, drain cooler, gland steam cooler, vacuum tanks, condenser hot well CBD tank, stator water tank, Stator water expansion tank and other pressure vessels, main oil tank and all oil tanks in BTG & BOP package. The level gauges shall be mica shielded steel armoured transparent glass type. Level gauges for condenser hot well shall be provided on both sides.
- ii) Level switches for HP/LP heaters, drain cooler, gland steam cooler, condenser hot well, deaerator, main oil tank and other pressure vessels, tanks, sumps etc. The separate switches for high, very high and low levels shall be provided as per interlocks and protection requirements.

External cage mounted magnetic level switches/ displacer type shall be employed for low pressure & low temp. services.

However conductivity type level switches shall be provided for high pressure & high temp services like HP heaters, CRH/HRH drain Pot, Turbine Drains etc.

- iii) Level Transmitters (Type as per Owner approval) for open sump/tank/bunker/vessel/heaters.
- iv) Level measurement for all BoP packages as decided during detailed engineering.
- v) Level switches for OLCS / Alarms / Interlocks / Protection. Level switches for sump/tank level high/normal/ low/very low interlocks.
- vi) Each ESP hopper must be provided with 3 nos. level switch (switches 2 nos. for high level and One no. for low level.)
- vii) Above are the min. requirements, actual quantities shall be as decided during detailed engineering by owner.

4. Flow Measurements:-

- a) Primary Elements: Flow nozzles shall be used for feed water flow and other critical measurements where weld-in construction is required. Flow nozzles shall be made of stainless steel, with three sets of pressure taps installed in the pipe wall where required. One no. spare set of pressure tap shall also be provided on flow nozzle,

wherever required. Installation of flow nozzles and pressure taps shall be made in the pipe fabricator's shop and shall be witnessed by a representative from the flow nozzle manufacturer.

- b) Paddle type orifice plates shall be used for other flow measurements where flanged construction and higher pressure loss are acceptable. Orifice plates shall be made of stainless steel. Orifice flanges shall be of the raised face weld neck type with dual sets of taps.
- c) Construction and installation of flow nozzles and orifices shall conform to the requirements of ASME Performance Test Code PTC-19.5, and discharge coefficients shall be predicted in accordance with data published in ASME Research Report on Fluid Meters.
- d) Airfoil or venturi flow sections, shall be used for measuring boiler combustion airflow.
- e) A special high accuracy flow nozzle pipe shall be provided to determine feed water flow to the economizer. This nozzle shall be hydraulically calibrated and utilized for feed water flow control and for turbine testing as described in ASME PTC 6 (latest revision).
- f) Orifice plates shall be supplied with carrier rings as per process requirement.
- g) Doppler effect type flow meters shall be used for sludge applications.
- h) For Raw water, water treatment plant and effluent treatment plant, ultrasonic type flow meters to be used.
- i) Secondary Elements: Secondary elements for differential type flow sensors shall be strain gauge or capacitance type differential pressure transmitters. Square root extraction required for the DP transmitters shall be performed electronically in the transmitter itself.
- j) HFO/LDO flow meters shall be based on coriolis mass flow technology. Fuel Oil meters shall be provided for fuel oil unloading system and near boiler after day oil tank (at main supply & return line).
- k) Flow nozzles shall be provided for following services in main plant:-
 - i) Steam flow measurement for BFP Turbines.
 - ii) Feed water flow measurement
 - iii) Auxiliary steam flow measurements
 - iv) HP bypass flow measurements
 - v) BFP suction flow.
 - vi) Deaerator water flow measurement
 - vii) HP heaters drain Flow measurements.

Orifices shall be provided for following services:-

- i) Spray water flow measurement

- ii) Condensate flow measurements
 - iii) DM/hotwell makeup to condenser.
 - iv.) Condensate dump flow to CST
 - v) Gland Steam Condensate flow measurements
- l) For DM water flow & Ash Slurry flows measurements online electromagnetic flow meter shall be used.
 - m) At CW & ACW pump discharge headers flow transmitters shall be provided (Non Contact ultrasonic Type are preferable). In addition flow measurement shall also be provided for CW water used any where except condenser service.
 - n) Instrument and Service Air - Vortex/Swirl type Flow meter
 - o) Flow transmitters for general applications shall be of the differential pressure type
 - p) Flow switches for OLCS / Alarms / Interlocks / Protection.
 - q) Lubricating oil Flow transmitter/meter with switch shall be provided for Bearing systems of APH, FD, PA, etc.,
 - r) Sight glasses flapper indication type shall be provided on lube oil cooling water piping as required to ensure indication of fluid flow.
 - s) On line Fuel flow & velocity measurement facility in each Pulverized Fuel (PF) pipe for each coal pulveriser shall be provided by bidder for accurate, absolute and simultaneous measurement of coal velocity, coal density, coal mass flow rate and air-to-fuel ratio. The equipments shall compromise of sensors working on micro wave technology.
 - t) In addition to the **conventional triple DP measurement techniques** involving venturi/Airfoil for secondary air flow measurement, One number **Flow measurement** system each on Left side and Right side shall be provided as **redundant/checking measurement for secondary air flow** which could be used in the optimization package.

On line secondary air flow & velocity measurement facility in each on left side & right side shall be provided by bidder for accurate, absolute and simultaneous measurement of air velocity & flow rate. The equipments shall compromise of sensors working on tribo-electric (Correlation technique) technology.
 - u) Any other flow element/meter required for system shall be finalised as per system requirement and as per approved drawings/documents by owner.

9.05.00

Process Connections

The type of instrument source connection shall depend upon the process parameters and the tapping size. The source connection drawings shall be finalised during the engineering stage.

Size of tapping point stub, number and size of root valves for different types of measurements are as follows:

Sl. No.	Quantity of root valves	Size of stub and root valve	Service Condition
Pressure and Differential Pressure Measurement			
(i)	2	25NB	≥ 40 bar(g) OR 425°C
(ii)	1	15NB	< 40 bar(g) AND 425°C .
Level Measurement			
(a)	Level Gauge & Switch		
(i)	2	25NB	≥ 40 bar(g) OR 425°C
(ii)	1	25NB	< 40 bar(g) AND 425°C
(b)	Level transmitter (displacement type)		
(i)	2	40NB	≥ 40 bar(g) OR 425°C
(ii)	1	40NB	< 40 bar(g) AND 425°C
(c)	Stand pipe for level measuring instrument		
(i)	2	80 NB	≥ 40 bar(g) OR 425°C
(ii)	1	80 NB	< 40 bar(g) AND 425°C
<i>Flow Measurement</i>			
(i)	2	25NB	≥ 40 bar(g) OR 425°C
(ii)	1	25NB	< 40 bar(g) AND 425°C
<u>Sampling system measurement (Steam and Water Service)</u>			
(i)	2	25 NB	≥ 40 bar(g) OR 425°C
(ii)	1	25 NB	< 40 bar(g) AND 425°C

Technical Specifications for C&I Systems-Table-No. 9.1

S.No.	System/Line Description	Piping Class	Impulse Pipe material	Schedule (Size)	Materials for fitting/ valve body	Valve steam material	Rating of Piping Fitting	Pressure Class of valve
1	Main steam, Up steam & down stream of HP bypass and up stream of auxiliary steam pressure reducing valve.	A	ASTM-A335 Gr.P-91/22 (Note-2)	XXS (½ Inch)	Note-3	Note-3	9000lb	3000 SPL
2	BFP discharge/ superheater attemperator/spray to PRDS	B	ASTM-A106 Gr. C	160 (½ Inch)	Note-3	ASTM-A-182 Gr.F6a	6000lb	2500 SPL
3	Reheater attemperator	C	ASTM-A106 Gr. C	160 (½ Inch)	ASTM-A-105	ASTM-A-182 Gr.F6a	6000lb	1500 SPL
4	Hot. Reheat/Down stream of Aux.Steam pressure reducing valve upto desuperheater/flash tank drain manifold, HRH upstream & down stream of LP Bypass valve.	D	ASTM-A335 Gr.P-91/22 (Note-2)	160 (½ Inch)	ASTM-A182 Gr.F-22	Note-3	3000lb	2500 SPL
5	Cold reheat upto Tee-off for HP bypass.	E	ASTM-A335 Gr.P-22	80 (½ Inch)	ASTM-A182 Gr.F-22	ASTM-A-182 Gr.F6a	3000lb	800
6	Cold reheat down steam of Tee-off (HP Bypass)	F	ASTM-A106 Gr. C	80 (½ Inch)	ASTM-A105	ASTM-A-182 Gr.F6a	3000lb	800

7	BFP suction/condensate system/Extraction to LPH/HPH and Extractions to BFPT, Desecrator, auxiliary steam.	G	ASTM-A106 Gr. C, ASTM-A335 Gr.P-11/22	80 (1/2 Inch)	ASTM-A105	ASTM-A-182 Gr.F6a	3000lb	800
8	Air/Flue gas outside furnace.	M	ASTM-A106 Gr.B/C	80 (3/4 Inch)	ASTM-A105	ASTM-A-182 Gr.F6a	3000lb	800
9	Air flue gas inside furnace	N	ASTM-A335 Gr.P-22	80 (3/4 Inch)	ASTM-A182 Gr.F-22	ASTM-A-182 Gr.F6a	3000lb	800
10.	Purge Air	O	ASTM-A106 Gr.C	80 (3/4 Inch)	ASTM-A105	SS316	3000lb	800
11.	DM Cooling water	P	ASTM-A312 TP 316	80/40 (1/2 Inch)	ASTM – A 182 F 316	SS316	3000lb	800
12.	CW & ACW	Q	ASTM-A106 Gr.C	80 (1/2 Inch)	ASTM-A105	SS316	3000lb	800

Note:-

- 1). Above requirements are minimum to be complied by bidder. Rating of piping / fittings / valves etc. is subjected to be approved by owner as per the final design pressure & temperature finalized during the detailed engineering, as per ANSI B 31.1.
- 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.
- 4). For DM Plant or DM water services, complete erection Hardware material shall be SS316 only.

9.06.00

INSTRUMENTATION AND CONTROL CABLES

9.06.01

General

Bidder's scope of supply, laying, erection & commissioning of instrumentation and control cables shall include the following:-

- a) Bidder shall supply, lay, erect, *terminate* all type of cables required for power plants i.e. the control, instrumentation, *interfacing (coaxial, fibre optic) cables etc.* irrespective of other end scope.
- b) All interconnecting cables and prefabs between bidder's supplied instruments, local JB, local instrument/transmitters, cabinets, panels and termination cabinets and interconnecting cables between Bidder's panels to equipment / instruments/ Plant Control Room. All field JB's / all field instruments/MCC/SWGR to DDCMIS/DCS cabinets in CER/ PLC cabinets/Relay cabinets/local control panels/desk etc. All power, Signal & Special cables from Sensor to JB, JB to MCC, JB/Drives to PLC/DDCMIS/DCS, MCC/SWGR to DDCMIS/DCS/PLC cabinets wherever one end or two ends are in EPC bidder's scope. Complete Cables shall be supplied, laid, terminated & commissioned by EPC bidder including preparation of Cable schedule and supply of cable Trays irrespective of other end scope.
- c) All co-axial cables/*fibre optic cables* and any other special cables *for interfacing with other packages via soft link (covering all packages irrespective of scope).*
- d) K Type Thermocouples Extension cables, T Type thermocouple Extension cables and S/R type Thermocouple Compensating cables
- e) Interfacing cables (*Coaxial, fibre optic etc*) between owner supplied PLC/control systems (if any) to DDCMIS.
- f) Fire survival cable
- g) Preparation of Complete cable schedule, Interconnection diagram & JB schedules shall be in bidder scope.
- h) All others cables not included above however required for completeness and operation of plant.
- i) The cables shall be provided in non returnable wooden drums. The drum length shall be 1000 m $\pm$ 5% up to & including 12 pair cables and 500 m $\pm$ 5 % for above 12 paired cables.

The quantity of the above types of cables shall be estimated by the Bidder based on his experience.

Any shortfall in cable quantity during actual laying at site shall be compensated by the Bidder at no extra cost to the owner.

Bidder shall supply the specified type of cable on as required basis for different cabling and interconnection work, provided the same meet the requirements of Bidder's I&C application.

9.06.02 SPECIFICATION AND STANDARDS

9.06.02.01 Except where specified otherwise all materials , cables and construction shall conform to the Indian Electricity Act and Rules and the Indian and other international standards with latest revisions and amendments issued up to date.

9.06.03 MATERIAL SPECIFICATIONS

9.06.03.01 General

9.06.03.02 All materials shall be new and of tested quality conforming to applicable National and Manufacturer's Standards and Indian Electricity Rules.

9.06.03.03 All materials shall be transportable to and suitable for installation at site with ease and without any damage. It shall give continuous reliable operation over long period under worst specified site conditions.

9.06.03.04 All materials shall be designed to withstand extremes of all magnetic, electrical, mechanical and thermal stresses which may be encountered during normal and abnormal operating conditions.

9.06.04 Cables – Design Criteria

9.06.04.01 Cables shall be so designed and manufactured that damage does not occur in handling, during transit, storage, installation and operation under any or all the climatic and operating conditions which they may be subjected to. Outer sheath of cables shall have rodent and termite repulsion property.

Cables shall be suitable for laying in conduits, ducts, trenches, trays or for direct burial in ground in both and wet locations.

9.06.04.02 Cables shall be capable of operating satisfactorily under the power supply voltage and frequency variations as specified in the specification. Current ratings and ratings factors of cables shall not be worse than the ones specified in IS: 3961.

9.06.04.03 Performance characteristics of cables shall be based on the following conditions of laying:

1. All cables shall be laid in multilayer and touching each other.
2. Cables shall be suitable for laying in duct or burying in ground upto a depth of 1.5 meters with uncontrolled back fill and chances of flooding by water.

9.06.04.04 Fillers in multiple conductor cables shall be flame retardant and moisture resistant.

- 9.06.04.05 All cables shall be provided with marking including manufacturer's name, insulation material, conductor sizes, no of pairs, voltage ratings, type of cable, etc, progressive markings to read marking of the length of the cable at each meter interval and "FRLS".
- 9.06.04.06 All cables shall be suitable for continuous operation at 85 deg C except for high temperature resistant Teflon insulated cables, which shall be suitable for continuous operation at 205 deg C.
- 9.06.04.07 All the cables used in the Hot/high temp. Zone (Combustor region), for emergency trip push buttons, Fire alarm system, safety critical circuits, Trip protection circuits and for other services specified elsewhere in the specification shall be fire survival cable conforming to IEC 60331, BS6387 (CWZ), BS6207 standard and this specification. The instrumentation cables in other area shall be FRLS conforming to IEC 60332 standards and this specification.
- 9.06.04.08 All external field signals for DDCMIS/DCS/PLC shall be terminated in separate marshalling/termination cabinets. Under no circumstances, Field cabling to be directly terminated in DDCMIS/DCS/PLC system cabinets.
- 9.06.04.09 All cables shall be paired cables.
- 9.06.04.10 All cables shall be provided with anti termite, Anti Rodent & moisture resistant properties.
- 9.06.04.11 All spare contacts/terminals on relays, control switches, limit switches or similar devices, process switches, duplex RTDs & Duplex T/Cs shall be wired to accessible terminal blocks/JBs for Owner's future connections. All wiring leaving a junction box or enclosure shall leave from terminal blocks and not from other devices in the enclosure. Two (2) pair (individual & overall shielded) cables shall be provided for terminating the thermocouples, transmitters & switches i.e Analog & Binary signals to local JB's. Similarly four (4) pair (individual & overall shielded) cables shall be provided for terminating the Duplex (3/4 wire) RTD to local JB's.
- 10% spare pairs or min 1 pair cable (which ever is more) shall be provided with all type of cables.
- 9.06.03.12 Cable size & type shall be as below for different type of signals and control system.
- a) Cables for analog signals shall be instrumentation cable of 0.5 sq. mm copper conductor size, with individual pair shielding & over all shielding as per cl. No. **9.06.04.02** mentioned below.
 - b) Cables for binary signals shall be instrumentation cable of 0.5 sq. mm copper conductor size as per cl. No. **9.06.04.02** mentioned below with exception of over all shielding only.
 - c) Cables for binary signals in relay based system and Fire protection & detection system shall be instrumentation cable of 1.5 Sq.mm conductor size, overall shielded as per cl. No. **9.06.04.01** mentioned below.

- d) Cable for power supply to each solenoid valves shall be control cable of 3C x 2.5 Sq.mm copper conductor size. Specification shall be as mentioned elsewherein the Electrical part.
- e) For cables single length more than 500 meters, the size of conductor shall be 1.5 sq. mm only irrespective of type of signals.

9.06.05 Cable Specification

9.06.05.1 The Instrumentation cables shall function without breakdown for surges experienced in the control system. Voltage class and insulation levels shall be compatible with the signals they convey.

9.06.05.2 Cable Specifications

Cable shall have the following specification: -

<u>Sr.No.</u>	<u>Description</u>	<u>Cable N</u>
1.	Voltage Grade and Type	660 V/1100 V grade multipair annealed tinned copper conductor overall shielded armoured instrumentation cable.
2.	IS Reference	IS: 1554 (Part-I Generally)
3.	Conductor	Nominal 1.5 Sq. Area concentric lay Annealed tinned high conductivity Stranded 7x0.53 mm dia. Electrolytic Copper conductor.
4.	Insulation	Extruded HR PVC type – C to IS:5831
5.	Shield	Minimum 0.06mm thick aluminum mylar tape shall be provided on each pair with hundred percent coverage, 25% overlap and tinned copper drain wire of diameter 0.8mm with 7 strands.
6.	Inner sheath	FRLS HR PVC type ST-2 to IS:5831/VDE 0207. Colour Black.
7.	Armouring	Galvanized steel wire/strip to IS:3975 & IS 1554 Part II
8.	Outer sheath	FRLS HR PVC type ST-2 to IS:5831/VDE 0207. Colour Blue.
9.	Lay	Twisted pair with 25 - 40lay/mt
10.	Tests for FRLS Properties	1. <u>Flammability Test</u> The cables shall pass The requirement of IEEE-332 part B fire propo- gation test in this regard.

2. Smoke generation by Sheath under fire
When tested as per ASTM-2843, the cable shall meet the requirement (60%) smoke density.
3. Acid gas generation of sheath during fire
When tested as per IEC-754-1, the maximum Acid gas should be less Than 20% by weight.
4. Oxygen Index Test
The oxygen index when tested under ASTM 2863 shall be minimum 29.
5. Water immersion test shall be carried out as per VDE 0815
6. Swedish Chimney Test

Other Tests:

1. Fire resistance test to IS-5831 for 20 minutes. (PVC insulation & sheath of electrical cables)
2. Thermal stability at 200 deg. C to IEC-540 for 100mts.
3. Rodent and termite proof.
4. Heat shock test to IEC-502.

11. Conductor and Pair : The wires of pairs shall be coded by base colours on insulation which are repeated in every unit. Base colours of the pairs in a unit shall be as follows:

	Pair	1	2	3	4
--	-------------	----------	----------	----------	----------

- | | | | | | |
|----|------|------|--------|-------|-------|
| a) | wire | Blue | Grey | Green | White |
| b) | wire | Red | Yellow | Brown | Black |

The units shall be coded by colours of rings on the insulation cores as tabulated below in order to distinguish between wires of various units in cables :

Unit:	Ring Colour:	Ring Group
-----	-----	-----

1.	PINK	I
2.	PINK	II
3.	PINK	III
4.	PINK	IIII
5.	PINK	IIIII
6.	ORANGE	IIIIII
7.	ORANGE	IIIIIII
8.	ORANGE	IIIIIIII

The vertical lines under column (Ring Group) in the above table indicate number of rings at intervals of approx 60 mm length of the wires of the units. For cables above 4 pair, each 4 pair units shall be open helically lapped with numbered binder taped for the purpose of binding & unit identification.

12. Marking Marking on length of the cable shall be at every meter interval on the outermost PVC sheath of cables.

13. **Electrical Properties at 20 Deg.C:**

- | | | |
|----|---|--|
| a) | Conductor resistance of the loop not greater than | 78.4 Ohms/Km
for 0.5 sq mm. Conductor size. |
| | | 24.6 Ohms/Km for 1.5 sq mm. Conductor size. |
| b) | Insulation resistance not less than | 100 Meg Ohms/Km |
| c) | Mutual capacitance at 0.8 KHz not greater than | 100 nF/Km |
| d) | Test Voltage-cond/cond. and cond/shield | 2000 Vrms |
| e) | Characteristic impedance at 0.8 KHz | 370 Ohms for 0.5 sq mm. Conductor size. |
| | | 230 Ohms for 1.5 sq mm. Conductor size. |
| f) | Image attenuation at 0.8 KHz | 0.11 dB/100 m |
| g) | Image attenuation at 10 KHz | 0.29 dB/100 m |
| h) | Cross talk attenuation at 0.8 KHz greater than | 70 dB/Km |
| i) | Coupling capacitance at 0.8 KHz not greater than | 200 pF/100 m |
| j) | Min Vol. Resistivity | : 3.5×10^{14} at 27 deg C |

3.5 x 10¹¹ at 85 deg C

k)	High Voltage Test	:	Duration
	Conductor to Conductor	:	2000 Vrms, 50 Hz for 1 min.
	Conductor to Shield	:	2000 Vrms, 50 Hz for 1 min.

9.06.05.3 Cable Specifications

Cables shall have the following specifications:-

<u>Sr.No.</u>	<u>Description</u>	<u>Cable – M</u>
1.	Voltage Grade and Type	660V/1100 V grade multipair annealed tinned copper conductor individual pair and overall shielded armoured instrumentation cable.
2.	IS Reference	IS:1554 (Part-I) (Generally)
3.	Conductor	Nominal 0.5 Sq.mm. area concentric lay annealed tinned high conductivity stranded 7 x 0.307 mm dia. Electrolytic Copper conductor
4.	Conductor size	: Overall dia of each conductor including insulation should be between 1.4 to 1.65 mm. For 0.5 sq mm. size conductor.
5.	Insulation	Extruded HR PVC type-C to IS:5831
6.	Shield	Through aluminum mylar tape min 0.06 mm (0.075 mm) with min 25% overlap and 0.8 mm dia tin coated copper drain wire (7 stranded) laid under the contact with aluminum side of the tape.
7.	Inner sheath	FRLS HR PVC type ST-2 to IS:5831/VDE 0207, Colour Black
8.	Armouring	Galvanised steel wire/strip to IS:3975
9.	Outer sheath	FRLS HR PVC type ST-2 to IS:5831/VDE 0207, Colour Black
10.	Test for FRLS properties	"See details as specified in Cable Type N".
11.	Colour Coding & Marking	- do-
12.	Electrical Properties	- do-

9.06.05.4 Specification for Co-axial Cables Cable-C

Co-axial cables are used for high frequency equipments and systems for transmission and reception purposes and computers. Co-axial cable should have minimum following characteristics:-

Construction	:	Solid silica coated, annealed tinned copper conductor.
Di-electric	:	Low loss solid polyethylene foam, semi and spaced construction.
Outer conductor	:	Braided or longitudinal tube of copper or Aluminum giving 100% coverage with slight overlap.
Outer sheath	:	FRLS PVC type ST2
Diameter over Di-electric	:	7.24 sq.mm.
Outer diameter	:	10.29 sq.mm.
Nominal impedance	:	75 ohms
Nominal capacitance	:	20.5 pF/ft.
Nominal attenuation	:	8 dB at 1000 MHz Per 100 ft.

Co-axial cable shall be low smoke (ASTM- E 662), flame retarded (IEEE 383) and halogen free (IEC 754: 1 & 2), MIL C-17 G.

9.06.05.5 Extension & Compensating Cables

1.	Applicable Standards	:	ANSI MC96.1; IS:1554 (Part-I) IS:5831-1984
2.	Type	:	Single / Multipair twisted and shielded type as per ANSI MC96.1
3.	Conductor Size	:	1.31sqmm, solid alloy (16 AWG)
4.	Conductor Diameter	:	1.29 mm
5.	Insulation	:	PVC insulated, heavy duty, Self extinguishing type. Colour coded extruded PVC inner sheathed with overall PVC sheathed Type ST2 FRLS IS: 5831. Insulation of each wire with high grade 0.6 mm 85 deg.C Extruded HR PVC Type C as per IS: 5831, voltage grading shall be 1.1 kV.
6.	Lay	:	Twisted pairs within 50 mm max. lay.
7.	Shield	:	Single pair cable assembly only. Multiple pair - each pair and cable assembly. Each conductor shall be individually and overall shielded Through aluminum mylar tape min 0.06 mm (0.075 mm) with min 25% overlap & 100% coverage and 7 strand 20 SWG minimum size tin coated copper drain wire.
8.	Outer sheath	:	FRLS HR PVC type ST-2 to IS:5831
9.	Conductor Identification	:	See "Cable Details" as below
10.	Armour	:	Galvanised steel wire/strip to IS:3975
11.	Multiple pair identification	:	Each pair numbered every 250 mm

12. Electrical Parameters:

Thermo electric specification, limit of error shall be as per IEC, ANSI

Description	KX type	SX/RX Type	TX Type
E.M.F at 100 Deg.C	4.095mV	0.646/0.647 mV	4.279 mV
E.M.F at 200 Deg.C	8.137mV	1.441/1.469 mV	9.228 mV
Tolerance	$\pm 2.2^{\circ}\text{C}$ from 0°C to 200°C	$\pm 1.5^{\circ}\text{C}$ from 0°C to 200°C	$\pm 1.0^{\circ}\text{C}$ from 0°C to 100°C
Conductor loop resistance for 1.31 sq. mm (16 AWG) size as per ANSI MC96.1 at 20 Deg.C Ohms/K.Mtr	760 (Typ)	95 (Typ)	390 (Typ)

Insulation Resistance (min) : 100 M ohm x KM

Mutual Capacitance at 0.8 resp. 1 KHz (max):

- Single pair and pair screened : 120nf/KM
- upto 4 pair overall screened : 96 nf/KM
- above 4 pairs overall screened : 80 nf/KM

13. CABLE DETAILS

ANSI Type	Conductor Material		ANSI Colour Code		
	Positive	Negative	Positive	Negative	Overall
KX type Extension cable for K type Thermocouple	(NICR/NIAI) Cromel	(Nichr/NiAl) Alumel	Yellow	Red	Yellow
SX/RX type Compensating cable for type S & R thermocouple	Cu (Copper)	Cu Ni (Copper-Nickel alloy)	Black	Red	Green
TX type Extension cable for type T thermocouple	Cu (Copper)	Constantan	Blue	Red	Blue

14. Tests to be conducted:

- Thermo-e.m.f characteristics
- Continuity test
- Measurement on capacitance, inductance and loop resistance.
- Insulation resistance
- High voltage tests as per IS(latest)
- Tensile and elongation tests
- Flame retardency as per IEC 332
- Oxygen index test

9.06.05.6 Fiber Optic Cable

A	Fiber: The optical fiber core shall be of ultra pure fused silica glass coated with UV-cured acrylate suitable to withdraw temperature of about 80 Deg C (continuous). Fiber Optic cables shall be suitable for installation on cable tray, duct bank, cable trench, direct burial as necessary.		
1	Type	Multiple single mode & Multi-Mode Fiber to avoid usage of any repeaters.	
2	Core Diameter	Multimode Fiber cable	Singlemode Fiber cable
		62.5 ± 2 microns or 50 ± 2 microns depending upon distance between source & destination.	9 ± 1 microns
3	Cladding Diameter	125 ± 2 microns	
4	Fiber Proof test	As per IEC/EIA & other international standard.	
5	Coating Diameter Test	As per IEC/EIA & other international standard.	
6	Number of Fibers/core	Six (Colour Coded) with min. 100% spare core (Fibers)	
B1	Optical Characteritics – Bandwidth, Attenuation & Numerical Aperture	For multimode fiber cable with core diameter 62.5 ± 2 microns:	For multimode fiber cable with core diameter 50 ± 2 microns:
1	Bandwidth @ 850 nm Bandwidth @ 1300 nm	160 MHz-Km min 500 MHz-Km min	500 MHz-Km min 500 MHz-Km min
2	Attenuation @ 850 nm Attenuation@ 1300 nm	3.0 dB/Km max 0.8 dB/Km max	3.0 dB/Km max 0.8 dB/Km max
3	Numerical Aperture	0.275 ± 0.015	0.200 ± 0.015
B2	Optical Characteritics - Attenuation	for Singlemode fiber cable outside plant:	for Singlemode fiber cable inside plant:
1	Attenuation@ 1310 nm Attenuation@ 1550 nm	0.35 dB/Km max 0.2 dB/Km max	1 dB/Km max 1 dB/Km max

C	Cable Construction:	
	Fiber Optic cable shall be of loose tube design. Typically, fibres shall be housed in groups of 6 (minimum) within gel-filled buffer tubes to protect against ingress of moisture and vibration. The tubes shall be manufactured with industry standard material tools & practices. The buffer tubes shall be stranded around the central strength member utilizing reverse oscillating lay (ROL). Blank fillers shall be used as necessary to maintain circular cable structure. Fillers shall be flame retardant and moisture resistant. The cable shall be of dual jacket & armoured. Optic Fibre cable shall be polymer coated, galvanised corrugated steel taped armoured, fully water blocked with central dielectric material for outdoor/indoor application so as to prevent any physical damage. Two highly visible ripcords are placed under the jacket to aid in sheath removal. A co-polymer coated steel tape is corrugated and wrapped around the inner jacket to provide additional cable compression strength and Termite & rodent protection. A ripcord is also placed underneath the armour for easy outer jacket removal.	
1	Outer Colour	Orange
2	Outer Jacket	Polyethylene minimum 1.5mm thick, Flame retardant & UV resistant.
3	Inner Jacket	Core-locked flame retardant polyethylene
4	Filler / Strength member	As per Manufacturer's standard
5	Central Strength member	FiberGlass reinforced plastic (FRP) and Buckle resistant material to provide both tensile and anti bucking strength to the cable.
6.	Details marked at every meter on outer sheath.	Manufacturer's Name, Month and Year of Manufacturer, Coded description of the cable based on telcordia's (bellcore) SR-2014 suggested optical cable code (SOCC), Sheath identification Number, Sequential Length marking in meter, A telephone Handset symbol to distinguish communication from power cable as per NESC section-35G.
7.	Life Expectancy	Fiber Optic cable shall provide a long life expectancy of minimum 25 years under continuous operation without degradation to optical or mechanical performance.
D	Stripping Ability	All layers easily removed with Commercially available tools
E	Installation:	
1	Minimum bending radius	20 X D (D=core Diameter) - During Installation , Short Term , loaded 15 X D (D=core Diameter) – Installed, Long

		Term , No load
2	Maximum Tensile Load/Strength	During Installation: 2200 N Installed: 1500N
3	Method of laying	Directly laid in cable trays / duct bank / clamped with available structure
4	Pulling	Ordinary cable grips
F	Storage Temperature	- 20 ° C to 60 ° C
G	Operating Temperature & Humidity	- 20 ° C to 70 ° C & 100%
H	Data Speed performance	10 Gbps minimum
I	Test Specification (EIA/TIA – STD455 or Equivalent):	
1	Impact Resistance	2000 Impacts minimum
2	Crush Resistance	4000 N/10cm minimum
3.	Compressive Strength	3000 N minimum
J	Moisture/Water Resistance	Water blocking layer, Cable shall withstand water penetration when tested with a one meter static head or equivalent continuous pressure applied at one end of a one meter length of filled cable for one hour. No water shall leak through the open cable end.
K.	Optical time Domain reflectometer	a. A recording optical time domain reflectometer (OTDR) will be utilized to test for end-to-end continuity and attenuation of each optical fiber. The OTDR shall be equipped with data storage, printer, help feature, compare trace features and OTDR software. The data storage unit must include a built-in floppy disk drive capable of storing a minimum of 100 test traces. b. Data traces saved to disk shall include the following labels. i. Fiber Identification (ID) with a minimum of 10 characters. ii. Cable ID with a minimum of 10 characters iii. OTDR location with a minimum of 20 characters iv. Far End location with a minimum of 20

		characters. v. Test operator initials with a minimum of 3 characters. c. The printer shall preferable be internal. The printer shall be able to print data traces within 30 seconds or less. The machine setting used to repeat tests at a later time shall include index, range, wavelength, average time, pulse width and scale settings. The test results (on printout) shall provide information including: loss, distance, reflectance, data and time. d. The requirements for the compare trace feature include the ability to recall two historical traces from a diskette and display them simultaneously for analysis and printing. The compare trace must compute and display a single graph representing any differences between two traces. The compare trace must be able to recall historical traces from a discrete and perform the same tests on connected live fibers. The compare trace shall perform a two point loss measurement test for any two particular fibers in a comparison analysis. The losses between the two points on the each fiber shall be displayed, and the differences between the two readings clearly shown. e. The OTDR must be equipped with software to support all of the required functions. The software shall provide for printing of whole set of traces (batch print) with minimal commands eliminating the time spent for printing traces individually. f. Bidder shall provide all mounting accessories, cables and connectors required to establish data communication.
L.	Fiber Optic splicer, terminator and tool kit box	Bidder shall provide new unused tools comprise of splicer and fusion jointer and tool kit comprise of cutter, stripper,

		polishing tool, handheld microscope, heat shrinkable sleeve, scissor, knife etc as required for maintenance and commission.
M.	Standards	Optical cable shall be conform to i) IEC 60794/IEC 60793 & EIA/TIA 455. ii) Low smoke(IEC 1034 -light transmittance of 80%). iii) Halogen free(IEC 754: 1&2- maximum acid gas generation shall be 2% by weight and PH >4.3). iv) Fire & flame retarded (IEC 331,IEEE 383). v) Rodent resistant. vi) Crush Resistant (EIA -455-41). vii) Impact Resistant (EIA -455-25). Bidder shall submit Type test report for review ,conform to IEC 60794, IEC 60793, IEEE 383, IEC 754: 1 & 2,IEC 331 ,IEEE 1034 and EIA/TIA standard. Colour codes shall be as per EIA/TIA 598-A.
N.	TESTS	Following minimum test as per any approved standard shall be carried out on the cables: a. Attenuation and Dispersion characteristics tests b. Proof Tests c. Macro-Bend resistance Test d. Mechanical Test e. Low and High Temperature cable Bend Test f. Impact resistance Test g. Compressive strength Test h. Tensile strength Test i. Cable Twist test j. Cable cyclic flexing test k. Environmental characteristics Test l. Temperature cycling test m. Colour permanence Test n. Cable Aging test o. Water penetration test p. Lightning Test q. Kink Test r. Crush Test

9.06.05.7 Data Cable:

Data transmission cables are control & signal cables used in electronics of computer system, electronic control equipment etc. in power plant data processing system. The cable has an overall screening which suppresses external electrical influences and ensures precise pulse transmission. The screen braiding of tinned copper wires is wrapped around the core or inner sheath.

i) Min. bending radius for flexing	:	15x cable diameter.
ii) Temp. Range	:	(-30 to +80) deg. centigrade
iii) Loop resistance	:	Max.78.4 ohm/km.
iv) Inductance	:	0.65 mH / Km.
v) Coupling	:	200 pF / Km.

Co axial and fibre optic cables are also used as data cables.

9.06.05.8 **NOTE:** All cables near high temperature zone 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.

9.06.05.9 Fire survival instrumentation Cables shall be similar to the Fire survival control cables specified in electrical section (Vol. IV) except that Cables for analog signals shall be annealed tinned copper conductor 0.5 sq. mm sized, with individual pair shielding & over all shielding and Cables for binary signals shall be annealed tinned copper conductor 0.5 sq. mm sized with over all shielding only. In addition the cables shall have high degree of immunity from electromagnetic interference.

9.06.06 **TYPE AND ACCEPTANCE TESTS FOR INSTRUMENTATION CABLES**

9.06.06.01 After completion of manufacture, type and acceptance tests as specified in relevant standards and herein shall be conducted and requisite number of copies of test certificates as per Distribution Schedule shall be furnished.

9.06.06.02 The Owner may, at his discretion, waive type tests provided type tests reports of tests carried out on identical materials(s) manufactured by the Bidder in India in last 5 years are furnished. The Bidder shall furnish copies of such type test reports with the Bid or indicate when they expect to make these available.
After completion of manufacture, following minimum type and acceptance tests as specified in relevant standards and herein shall be conducted and requisite number of copies of test certificates shall be furnished. The Owner may, at his discretion, waive type tests provided type tests reports of tests carried out on identical materials(s) manufactured by the Bidder in India are furnished. The Bidder shall furnish copies of such type test reports with the Bid or indicate when they expect to make these available.

I. TYPE TESTS:

The type tests shall be carried out on one drum out of every 10 drums or less for each size of cable in each lot, in presence of Owner's representative as per applicable standards in Govt. approved Laboratory if adequate testing facility is not available at works of the supplier.

Sr. No.	Name of Test	Governing standard	Special requirements as per owner's specification.
1.	Annealing test (for copper)	IS : 8130/84	As per IS: 8130/84
2.	Conductor resistance test & Diameter test	IS : 10810	As per approved G.T.P.
3.	Per sulphate test (for tinned copper wire)	IS : 8130/84	As per IS: 8130/84
4.	Test for armours wires / strips	IS : 3975	As per IS:3975
5.	Test for measurement of DC resistance of armour	IS: 1554 (I)	As per approved G.T.P.
6.	Test for measurement of thickness of insulation & sheath & other dimensions.	IS : 1554 (I)	As per approved G.T.P.
7.	Measurement of volume resistivity of HRPVC insulation	IS : 5831-1984	i. 3.5×10^{14} Ohm-cm at 27°C / room temp.(Min). ii. 3.5×10^{11} Ohm-cm at 85°C (Min.)
8.	Tensile strength and elongation test for insulation & sheath.	IS:5831/1984	As per IS:5831/84
9.	Ageing test for insulation & sheath. Loss of mass test for PVC insulation & sheath.	IS:5831/1984	As per IS:5831/84
10.	Shrinkage test for PVC insulation & sheath.	IS:5831/1984	As per IS:5831/84
11.	Shrinkage test for PVC insulation & sheath	IS:5831/84	As per IS:5831/84
12.	Hot deformation test for PVC insulation & sheath	IS:5831/1984	As per IS:5831/84
13.	Cold bend test for PVC insulation.	IS:5831/1984	As per IS:5831/84
14.	Cold impact test for PVC sheath.	IS:5831/1984	As per IS:5831/84
15.	Heat shock test for PVC insulation & sheath.	IS:5831/1984	As per IS:5831/84
16.	Thermal stability test for PVC insulation and sheath.	IS:5831/1984	As per IS:5831/84

17.	Test for bleeding and blooming of pigments for PVC insulation of sheath.	IS:5831/1984	As per IS:5831/84
18.	Colour fastness to water.	IS:5831/1984	As per IS:5831/84
19.	Colour fastness to day light.	IS:5831/1984	As per IS:5831/84
20.	High voltage test (water immersion test)	IS:1554(I)	IS:1554(I)
21.	Test for rodent & termite repulsion property of sheath.	-	Presence of lead shall be detected.
22.	Oxygen index test on inner & outer sheath material.	ASTM:D-2863/77	Min.29
23.	Temp. index test on inner & outer sheath material	ASTM:D-2863/77	Min.250°C
24.	Acid gas emission test on inner & outer sheath material.	IEC-754-1	Acid gas generation shall be less than 20% by weight.
25.	Smoke Density test on inner & outer sheath material	ASTM-D-2843/77	Min. 40% light transmission during test.
26.	Flammability test on finished cable samples as per following methods: i. Swedish chimney test ii Vertical tray flame propagation test. iii. Single vertical cable fire resistance test.	SS-424-14-75 Cl. F-3 IEEE-383 IEC-332-1	SS-424-14-75 Cl. F-3 IEEE-383 IEC-332-1
27.	Tests for all electrical properties at 20°C & maximum operating temp. as per GTP.	As per GTP	As per approved G.T.P.
28.	Oxygen index test & Acid Gas generation test for Fillers	ASTMD – 2863, IEC 60754-1	As per approved GTP
29.	Continuity test, Shield thickness, Overlap test of Al Mylar shield	As per GTP	As per approved GTP
30.	Noise interference test, Cross talk test, Mutual capacitance, Drain wire continuity test.	IEEE Transaction, VDE 0472	As per approved GTP

II Routine Test:

Routine test shall be carried in presence of owner's representative for all types of cables.

- | | | | |
|----|---------------------------|-------------|------------------------------|
| 1. | High voltage test | IS:1554 (I) | 2 KV (RMS)
for one minute |
| 2. | Conductor Resistance Test | IS:8130/84 | As per GTP |

III Acceptance Tests:

Following tests shall be carried out on 1 drum out of every 10 drums or less for each size of cables in each lot, in presence of owner's representative.

- | | | | |
|----|--|--------------|---|
| 1. | High voltage test | IS:1554 (I) | 2 KV (RMS)
for one minute |
| 2. | Conductor Resistance Test | IS:8130/84 | As per NIT |
| 3. | Volume Resistivity | IS:5831-1984 | (i) 3.5×10^{14} -cm
at 27 deg C/room temp (Min)
(ii) 3.5×10^{11} ohm-cm
at 850C Min. |
| 4. | Measurement of Mutual capacitance at 0.8 KHZ | | 100 NF/Km (max) |
| 5. | Calculation & Verification of Characteristic impedance on the basis of value obtain for mutual capacitance at 0.8 KHZ with the help of following formula | | |

$$Z = \frac{R}{2fc} \quad 320 \text{ Ohms(nominal)}$$

where Z = characteristic impedance in ohm

R = Loop resistance of cable per km in ohms at 20 °C
f = Frequency of test in Hz (800)
c = mutual capacitance per km.

- | | | | |
|-----|--|--------------------|------------|
| 6. | Measurement of thickness of insulation and sheath & other dimensions | IS:1554 (I) | As per NIT |
| 7. | Tensile strength and elongation at break of insulation & sheath | IS:5831/84 | IS:5831/84 |
| 8. | Oxygen index test on inner & outer sheath at room temp. | ASTM-D-2863 Min.29 | |
| *9. | Temp. index test on inner & outer sheath | --do-- | Min.250°C |

*10.	Acid gas emission test on inner sheath & outer sheath.	TEC-754-1	Max.20% by weight
11.	Smoke density test on inner sheath & outer sheath	ASTM-D-2843	Min.40% light transmission during test.
12.	Flammability test	SS-424-14-75	SS-424-14-75
		Class F-3	Class F-3
13.	Additional Test	IEC 331	for fire survival characteristics

* (If no. of drums selected for acceptance test for a particular cable size are more than one, the tests marked with * i.e. 5 no. 9&10 under acceptance tests shall be carried out on one drum only).

9.07.00 SHOP TESTS FOR ERECTION HARDWARE

i) General Requirements:-

- a) The equipment as per this section shall be subject to shop tests.
- b) The Conductor shall furnish all materials, equipment, tools, instruments, bulkheads, blanking plates and all personnel required for completing these tests.
- c) Personnel performing the tests shall be qualified and experienced. Tests shall be performed as many times as necessary to assure Proper quality of materials and workmanship. If any test reveals Unsatisfactory materials or workmanship, such materials shall be Repaired or replaced to the satisfaction of the Owner.
- d) Hydrostatic and pneumatic tests shall be performed on all pipes, Tubings and systems supplied by the Bidder and shall conform To ANSI B31.1 – Code for Pressure Piping.

ii) Hydrostatic Testing

All instrument piping, which connects to process piping, shall be Hydrostatically tested.

SPECIFICATION FOR PLC

4.02.00 Control System Basic Features/Design Requirements

4.02.01 Design Requirements

1. The instrumentation and controls shall be designed for maximum availability, reliability, operability and maintainability.

All components shall function in a satisfactory manner within their rated capacity under the specified conditions during the continuous service life of the plant.

2. All like instrumentation, control hardware, control and protective system should be of same make and model no. in order to achieve the goal of consistent control philosophy and to minimize the diversity of I&C equipment & spares.
3. Control system shall comply with following general failure criteria :
 - a. No single fault can cause the complete failure of the control system.
 - b. No single fault can cause the boiler or turbine/generator protection system to malfunction or become inoperative.

- c. The grouping of control functions into system blocks shall be arranged such that failure of any one block will only partly degrade the control of the overall system. Such degradation shall always be manageable by operator intervention.
 - d. The control system shall be structured to reflect the redundancy provisions of the plant so that no single fault within the control system can cause the failure of the duty equipment or make the standby equipment unavailable. Start command or stop command/trip command towards safety of process or process equipment shall be hardwired parallel from the **two different DO cards**.
 - e. As a result of a control system fault, a plant item or control function shall always respond to its controls at the actuator level (i.e., remote manual control). That item or control function shall be required to be isolated from automatic control system.
 - f. No single random fault in the entire automation and control system will cause a load loss, forced outage or unit trip.
 - g. No two simultaneous faults shall lead to or potentially cause damage to plant
 - h. Safety related instrumentation and control shall be designed with a fail-safe mode.
 - i. No single fault shall jeopardise the functioning of the entire system.
 - j. The control and automation system and the field instruments and actuators as well as its support systems, power supplies and data networks shall be immune to the electromagnetic interference and shall conform to the internationally accepted standards.
 - k. To meet the operational and safety requirements, the control system hardware and software shall conform to a modular, hierarchical architecture.
 - l. When more than one device utilizes the same measurement or control signal, the transmitter and other components shall be fully equipped to provide all signal requirements without overloading and with proper isolation. Transmitters required to serve multiple receivers shall be arranged so that disconnecting, shorting or grounding of one receiver device shall not have any perceptible influence on any other consumer point of the same signal nor shall change the transmitter calibration.
4. Distributed control equipment shall employ modern distributed microprocessor based technology, as required to comply with the project specification and the DDCMIS system should not be more than 5 year old. A truly integrated DCS is envisaged with all the self sustaining subsystems communicating with each other over the bus network and thus ensuring that the system has a truly global data base.
 5. The active control system including the plant protection system is the heart of the DCS system and therefore must stringent safety, availability and reliability

requirements have to be fulfilled by this subsystem. The bidder must bring out very clearly in his proposal how he intends to satisfy these requirements.

6. The control system shall be functionally distributed, (For Boiler, TG and BOP and similarly the control for 2 similar equipments like ID Fan A, B and C should be in different controllers & I/O cards) highly modular and arranged to reflect the functional grouping plant equipment and systems to be controlled. This functional group control strategy shall also form the basis for the partitioning of the controller to enhance the system reliability and flexibility. In case of redundant Analogue and Binary Signals, these will be connected to different input modules and different CPU. Similarly whenever inputs are more than one and needs temperature and pressure correction, the same shall be carried out in different CPU.

In case of redundant/multi Pumps/Drives for same service, all related Inputs & outputs of main pump/drive shall be in separate I/O cards and similarly all related Inputs & outputs of respective standby pump/drive shall be in separate I/O cards. Inputs/outputs of any two same services pumps/drives shall not be mixed in one common I/O card.

7. To meet the above failure criteria at sr. no. 3, the I&C system shall incorporate self-checking facilities so that internal faults can be detected within the system itself prior to any resulting disturbance to the process. In addition, the protection and safety systems shall incorporate channel redundancy or diversity of measurement as well as self-checking and adequate test facilities. For some important systems, "on line" test shall be employed with no effect to the proper functioning of the protection system.
8. In order to make sure that the DDCMIS is an extremely user friendly system a centralized engineering subsystem is envisaged. An integrated subsystem has to be provided which takes over the complete task of planning, I/O allocation, generation of function schemes and wiring documentation (in design stage) and finally the automatic linking and loading of the planned functions in the target hardware.

The complete engineering of all the automation and data acquisition functions should be possible from this central tool. This shall include all modulating and sequence control functions as far as the automation is concerned, generation of plant graphics, logs and other MMI functions. In addition the central engineering system must support all service, maintenance and commissioning assistance functions.

9. For protection applications, multi-channel measurements shall be provided incorporating 2 out of 3 trip action. Facilities for the on-line testing of each independent channel shall be provided without loss of protection. Each measurement channel shall include discrete transmitters and instrument loops, i.e. multi channel measurement of the same process variable shall not be derived from common instrument. As per NFPA, Triple supply viz. 240VAC UPS, 24 V DC and 220 V DC shall be ensured for critical Boiler and Turbine protection. Both redundancy and diversity of trip criteria shall be considered to achieve sufficient guarantee against non operability or unnecessary operation of the

protection system. The principle of de-energized to trip (Fail safe logic) shall be adopted.

10. Individual control elements shall be equipped with permissive to prevent the inappropriate operation of the item and “active interlocks” to trip the item in case of dangerous operation conditions.
11. Each of the multifunction controller together with its I/O and drive level control modules is to be understood as a self-sustaining automation island, which executes the functional located to it independently and is not affected by a disturbance in the adjacent island. For the purpose of lateral communication between the automation islands, a high speed redundant bus (the so-called control bus) should be provided which should be solely responsible for the automation (control) signal exchanges.
12. Alarms shall be provided for all abnormal conditions over which the operator has control in the control room, plus those abnormal conditions which are of interest to the operator because they may affect plant operation or security.
13. The following colors shall be selected for equipment status indicating lights:
 - Red----energized, running, valve open
 - Green----de-energized, stopped, valve closed
 - Light yellow ----abnormal, discrepancy
 - White----control power available
14. The functions of DDCMIS System are achieved through bus communication units, bus interfaces, process controllers, I/O modules and computers. The system shall be versatile and provide the user, the flexibility to freely choose configuration and redundancy. The system shall ensure very high reliability and safety through complete distribution and decentralization which goes right down to the individual I/O level.
15. Interposing relays with suitable contact rating shall be provided between DCS/PLC and MCC/Swgr in Interposing relay panels for giving command signals ON/OFF or OPEN/CLOSE. Interposing relays shall have minimum 2 NO and 2 NC contacts.
16. All parameters on which protection is achieved through pressure/ temperature/ flow switches; the measurement shall also be made available through transmitters. “ **Provision of transmitter/remote sensor will be applicable for 70% of total protection signals for such important services which will be decided during detailed engineering**”
17. Also 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 the devices from their normal operating mode.
18. The system shall execute all control functions with the help of a set of pre-programmed functions resident in controllers.

The offered system shall have provision for open system architecture to establish communication to any other system using open system standards such as UNIX, WINDOWS NT, WINDOW XP/7, TCP/IP, OSF, MOTIF, SQL Access etc.

19. 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.
20. The system shall provide inherent safe operation under all plant disturbances and component failures so that under no circumstance safety of the plant personnel or equipment is jeopardized.
21. The design of the control system and related equipment shall adhere to the principle of "fail safe" operation at all system levels and provide reliable and efficient operation of the plant under dynamic conditions and attainment of maximum station availability.
22. The DDCMIS shall be fully capable to operate plant in all regimes of plant operating conditions, including emergency operation/trip conditions, block out conditions etc. without resorting to manual control. The DDCMIS shall be capable of bringing the plant to safety state automatically without operator interventions.
23. All process input/output cards shall have built in galvanic/optical/electronic isolation for each input and output channel.
24. The failure of controller module and each I/O module shall be indicated on control cubicles and all operator stations.
25. For all the trip signals (very high/very low) employed for the boiler/Turbine Control System, **the alarms (High/Low) shall appear for correcting the process by the operators.**
26. For measurement of boiler metal temperature flue gas temperature, air pre-heater grid temperature etc., The bidder shall provide permanent/removable duplex type mineral insulated thermo-couples terminated in junction boxes at boiler platforms. Remote I/O unit has been envisaged for these inputs. The remote I/O panel shall be provided with I/O cards, redundant power supply unit and redundant communication modules etc. These parameters are brought to DDCMIS via DDCMIS I/O bus or via redundant soft link (either TCP/IP or OPC or MODBUS with RS485) to have real time data. This remote I/O panel shall be powered from UPS or 24V DC source of respective unit. The unit enclosure shall be of weather proof, dust tight and water proof. Bidder shall provide necessary air conditioning unit, if require for the system. This panel shall also be accommodate able for 4-20 mA and RTD signals of monitoring parameter and not for control parameters. The quantities **of remote I/O panels** shall be decided during detailed Engineering.
27. For measurement of turbine metal temperature turbine casing temperatures, stator winding temperature, Generator seal oil system, Turbine bearing temperature, Turbine oil temperature, Turbine bearing drain oil temperature, BFP turbine measurement parameters, MDBFP measurement parameters etc., The

bidder shall provide permanent/ removable duplicate type mineral insulated thermocouple/ RTD terminated in junction boxes at respective turbine side floors. Remote I/O unit has been envisaged for these inputs. The remote I/O panel shall be provided with I/O cards, redundant power supply unit and redundant communication modules etc. These parameters are brought to DDCMIS via DDCMIS I/O bus or via redundant soft link (either TCP/IP or OPC or MODBUS with RS485) to have real time data. This remote I/O panel shall be powered from UPS or 24V DC source of respective unit. The unit enclosure shall be of weather proof, dust tight and water proof. Bidder shall provide necessary air conditioning unit, if required for the system. This panel shall also be accommodate able for 4-20 mA and RTD signals of monitoring parameter and not for control parameters. The quantities **of remote I/O panels** shall be decided during detailed Engineering.

28. **8 Nos. temperature elements/sensors in each units control room** shall be provided for monitoring the room temperature.
29. On unit tripping, about hundred Engineers shall be informed through SMS automatically from DDCMIS. In case of tripping of major fans/pumps/HT drive the concerned Engineer configured in such a way shall get the SMS information.

To achieve the automatic SMS facility, GSM (global system for mobile Communication) with redundant Ethernet connectivity shall be provided by bidder for SMS facility. Same shall be connected with DDCMIS/OPC server/MIS server as decided during detailed engineering.
30. For Auto generation of trip message of unit & major fans/pumps/HT drive through Email, Email facility in DDCMIS/OPC server shall be provided by bidder.
31. All the 4 nos. 40" LED TV monitors per unit and 2 nos. 40" LED TV monitors for common system at CCR shall be erected at the false roof top of central control room.

4.02.02 CONTROL SYSTEM PHILOSOPHY

- 4.02.02.1 In order to minimise the burden on the unit operator, all control functions within the operational load range shall be fully automated. The control system shall be structured in accordance with a well-defined control hierarchy to permit operator intervention at appropriate levels during abnormal modes of operation.
- 4.02.02.2 The automation shall meet the following objectives as minimum:
 - (a) Consistent start-up, shut down and running of the plant under all operational condition
 - (b) Achieve minimum run-up and loading time
 - (c) Maximize fuel economy during start-up, shut down and normal on load operation cycle
 - (d) Maximize plant life expectancy

- (e) Contribute to power grid during normal and disturbance condition
- (f) To meet the operational and safety requirements, the control system hardware and software shall conform to a modular, hierarchical architecture. The system hierarchy shall be at four levels.

4.02.03 Different Level of Controls

4.02.03.1 Drive Level

- 4.02.03.1.1 The first and lowest level shall cover all the modulating, sequence and protection control functions directly associated with all remotely controlled plant items. It shall also incorporate all necessary interlocks, initiations and trip functions for starting and stopping a main drive motor.
- 4.02.03.1.2 Control at this level shall either be initiated directly from the remote manual control interface or automatically by the next hierarchical level.

4.02.03.2 Subgroup Level

- 4.02.03.2.1 The second level shall coordinate the control of all first level drives, both closed loop and open loop, associated with a particular functional subgroup. In the case of a pump subgroup, for instance, the permissive checks, the coordination of the operation of the suction and discharge valves, the main drive initiations and the basic modulating control loops shall be executed at this control level. The major monitoring functions (e.g. turbine supervisory measurements) shall also be identified with this level.
- 4.02.03.2.2 Typical control functions associated with this level are:
 - i. Auto- Start and stop initiation or set point guidance from the next higher control level
 - ii. Start-stop- Normal initiation of the auxiliary start and stop sequence.
 - iii. Auto Standby-Start initiation in the event of duty item failure.
- 4.02.03.2.3 A functional group consists of different units, which individually represent and control a part of the complete plant and can be divided into two or more groups. Every sub group is controlled by an independent sub group control, which controls the operation of various drives. Once a start signal issued by a functional group, the sub group control brings the sub group from one state into another operating condition by issuing command signals in a programmed sequence. It brings the sub group from a shut down state into a working condition and vice-versa. The functional group instrumentation and control system co-ordinates the entire sub group controls belonging to one functional group.

4.02.03.2.4 Group Level

- 4.02.03.2.4.1 The third and penultimate level shall coordinate the individual subgroup control function (both modulating and sequence controls) within the main functional groups of the system.
- 4.02.03.2.4.2 The group co-ordinate the sub group of a functional group. Its main function is to

deliver start-up or shutdown command signals to the sub-group and change over from a faulty subgroup to the reserve sub group, the group co-ordination control supervises. the actual and the required position of the switchgear in the sub group and then decides whether the sub group shall be switched "ON" or "OFF"..

4.02.03.2.4.3 The aforesaid concept of functional group control is independent of the control techniques-freely programmable.

4.02.03.2.5 Unit Co-Ordination Level

4.02.03.2.5.1 The fourth level, which stands at the apex of the hierarchical triangle, shall perform the overall unit coordination. It shall incorporate, for example, the master load control function which should regulate the load generated by the generator to the demand set point value. In general for automatic start-up and shutdown control, the sequential initiations of the functional group sequences should be generated at this level.

4.02.03.2.5.2 The typical sequence control functions to be implemented at this level would include:

- i. The sequential initiation of the subordinate functional group sequences for automatic start up and shutdown.
- ii. The sequential initiation of the subordinate functional group sequences for automatic start up and shutdown of a part/full.
- iii. The sequential transition to the various combination of subordinate functional Groups.

4.02.03.2.5.3 The modulating control functions to be implemented at this level would include the following:

- i. Unit load control with frequency regulation incorporating load balancing (remote set point adjustment from the CCR /LCR shall be provided).
- ii. Station load demand and demand rate limiting

4.02.03.2.5.4 In general the operator shall have direct access to all four control levels where these are identified, through the operator control interface located in the CCR.

4.02.03.2.5.5 Communication links shall be provided between the various control systems to allow for access to the system from any of the operator's interface stations.

4.02.04 CONTROL SYSTEM - LEVEL OF AUTOMATION

4.02.04.1 The unit control and monitoring shall be performed from control room by means of OWS/KB operation interface mounted on unit control desk, through a microprocessor based distributed Digital control monitoring and information system.

4.02.04.2 The unit shall be remotely controlled, but a fully automatic system of the plant shall be provided, i.e. all valves, motors, final control elements and other equipment that have to be operated during start up, operation and shut down, belonging to the Main Systems, shall be remotely controllable from unit control room by the operator through Distributed digital control monitoring and Information system.

4.02.04.3 Subordinated drives belonging to one main aggregate shall be managed by means by sub group control systems. Automatic open/closed loop controls shall be installed wherever it is possible to lighten the work of the operation.

4.02.05 CLOSED LOOP CONTROL SYSTEM (CLCS)

4.02.05.1 The CLCS shall control the process variables automatically both under steady state and dynamic conditions with in the limits specified under guarantee clauses over the entire operational range of the equipment/system.

4.02.05.2 The CLCS shall have the following features:

- (a) Provision of predictive and/or adaptive controls in addition to PID controls as required by the system. Availability of **advance control techniques/Algorithms** ensuring process optimization.
- (b) Set point adjustments and indication from operating work stations/ KBs for process variables which need to be changed during load changes, start-up, shutdown, normal or under any other emergency conditions.
- (c) Fixed set point at the software level/hardware level (only changeable by the maintenance engineer) and indication for those process variables which need not be changed with respect to load or otherwise.
- (d) Bias adjustment with indication where a single controller is controlling more than one final control element (control valve, control damper, speed drive etc.) to maintain the same process variable.
- (e) Auto and manual control facility shall be transferable in both directions without bump of the value of the process variable to control the parameter during manual operation. Both master Auto Manual station and Auto / Manual station for individual control element shall be provided in OWS. Auto tuning facility shall be an inherent feature of the DDCMIS. Availability of control loop of process parameters in aut o for different loads. If required, the system shall have the feasibility of **auto changing of PID constants (K constants)** in micro-processor/controller for different loads so as to avoid hunting of control valve.
- (f) Characterization of final control element to suit the various applications with respect to load or otherwise as dictated by the process.
- (g) Function generator to provide necessary characterization or variation of set points with respect to load, speed or any other requirement.
- (h) Soft Auto /Manual station interlocks to drive the final control elements to a suitable position for safe plant operation in the event of process/equipment abnormal conditions.
- (i) Blocking/Interlocking function as dictated by process/equipment.
- (j) Monitoring of loop failures or any hardware failure in the loops.
- (k) Fail safe operation of final control elements in case of failure of motive power or

Signal.

- (l) Redundancy criteria of sensors for CLCS shall be dictated as per NIT, Vol. V, Cl. No. 2.05.05.
- (m) Redundancy criteria of I/O cards and Wiring for redundant or non redundant signals from field to control system (I/O cards & controllers) shall be dictated as per NIT, Vol. V, Cl. No. 4.02.08.02 and 4.02.08.02.1 respectively.

4.02.06 OPEN LOOP CONTROL SYSTEM (OLCS)

4.02.06.1 Protection, interlock and sequence controls constitute OLCS. This system shall enable the operator for safe start up and shutdown and carryout normal operation both from control room and local areas. Protection and Interlock shall be provided for all the equipment and system to safeguard the equipment against abnormal conditions which may result in the failure and less utility of the equipment and protect the operating personnel. Controls shall be provided to start/shutdown various systems and/or any equipment with associated auxiliaries and to operate the Unit on line with optimum number of operations and higher safety.

4.02.06.2 The OLCS shall have the following features as a minimum:

Features-General Requirements

- (a) The logic and sequence control shall be Digital distributed microprocessor based and programmable.
- (b) Enable the operator to start/stop various unidirectional motors, to open/close various valves and dampers and carry out inching operation of bypass valves or any other similar equipment both from control room and local areas.
- (c) The system shall be designed based on the philosophy of command to energise a relay or solenoid valve.
- (d) Where there is more than one pump or fan for the same service (say 2 pumps), auto standby features shall be provided to select the standby unit and this standby unit shall start automatically on failure of running pump or on applicable process criteria (say low discharge pressure) with an annunciation.
- (e) All the contacts of the sensors used in protection circuit shall be monitored.
- (f) Triple redundant sensors shall be provided when used in protection circuits for major critical equipment and 2 out of 3 logic shall be derived for further use in protection circuit

4.02.06.3 Features-Interlock Requirements

- (a) Permissive conditions for a equipment start shall be provided. The permissive conditions within the equipment are bearing temperature normal, winding temperature normal, adequate suction pressure, bearing vibrations normal, bearing lubrication oil pressure normal, switchgear in service, switchgear not in test, no protection trip command persisting (as applicable) etc.
- (b) The permissive conditions from a process system related equipment are

establishment of free path for the flowing medium under all start-up, emergency and shutdown conditions, closure of discharge valve for the starting of first of the identical pumps/fans and then opening the valve after the operating condition is established etc.

- (c) Selection of standby equipment and starting the equipment automatically on the tripping of running equipment and/or desired process parameter conditions (say loss of discharge pressure or low level in the discharge tank etc.)
- (d) Isolation of the tripped equipment from the main process.
- (e) Any other conditions for safe starting and shutting down the equipment.

4.02.06.4 Features-Sequence Control Requirements

Sequence control shall be provided to start and stop the equipment and the associated auxiliaries. The sequence control shall have the following features:

- (a) Once the start-up or shutdown of an equipment is initiated either manually or automatically from the system, the control of associated auxiliaries shall be automatic with facility for manual operation at each stage (step).
- (b) Criteria check up for each stage of operation with monitoring and displaying.
- (c) Bypass facility for each criteria when only the feedback signal/display is incorrect but the actual condition is fulfilled. This activity shall be logged and annunciated in control system (DCS / PLC).
- (d) Adequate time delay between the steps as dictated by the process to establish an operating parameter or healthiness of an equipment.
- (e) Normally, the auxiliaries of the standby equipment should be running (as applicable) so that the standby equipment is started without loss of time.

4.02.06.5 Features-Protection Control Requirements

The following minimum protection shall be provided for the various equipment/system as applicable to trip the equipment.

- (a) Any condition which endangers the safety of the plant personnel
- (b) Any of the permissive conditions becoming abnormal thereby producing a dangerous condition in operating the equipment.
- (c) The conditions from process such as dry flow conditions, flashing conditions or any other conditions that may create cavitation.

4.02.06.6 Redundancy criteria of sensors for OLCS shall be dictated as per NIT, Vol. V, Cl. No. 2.05.05.

4.02.06.7 Redundancy criteria of I/O cards and Wiring for redundant or non redundant signals from field to control system (I/O cards & controllers) shall be dictated as per NIT, Vol. V, Cl. No. 4.02.08.02 and 4.02.08.02.1 respectively.

4.02.07 System Architecture for Main Plant Control System (unit wise)

Following Operating work stations & Engineering work stations per unit except wherever specifically asked for both unit, are envisaged for control & operation of main power plant from Unified Distributed Digital Control, Monitoring and Information System (DDCMIS) (Refer System Configuration Drawing, # 114-01-0100).

4.02.07.01 Option 1 – For Unified DDCMIS

4.02.07.01.01 Operating Work stations:-

- i. 6 nos of Operating Stations (one no. of boiler control system like MFT, two nos., for BMS (FSSS), Boiler auxiliaries, two nos. for Turbine auxiliaries and one no. for electrical system & BOP) shall be connected directly on Proprietary/ preferably Industrial Data Highway/higher level network of DDCMIS with 2 LJP A4 B/W and 1 LJP A4 Color.
- ii. 2 nos. of Operating Stations for Turbine Control System (governing system), like DEHGC, ATRS, ATT, ETS from the respective system shall be connected directly on Proprietary/ preferably Industrial Data Highway/higher level network of DDCMIS with 1 LJP A4 B/W & 1 LJP A4 Color.
- iii. 1 no. of Operating Station for TSE for Unit incharge (shift supervisor) with 1 LJP A4 Color (if this is not integral of DDCMIS, TSE shall be connected with DDC MIS through redundant OPC connection).
- iv. 1 no. of Operating Station for Unit incharge (shift supervisor) - Printer not required
- v. 1 no. of Operating Station for Station incharge (in the cadre of Executive Engineer) with 1 LJP A4 B/W.
- vi. 1 no of Operating Station for performance calculations & optimization for Unit incharge (shift supervisor) shall be provided with 1 LJP A4 B/W.
- vii. 1 no. of Operating Station for performance calculations & optimization at the Office of Executive Engineer/Efficiency shall be provided with 1 LJP A3 B/W.
- viii. 1 no. of Operating Station for water chemistry parameters connected with performance calculations & optimization at the SWAS / Chemical Express lab shall be provided with 1 LJP A4 B/W.
- ix. 1 no. common Operating Stations at Factory manager, and 1 no. common Operating Stations at Electrical System incharge room shall be provided for both units, operation/ command shall not be executed from these three consoles to start/stop the equipments. Software and hardware security lock shall be provided not to use these controls for any operations. 1 LJP A4 Color with each Operating station shall be provided.

- x. 2 nos. of common Operating Stations for both units at common DDCMIS network in CCR with A3 sized color LJP.

4.02.07.01.02 Engineering Work stations & Servers:-

- i. 2 nos. of Engineering Stations for system maintenance Engineer for unit DDC MIS system with 2 LJP A4 Color, 1 No. A3 sized Scanner, copier cum printer, 1 LJP Heavy Duty Industrial grade A3 Color.
- ii. 1 no. Engineering Station for system maintenance Engineer for Turbine Control System with 1 LJP Heavy Duty Industrial grade A3 Color.
- iii. 1 no Engineering Station for Turbine Stress Evaluation with 1 LJP A4 Color (if this is not in integral of DDCMIS, TSE shall be connected with DDC MIS through redundant OPC connection).
- iv. 1 no. of Engineering Station for Sequential Event Recording with 1 no. A3 sized DMP
- v. Redundant Historian server (Historical Data Storage & Retrieval system) with Work station and 2 no. A3 sized DMP.
- vi. 1 no. redundant server system for performance calculation & optimization (PADO) with Engineering work Station and Heavy Duty Industrial grade A3 Color printer.
- vii. Redundant OPC server for OPC connections with DDCMIS from other systems with Work station & 1 LJP A4 B/W.
- viii. Redundant MIS server with one no. MIS work station, and 1 no. LJP A4 B/W.
- ix. Common Redundant OPC server for OPC connections with both units DDCMIS from other common systems with Work station & 1 LJP A4 B/W.

4.02.07.01.03 "The local operating stations 6 nos. per unit namely at locations like ESP, Zero M Elev. Turbine building, Boiler - A Elevation, HT Switchgear room, SWAS / Chemical Express lab room & CWPH (with 1 no. A4 sized B/W LJP) and 1 nos. namely at common locations like FOPH shall be provided with 24" LED color screen/OWS, with minimum configuration connected to DDCMIS on redundant connection to show the status/conditions of various process parameters/equipments in process mimics, trends, logs etc with real time data.

Operation/command shall not be executed from these local operators' consoles to start/stop the equipments. Software and Hardware security lock shall be provided for not using these consoles for any control/operations. Specification of these local stations shall be same as specified at cl. no. 4.03.03.04 respectively.

All the locations/rooms availing the operating stations namely FOPH, CWPH, Boiler A elevation, Turbine 0 meter, ESP, Ash handling Control room, HT Switchgear room, 400 KV switchyard control room and SWAS / Chemical Express lab, DM Plant are to be air conditioned.

4.02.07.01.04 All operating stations connected on redundant data highway shall be interchangeable and operation of the plant shall be possible from Engg. station after security check. All operator stations shall have full access to the entire plant data base and shall have identical functionalities. The system shall have full data base redundancy. The data base shall be independent and shall reside separate from the operator stations.

4.02.07.02 Option – 2

- i. Separate DCS based control system is provided for Turbine integral control and DEHGC, ATT, same shall be provided with complete configuration (OWS & EWS with printers) as specified above at cl. No. 4.02.07.01.01 (ii) & 4.02.07.01.02 (ii) and TSE's work stations & TSE's Engineering stations with printers & TSI work station with printers as specified else where in the specification.
- ii. Separate DCS based control system is provided for Turbine protection (ETS – Emergency trip system), same shall be provided with one no. operating station and one no. operating cum engineering station and one no. A4 sized B/W LJP.
- iii. Separate DCS based control system is provided for MFT & Boiler protection controls, same shall be provided with one no. operating station, one no. operating cum engineering station and one no. A4 sized B/W LJP and one no. A4 sized color LJP.
- iv. For option 2, Quantities of OWS & EWS shall remain same with DDCMIS as specified above at cl. No. 4.02.07.01.01 (i & iv to viii), 4.02.07.01.02 (i & iv to vii) & 4.02.07.01.03 irrespective of separate control systems (DCS) for Boiler integral controls and Turbine integral control respectively.
- v. In case bidder provide separate Turbine control system & Boiler control system from DDCMIS. Then configuration of LVS shall be 4 no. LVS with Display controller as part of DDCMIS package, 1 no. LVS with display controller as part of Turbine control system and 1 no. LVS with display controller as part of Boiler MFT control system.

4.02.07.03 Option – 3

- i. Separate DCS based control system is provided for DEHGC, TSC, ATT & Turbine protection (ETS – Emergency trip system), same shall be provided with complete configuration (OWS & EWS with printers) as specified above at cl. No. 4.02.07.01.01 (ii) & 4.02.07.01.02 (ii), one no. OWS for ETS/Turbine protection, and TSE's work stations & TSE's Engineering stations with printers & TSI work station with printers as specified else where in the specification.
- ii. MFT & Boiler protection controls shall be part of DDCMIS.
- iii. For option 3, Quantities of OWS & EWS shall remain same with DDCMIS as specified above at cl. No. 4.02.07.01.01 (i & iv to viii), 4.02.07.01.02 (i & iv to vii) & 4.02.07.01.03, irrespective of separate control systems (DCS) for Turbine integral control system.

- iv. In case bidder provide separate Turbine control system from DDCMIS. Then configuration of LVS shall be 5 no. LVS with Display controller as part of DDCMIS package and 1 no. LVS with display controller as part of Turbine control system.

4.02.07.04 Total 6 No. 80/84" diagonal sized LVS per unit shall also be provided for monitoring, operation and control of power plant as per details specified elsewhere in the specification.

2 no. common 80/84" diagonal sized LVS with their own display controller connected to both unit DDCMIS on common redundant OPC network to show the status/ conditions of various process parameters/equipments in process mimics, trends, logs etc of common BOP/Offsite packages with real time data shall be provided by bidder. These two nos, LVS are common to both 2 X 660 MW units and shall be located in C CR. Operation/command shall not be executed from these LVS to start/stop the equipments. Software and Hardware security lock shall be provided for not using these local LVS for any control/operations.

4.02.07.05 Modulating Controls (CLCS) and Discrete Open Loop Control (OLCS) shall be designed to eliminate the necessity of operator action except manual / auto selection, set point changes, biasing and similar actions during normal operation. Bumpless and balance less transfers between automatic and manual operation modes and vice-versa shall be provided automatically without need of operator action. Complete backup shall also be provided for safe shutdown operation of plant.

The system shall have built in redundancies for all system functions both at the processor and device level. No failure of any single device or processor shall lead to any system function being lost. It shall have redundant data highway on a "master less" principle.

Redundant equipment wherever provided shall be powered from redundant power supply units in order to improve system availability and reliability.

The system shall have the capability and facility for expansion through addition of station/drops, controllers, processors, process I/O cards etc., while the existing system is fully operational. The system shall have the capability to add any new control loop in CLCS and new group, sub group, drive functions in OLCS while existing system is fully operational. Intelligent I/O cards will be preferred.

All the basic systems shall be connected through redundant data highway/bus system. The local bus system with associated bus couplers shall be provided for communication between different I/O modules and processors. The communication system shall be designed keeping in view the integrity & security aspects for the control system. In case the system employs master communication controllers, facility for 100 % hot back up controllers with automatic switch over shall be provided and it shall be ensured that no loss of data takes place during failure of communication controller.

The DDCMIS shall be fully capable to operate plant in all regimes of plant operating conditions, including emergency operation/trip conditions, black out conditions etc. without resorting to manual control. The DDCMIS shall be capable of bringing the plant to safety state automatically without operator interventions.

The application programmes for the functional controllers shall reside in EPROMS or in non volatile RAMS. The application programme shall be alterable by access through programmer's console. Parts replacement or parts removal shall not be required for accomplishing changes in application programmes including control loop tuning. Each controller shall be equipped with the amount of functional capacity required to perform its specified functions and still have an overall spare capacity of 40%.

4.02.08 Redundancy & Availability Requirements

The CPU / Controllers, communication modules, data highway, power supply modules, etc for all DDCMIS/DCS/PLC shall be 100% hot standby redundant. I/O cards redundancy shall be as per cl. No. 4.02.08.02.

4.02.08.01 Controller Redundancy

All functional controllers for sequence control, functional controllers for closed loop control and functional controller for DAS & monitoring shall be provided with hundred percent hot standby controllers. However controller redundancy is not mandatory, where controller is purely executing data acquisition & monitoring functions. DAS function can also be integrated within CLCS/OLCS controller. All processors for modulating controls shall have self-tuning facility.

All the 100% hot back up controllers shall be identical in hardware and software to their corresponding main controllers. Further, each of the 100% hot back up controller shall be able to perform all the tasks of their corresponding main controller. The 100% hot back up controller shall continuously track/update its data corresponding to its main controller. There shall be an automatic and bumpless switchover from the main controller to its corresponding back-up controller in case of main controller failure and vice versa. The changeover shall take place within 50 msec. Engineered solution for redundancy in CPU are not acceptable. Dual redundant controllers shall be placed separately and shall not share the same motherboard or shall not have any other common sharing point.

Any switchover from main controller to 100 % hot back up controller and vice versa, whether automatic or manual shall not result in any process upset or any change in control status. The transfer from main controller to the back-up & vice-versa shall be indicated as alarm on all operator station OSs.

In case of switchover from main controller to back up controller, the back-up controller shall be designated as the main controller.

All the input variables shall be available to the main controller as well as its 100% hot back up controller so that any failure within the main controller shall not degrade the input data being used by the 100% hot back-up controller and vice-versa.

Each controller shall have 40% spare functional capacity to implement additional function blocks, over and above implemented logic/loops under worst load conditions. Each controller shall have battery backup or EEPROM/NVRAM for program memory.

Parts replacement or parts removal shall not be required for accomplishing changes in application programmes including control loop tuning.

Each of the corresponding communication controllers shall also have same spare capacity as that of controller.

For controller, the worst loading condition shall include the following tasks:

- (a) All process inputs scanning and processing is in progress and all the data is transmitted over the main data bus every one (1) second.
- (b) All closed loop controls in operation
- (c) All open loop controls in operation
- (d) All output devices are in operation with rated performance/speed.
- (e) Control/information request is initiated on all control Operating stations.
- (f) In burst mode operation (in case of major equipment trip), 100 digital alarms are generated per second for a period of 10 seconds.

4.02.08.02 Redundancy in Input/output Modules

Hot standby 100% redundancy shall be provided for all input/output cards where inputs/outputs are used for CLCS and OLCS. All input/output of SCADA from/ to breaker & isolators shall be redundant. No redundancy at I/O card level is required which are executing purely data acquisition/monitoring functions. I/O card shall have 16 channels per AI/RTD/TC/AO card and 32 channels for DI/DO card. No. of channels per I/O card indicated are maximum, which may also further reduced to meet the I/O cards features specified elsewhere in specification.

Wherever redundant I/O modules/cards are used as per specification requirement, both (1:1 redundant) input or output modules shall execute the designated functions parallelly. The offered system shall have facility to enable final output from any of redundant input/output module, in case both modules are healthy. In case one of redundant card/module is unhealthy, the system shall detect the same and the output to and from system shall be given from the healthier card. I/O card redundancy shall not be achieved through relays, diodes or any other additional hardware or software, Engineered solution for redundancy in I/O cards are not acceptable.

Wherever redundant sensors are employed each sensor shall be wired to both input modules of redundant modules so that even if one input module fails, the both signals will be available from the other input module. This arrangement is necessary to avoid loss of both input signals due to failure of one input module where both the signals are connected.

In addition to above, 20 % fully wired input/output spare channels should be provided for each I/O modules.

Bidder to note that all type of hardwares & electronic modules like controllers, I/O cards, communication modules and interface modules etc used in DDCMIS/DCS/PLC shall be sourced/supplied from their Principal's works.

4.02.08.02.1 Wiring Scheme for inputs/outputs to/from control system shall be as follows:

- i. Each of the triple redundant binary & analog inputs shall be wired to separate input modules. In addition, for functions employing 2V3 controllers (eg. Turbine protection, MFT, Boiler protection, DEHGC etc.), each of the triple redundant binary & analog signals shall be wired to separate input modules associated with each controller, so that even if one input module fails, the signal will be available from the other input module.

In case of dual redundant binary & analog inputs, each of the signal shall be wired to both input modules of redundant modules, so that even if one input module fails, the both signals will be available from the other input module. These redundant modules shall be placed in different racks, which will have separately fused power supply distribution. Implementation of multiple measurement schemes of these inputs will be performed in the redundant hardware. Loss of one input module shall not affect the signal to other modules. Other channels of these modules can be used by other inputs of the same functional group.

- ii. The single (i.e. non-redundant) binary & analog signal required for control purposes shall be wired as follows:

All single analog & binary inputs (used for OLCS & CLCS) including the limit switches of valves/dampers MCC/SWGR check-backs of all drives, SOE & information related signals shall be wired to redundant input modules.

The binary and analog outputs from one subsystem of the Control System to other which are required in these systems for control & protection purposes, shall be made available from triple/dual redundant binary and analog output modules. Other binary & analog outputs used for DAS shall be non-redundant only. Failure of any single module shall not affect operation of more than one single drive.

4.02.09 DDCMIS/DCS Controller Grouping/Partitioning

All controllers shall be dual redundant except Triple modular redundant controllers for Turbine DEHC, Turbine protection & Boiler MFT/protection. Following tentative segregation for controls (OLCS, CLCS) & DAS is proposed, however final segregation shall be subject to Owner's approval during detailed engineering:-

- a) Coordinated master controls, FTP, Oil System, Misc. Drives, Burner Tilt
- b) IDF A, FDF A, Air flow and excess air correction, PA fan –A/AH – A/SCAPH-A/PA header Pr. Control.
- c) IDF B, FDF B, Furnace draft, PA fan –B/AH – B/SCAPH-B
- d) Mill related controls such as air flow/feeder rate/outlet temperature, Mill Lub oil controls; Two mills per redundant processor
 - i. AB
 - ii. CD
 - iii. EF
 - iv. GH
 - v. JK
 - vi. MN
- e) Feed water/BFP Scoop control/CBD

- f) TDBFP - A integral controls per redundant processor
 - i. ATRS 1 SGC & Turbine Protection
 - ii. ATRS 2 SGC, TSI & CLCS
 - iii. DEHC (Digital Electro Hydraulic Governing System)
- g) TDBFP - B integral controls per redundant processor
 - i. ATRS 1 SGC & Turbine Protection
 - ii. ATRS 2 SGC, TSI & CLCS
 - iii. DEHC (Digital Electro Hydraulic Governing System)
- h) MDBFP – C & Aux and Boiler fill up Pumps
- i) Deaerator (three element controls), CEP, hot well, & Hot well makeup Pumps.
- j) HP heaters 5, 6, 7 & 8.
- k) LP Heaters 1, 2, & 3.
- l) SH steam temperature control (multi variable control) & RH steam temperature control (multi variable control), Metal Temp.
- m) DMCW Pumps & DMCW system for SG & TG and CPU* (* CPU incase DDCMIS controlled) .
- n) COLTCS, HP & LP Dosing System and Cooling Tower & Aux.
- o) Electrical system 1
- p) Electrical system 2
- q) Electrical system 3
- r) **Remote I/O panel** with r edundant pr ocessor f rom D DCMIS f amily is to be implemented with following grouping for CW & ACW system
 - i. CW Pump – A, CW Pump – C, ACW Pump A & CW lines to/from unit # 1 Condenser/Hotwell.
 - ii. CW Pump – B, ACW Pump B, CW makeup system & CW lines to/from unit # 2 Condenser/Hotwell.
- s) Turbine integral controls per redundant processor
 - i. ATRS SGC Oil Supply, Turbine & Drains
 - ii. ATRS SGC Condensate & Evacuation System
 - iii. GSPC (Gland Steam Pressure Control), LP Bypass
 - iv. GAMP (Generator Aux. Monitoring)
 - v. TSC (Turbine Stress Evaluation Control System) & TSI
 - vi. ATT (Automatic Turbine Tester)
- t) SG integral controls per redundant processor
 - i. Oil A B & Oil CD
 - ii. Oil E F & Oil G H
 - iii. Oil J K & Oil M N
 - iv. Coal A B
 - v. Coal C D
 - vi. Coal E F
 - vii. Coal GH
 - viii. Coal JK
 - ix. Coal MN

- x. SADC & APRDS
 - xi. SBC controls, SBC PR & Drain Temp. controls.
 - xii. HPBP
- u) Steam Turbine controls like DEHGC (TMR – Triple modular Redundant philosophy) and Turbine Protection (TMR – Triple modular redundant philosophy) with fail safe design cards can be Integral or separate stand-alone.
 - v) Triple Modular Redundant (TMR) processors for MFT & Boiler protection with fail safe design cards can be Integral or separate stand-alone.

All controllers at “sr. no. a to t shall be dual redundant (92 Nos. total)” and at “sr. no. u to v shall be triple redundant (9 Nos)” for each unit. Hence, altogether minimum 101 processors are envisaged for each unit. During detailed engineering, processor task allocation will be done amongst these processors (and shall be subject to owner's approval) taking into consideration the turbine control, boiler control and the station C&I portion altogether. In addition, loading of signal interfacing from other BOP packages, Aux. & control/monitoring system shall be considered for finalization of quantity of controllers.

For common system between two units, following redundant controller groupings shall be provided with unit 1 DDCMIS, which shall also be interfaced with unit - 2 DDCMIS for control & operation. **Remote I/O panel** with processor from DDCMIS family is to be implemented because of the long distance. Controllers shall be 1 no. dual redundant (2 Nos. total).

- i) BTG (FOPH) Fuel Oil System

Above quantity of controllers is minimum, indicative and tentative only. However final quantities of processors in addition to above quantities shall be finalized depending upon I/O handling capacity of the processor and design parameters like response time, communication bus speeds etc. Overcrowding of control loops in controllers shall be avoided.

Each group has sufficient spare capacity of at least 25% to meet modification/extension of the system. Multi-function processors can incorporate the corresponding interlocks (open loop control tasks of the system). Interlock and modulating controls are to be so assigned to the processors in such a way that failure of any processor does not lead to shut down of the entire unit. In no case CPU loading should exceed 60% of its capacity. Bidder to submit calculation of CPU loading along with his bid.

4.02.10 Response Times

The system shall have adequate speed of response through all regimes of system loadings. The minimum criteria to be ensured are as follows:-

- a) Key board command to field equipment shall be executed and its confirmation shall be displayed on the screen within 1 second.
- b) The response for operator requested display (time between pressing of last key and appearance of last character on screen) shall be of the order of one to two seconds under all loading conditions.
- c) Dynamic parameters in the OS displays shall be updated in one second interval.

- d) The cycle time for open loop and closed loop controls shall be as follows:-
 - i) For critical closed loops like Steam Separator level control, main steam temp. control, feed water flow control, HRH steam temp. control, HP/LP bypass control, furnace draft control & combustion control, the loop cycle time shall be max. 100 milli seconds preferably 50 milli seconds.
 - ii) For non-critical closed loops it shall be max. 250 milli seconds (preferably 150 milli seconds).
 - iii) For all open loops, sequential interlocks & protection it shall be max. 100 milli seconds.

(The loop cycle time is defined as the time taken from change at input module to change in output module for command).
- e) All analog inputs to CLCS shall be acquired and data base updated within an interval of 50 milli seconds. Data for critical loops shall be acquired & data base updated at a faster rate to suit the requirements of (d) above.
- f) The digital inputs for SOE shall be monitored at 1 milli second resolution.
- g) The system shall acquire & check all inputs at the input scan rate. If the input is in alarm state (i.e. the input is in an off normal condition) the alarm status shall be annunciated, printed out and displayed within 1 second after the input is scanned.

4.02.11 Established Reliability

- i) All components and systems offered by the Bidder shall be of established reliability. The minimum target reliability of each component shall be established by the Bidder, considering its failure rate/meantime between failures (MTBF) & meantime to repair (MTTR), such that the availability of the complete system is assured for 8700 hours / year (99.7%) or better.
- ii) In order to ensure the target reliability the bidder shall perform necessary availability tests and burn in tests for major systems. Surge protection for electronic control systems, annunciator system and other solid state systems conforming to SWC test per ANSI C 37.90a (IEEE standard 472) and selection of proper materials, manufacturing processes, quality controlled components and parts, adequate derating of electronic components and parts shall be ensured by the Bidder to meet the reliability and life expectancy goals.
- iii) 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.
- iv) In general, failure of equipment used for alarm purpose will cause switching to the alarm state.

4.03.03.04 Specifications for Operator Station, Engineering Work Stations

Each operating station & Engineering work stations and any other work stations/PC envisaged in plant shall meet following minimum requirements & as per latest trends at the time of supply:

- On board Intel – Xeon quad core, 3.46 GHz processor with 1066 MHz bus with Hyper threading or higher.
- 4GB DDR3 RAM (min.)
- 1 x 1000 GB IDE Hard Disc Drive of 7200 RPM or higher
- 1024 MB Graphic Accelerator
- System chipset: Intel Express
- 2 x RS – 232 ports
- 1 x parallel port
- 4 nos. USB ports. (2 nos. on front side)
- 1 x 52X DVD/CD Read Drive
- 16 X DVD R/W Drive
- 2 x Ethernet (10 / 100 / 1000MB) cards (Industrial Grade)
- UXGA graphics and monitor 1920 X 1080 , 256 colours with MRP II compliant, viewing angle 178° vertical & Horizontal and fastest response time.
- 1 x windows XP/7 Professional or latest & proven version of Windows OS professional with Multimedia
- Ethernet adapter
- Third party operating system, graphical users interface and software, if required.
- 2 nos. graphic output cards minimum

- Optical mouse
- Sound card
- Internal speakers
- Wireless internet & Blue tooth Interface
- Redundant power supply (In built)
- General MS Windows latest, MS-Office Professional, Adobe Acrobat, anti-virus McAfee or equivalent, AutoCAD etc.
- Application engineering & HMI software - to suit project Specific requirement
- All OWS shall be interchangeable

Preferred makes of OWS/EWS/PC's are DELL, HPCOMPAQ, NEC & IBM.

4.03.03.04.01 Peripherals for Operator Station, Engineering Work Stations & Server System

4.03.03.04.02 Full flat Monitors with LED back lighting

The bidder shall furnish OWS/EWS/Servers/PC with coloured **Full flat Monitors with LED back lighting**. OWS/EWS/Servers/PC with **Monitors** shall have a fast cursor control device like a track ball/optical mouse. All **Monitors** shall be of high resolution colour graphics type and with not less than 32 colours. The picture frequency shall not exceed 85 Hz. The resolution required is 1920 X 1080 pixel or better. The picture shall be stable and completely free of any flickering. The screen illumination shall be enough to give good readability. The screen dimensions shall not be less than 24" screen diagonal.

Antiglare hard coating shall be provided. High reliability and long life 24" (Industrial type) or better size monitors shall be supplied by the bidder. **Monitors** shall be equipped with all adjusting elements accessible on the front plate. Monitors with 3D capabilities for graphics shall be provided by bidder.

Monitors along with keyboard & optical mouse shall be mounted on supervisory control console specified elsewhere in the specification.

4.03.03.04.03 Key Board:

Functional key boards for plant operator station shall be of special type adopted to operation tasks and monitor functions. It shall contain all keys necessary for plant operation arranged in an ergonomically manner. Multi function keys shall be provided with automatic display for modified functions. Freely programmable keys (Minimum 101) shall be available for special user application.

Key Board shall be integrated into supervisors control consoles horizontal part.

Provision of functional keyboard shall be in addition to facility for operator control through mouse/track ball.

Membrane type keyboard shall be provided for operator interface with process for plant control and display functions to access plant data in conjunction with control OPERATING STATIONS. Membrane keypad shall be assignable with LED alarms, dedicated display selection keys with spare provision, hardware locking facility to set OPERATING STATION in engineer, supervisor or operator mode. The keyboard

shall have a minimum of 101 configurable keys for assigning most frequently used displays. A minimum of forty of those keys shall have two independently lit LED's used for event-specific alarm annunciation.

Keyboard shall be provided to enable the shift supervisor to develop graphic displays, control system software and system configuration for the DDCMIS. It shall be possible to perform operating interface functions from engineering OPERATING STATION. Assignable function keys shall be provided for execution of command, program etc. Hardware facility shall be provided to set OPERATING STATION in engineer or operator mode. QWERTY type keyboard shall be provided for engineer's functions. QWERTY type Key Board may be offered alternatively for OWS.

4.03.03.04.04 PRINTERS

Line Impact Heavy Duty Dot Matrix Printers

All printers shall be low noise (less than 60dB) type with a minimum of 136 columns. Printing speed shall be a minimum of 300 characters per second. Since the control room printers are high-speed printers, the system shall output to these printers at the rate of 1000 lines of printout per minute as a minimum. This rate shall be independent of the number of printers in simultaneous operation. Style of printing available shall be indicated by the Bidder. The printers shall have graphic capability and any OPERATING STATION display may be printed on the printer. The printing shall be bi-directional and in two colours black and red for sequence of event recording. Paper input capacity shall be with continuous paper feed.

Printers shall accept and print all ASCII characters via an EIA RS-232 C or twenty milliamp current loop interface. Parity checking shall be utilized.

All printers mounted shall be provided with a separate printer enclosure each. The enclosures shall be designed to permit full enclosure of the printers at a convenient level. Plexiglas windows shall be used to provide visual inspection of the printers and ease of reading.

Printer enclosures shall be designed to protect the printers from accidental external contact and each should be removable from hinges at the back and shall be provided with a lock at the front.

If one of the printers fails to operate, its functions shall automatically be transferred to the other printer. Failure of the printers shall be indicated on all OPERATING STATION's. Printer shall be offered and supplied from reputed manufacturer with latest proven technology. 5 Rims of papers shall be provided by bidder for each printer provided with subject plant.

Coloured Laser Jet printer

Printing Speed	20 ppm (min.)
Resolution	1200 X 600 dpi
Memory	128 MB (min.)
External Port	1 no. USB 2.0 port, and TCP/IP 10/100 Ethernet, Blue tooth interface

Duty Cycle	40,000 pages per month
Pages size	A3, A4, and Transparency etc. with automatic duplex printing facility.

Laser Jet printer (B & W)

Printing Speed	30 ppm (min.)
Resolution	1200 X 1200 dpi
Memory	128 MB (min.)
External Port	1 no. USB 2.0 port, and TCP/IP 10/100 Ethernet, Blue tooth interface
Duty Cycle	15,000 pages per month
Pages size	A4, A3, and Transparency etc. with automatic duplex printing facility. Paper tray - 2

Ink Jet Printers (Coloured)

Printing Speed	30 ppm (min.)
Resolution	1200 X 1200 dpi
Memory	64 MB (min.)
External Port	1 no. USB 2.0 port, and TCP/IP 10/100 Ethernet, Blue tooth interface
Duty Cycle	5,000 pages per month
Pages size	A4, Transparency etc.
Duplex printing	Automatic

Five sets of print cartridges and Five rims of papers shall be provided with each printer provided anywhere in the plant by bidder with each DDCMIS, DCS & PLC system and any other system specified elsewhere in specification.

Preferred makes of printers are HP, Canon, Fuji Xerox, & Epson.

4.03.03.04.05 External DAT Drive

The DAT drive is a serial back-up device. The DAT drive shall have read/write capability and shall be provided with all required hardware interface including error detection and correction facilities in each control room. The tape (total 10 nos.) of Sony make shall have the capacity of 12/24 GB min. The tape drive shall be specified as follows:-

- DC drive
- Tape format - QIC-80
- Data Transfer Rate – 5MB/minute.
- Seek time – 22 milli second

4.03.03.04.06 Hard Copy Facilities

The system shall be capable of copying hard copy of OPERATING STATION graphics through a video colour copier switch able to any OPERATING STATION.

The printer/copier offered shall be capable of copying OPERATING STATION image in 20 seconds.

4.03.03.04.07 USB Port Pen Drive

Twenty Five (25) no. USB Port pen drive per unit having 32 GB memory with read/write facility shall be provided.

Preferred makes of USB pen Drive are HP, Sandisk, Kingston, Strontium.

4.03.03.04.08 Scanner, Copier cum Printer (A3 size)

Resolution	:	1200 x600 dpi (optical) (min) for Printer 600 x600 dpi (optical) (min) for Scanner
Colour Depth	:	48 bit
Scaling	:	10 to 2000% in 1% increments
USB interface	:	required.
Memory	:	1 GB
Printing Speed	:	30 ppm (min.) for A4 size 20 ppm (min) for A3 size
Duplex printing	:	Automatic

4.03.03.04.09 DVD Writer

The DVD writer should be capable to read and write any DVDs as well as CDs. and shall be provided with all required hardware interface including error detection and correction. The DVD writer shall meet following minimum requirements:

- DVD write speed - 16x
- CD write speed - 52x
- Cache / Buffer size - 2MB
- Buffer under protection technology

Five nos of DVD (Re-writeable) shall be provided with each OWS/server provided anywhere in the plant by bidder with each DDCMIS, DCS & PLC system and any other system specified elsewhere in specification.

4.03.03.04.10 Digital B/W Copier cum Printer (A3 size)

01.	Type	:	Laser, tabletop / latest
02.	Printer Memory	:	512 MB (min.)
03.	Speed	:	Monochrome 30 ppm - A4 20 ppm – A3
04.	Resolution	:	600 x 600 DPI
05.	No. of color (Basic)	:	Monochrome
06.	Duty cycle	:	Monochrome more than 75000 pages / month
07.	Power supply	:	240 V, 50 Hz, 1 phase UPS
08.	Ambient temperature	:	0-50° C
09.	Humidity	:	95% non-condensing.
10.	Size of paper	:	Paper weight of 45 to 165 g/M ²

- | | | |
|-----|-------------------------|---|
| 11. | Networking Capability : | USB / Ethernet |
| 12. | Coping : | Max Original Size – A3, Continuous Coping (1-999) |
| 13. | Accessories : | i) Adapters
ii) Connector Cable
iii) Duplex Unit. Automatic
iv) Optional Paper feeder- 2 Nos |

4.03.03.05 Lap Top

The LapTop shall meet following minimum requirements:

- a) Intel Centrino™ Mobile Technology.
- b) Intel Core – i7 Processor with 3.46 GHz, 4 MB L2 cache, 1066MHz FSB.
- c) 14" WXGA LED Screen with wide angle viewing.
- d) 500 GB 7200 rpm HDD with shock absorber.
- e) 4 GB 800 MHz DDR3 SDRAM (slot for 1no. additional RAM slot should be provided)
- f) 1 x windows XP Professional or latest & proven version of Windows O S with Multimedia
- g) Slim type DVD-RW/DVD ROM combo drive.
- h) Internal 10/100/1000Mbps Ethernet card
- i) IEEE 802.11B connectivity port
- j) IR port
- Optical mouse
- k) 2Nos. USB ports & Wireless INTERNET & blue tooth interface
- l) External mouse connectivity and optical mouse
- m) Minimum 8 hrs battery backup.
- n) Recovery software tools.
- o) Sound cards
- p) Internal speakers
- General MS Windows latest, MS-Office Professional, Microsoft Visual Studio, Adobe Acrobat, anti-virus McAfee or equivalent, etc.
- q) Application engineering & HMI software - to suit project specific requirement

Preferred makes of Laptop are DELL, HPCOMPAQ, VAIO (Sony), Lenovo.

4.03.03.06 General Specification of the server:

- | | | |
|-----------|---|--|
| Enclosure | : | 6U Rack Mountable server / Tower type Sever |
| Processor | : | Intel Xeon Quad (4) Core 64 bit Processor capable 3.6 GHz with 16MB L3 cache memory per processor, Dual independent 1333 MHz system bus (2 way SMF) or better. |
| Memory | : | 64GB ECC DDR – 3, 800 SDRAM |

Video	:	Integrated with 64MB SDRAM
Resolution	:	1920 x 1080
Drives	:	HDD – RAID 5 (1000 GB) Ultra 320 SCSI adaptors with internal storage capacity 3.6 TB DVD/CDROM – 24X CD – RW/DVD IDE combo USB – 4 ports DAT – 36 / 72 GB
Peripherals	:	PS/2 keyboard Optical Mouse
Operating system	:	Windows 2008 server version standard / latest Enterprise Edition or latest & proven version of Windows Operating system
Backup & Disaster Recovery	:	VERITAS \ CA \ Tivoli \ any other
Environmental	:	Operating Temp range - 10°C to 35°C Humidity range - 8 to 80% (Non-Condensing) Vibration 0.25 G at 3 to 300 Hz for 15 Minutes.
Software	-	General MS Windows latest, MS-Office Professional, Adobe Acrobat, anti-virus McAfee or equivalent, etc. Application engineering & HMI software - to suit project Specific requirement
Miscellaneous	:	i. 1 Parallel port ii. 1 Serial port iii. 4 – 10/100/1000 MB/1GB network ports iv. Two non-boards and two added v. External SCSI port vi. Dual hot plug power supplies vii. Dual Hot plug fans viii. 2 PCI Express slots (1x4 lane and 1x8 lane) ix. 2 PCI X slots (64bit/100MHz) x. 2 PCI slots (one 32bit/33MHz, 5V & one 64bit/66Mz) xi. Redundant Server shall be provided, wherever required. xii. LED based 24" sized Monitors.

Preferred makes of OWS & Servers are DELL, HPCOMPAQ, Lenovo.

4.03.03.07 Industrial grade managed type Ethernet switches

Industrial grade managed type Ethernet switches shall be provided with in built diagnostic features, 20% spare ports & inbuilt redundant 24 V DC power supply features and Integrated Security features (IPS, ACL, Firewall). Industrial grade managed type Ethernet switch shall be rack mounted and comply with the IEC 61850 (3) and IEEE 1613 requirements. Switches shall have 10 GB module support for future upgradeability

4.03.03.08 The Firewall shall meet following minimum requirements:

Industrial grade Firewall appliance should facilitate multi-vendor, multi-application environment and should support third-party products on open alliance. It should support Active-Active configuration.

- i. The firewall should contain following features:
 - (a) Stateful inspection of packets.
 - (b) NAT functionality, including dynamic and static NAT translations
 - (c) Latest version of SNMP
- ii. The firewall must send log information to a separate log server via an encrypted connection. Firewall logging must not impact firewall performance.
- iii. Remote network access to the firewall should only be possible through the administration interface.
- iv. The firewall administration station must be capable of pushing firewall security policies and configurations to individual or multiple firewalls through a secure, encrypted connection to the firewall administration interfaces.
- v. Graphical User Interface (GUI) and a Command Line Interface (CLI) for making changes to the firewall rules set should be provided. (Access to the firewalls via the GUI or the CLI must be through an secure encrypted channel).
- vi. Any changes or commands issued by an authenticated user should be logged to a database configured on any of the machines in the LAN. The administration station must allow for a hierarchical architecture for rules set administration and viewing of firewall configurations Management.
- vii. The firewall must not support any unencrypted means of access to the firewall.
- viii. It should Monitor ALL network traffic-traffic at Firewalls (Internet and external networks), in the DMZ and detect known threat through deep packet inspection.
- ix. Detects unknown threats via anomaly scanning.
- x. Detect unknown threats via behavior pattern to protect from zero day attacks.
- xi. Keeps up-to-date on new threats and vulnerabilities.

4.03.03.09 Software License:

The Bidder shall provide software license for all software being used in DDCMIS/PLC/simulator/any other electronic/microprocessor based system. 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 Owner to seek a new license/renew license due to upgradation/change of hardware/machine in

DDCMIS/PLC/simulator/any other electronic/microprocessor based system at site. All licenses shall be valid for the continuous service life of the plant.

In case the s/w license is dependent on no of points, then quantity to be considered is 30% above the finally implemented points.

Software Upgrades

As a customer/owner support, the Bidder shall periodically inform the designated officer of the Owner about the software upgrades/new releases that would be taking place after the each system is commissioned and handing over to owner, so that same can be procured & implemented by bidder at site.

The future updated version of any type of software shall be supplied free of cost as and when such software is upgraded, on request by owner until 5 years from the date of commissioning of the unit.

- 4.03.03.10 Separate Laptops shall also be provided with all master software loaded and engineering of DDCMIS, DCS, simulator & any other control system individually. Similarly additional Laptops shall be provided with all master software loaded and engineering of PLC system individually.

As explained above, One No. Laptop with necessary master software loaded and engineering of each control System shall be supplied individually.

4.03.03.11 **SOFTWARE DOCUMENTATION AND SOFTWARE LISTINGS**

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, DCS & PLC / any other microprocessor based control system/simulator etc shall be furnished. The Bidder shall furnish a comprehensive list of all system/application software documentation after system finalisation for Owner's review and approval.

The software listings shall be submitted by the Bidder for source code of application software and all special-to-project data files.

4.03.04 **Programming, Diagnostic and Engineering Work Station**

There shall be Two (2) no. work station with 24" sized (Industrial type) LED monitor, associated hard disk 3½", Two color laser jet printer and associated peripherals, as like 52X CD drive, DVD Drive, DVD/CD writer, 1 No. A3 sized Scanner copier cum laserjet printer, and A3 heavy duty industrial grade Coloured LJP with DDCMIS.

For PLC based control system, same shall be provided as listed in Annexure A.

The Engineering stations provided with DDCMIS, DCS & PLC shall have all the function of programming/ configuration/modification/ reconfiguration and documentation. The features and facilities to be included are as under:-

- a) Configuration or re-configuration of a system.
- b) Possibility to introduce or modify parameters.
- c) Documentation of system configuration.

4.05.00 Design Criteria for BOP packages' Control System

4.05.01 Design Criteria for Programmable Logic Controller (PLC) System

The PLC for BOP packages shall have following features:

- i. The PLC system shall fulfill and demands emanating from the domains
 - Automation
 - Monitoring
 - Process control
 - Management
 - Engineering
- ii. Uniform operator machine interface
- iii. Reliable user guidance
- iv. Comprehensive redundancy concept
- v. Modern object oriented software structure
- vi. Shall be able to communicate with external system and intelligent field equipment
- vii. Simple central project planning and configuration aids
- viii. Integrated documentation system
- ix. Integrated diagnosis and service
- x. Commissioning support
- The Control System shall have on-line simulation & testing facility.
- xii. 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.
- xiii. Fault Diagnostics
 - Complete software for microprocessor based system including the communication software between systems, MIS system etc., shall be supplied and implemented. The software shall be also included for equipment performance test, life evaluation, equipment capability curve and alarm analysis, Management information system, etc.
- xiv. General I/O requirements of PLC based system shall be as per cl. No. 4.02.08.02, 4.03.11 and Annexure B.
- xv. Bidder to note that all PLC system shall be from same manufacturer only. PLC system supplied & engineered through system house shall not be acceptable. It should be supplied & engineered directly from PLC manufacturer only. It is preferred to have each PLC system with hardwares from same family of Plant DDCMIS.
- xvi. Design & Functional Requirements as per the cl. No. 4.02.00 detailed for DDCMIS/DCS system shall be applicable for each PLC based control systems.
- xvii. PLC shall be provided with necessary redundant ports & complete hardwares for Auto time synchronization from Master clock time by bidder.

4.05.02 Technical specification for PLC

- 4.05.02.1 The latest proven PLC system shall be provided. PLC should be sourced from original manufacturers; PLC from system house shall not be acceptable. PLC system shall be complete with hot standby redundant CPU of word length of 32bits minimum, Input /

Output modules, dual serial link interface module for connecting Input / Output Modules, dual Communication Processors, dual Memory modules and redundant Power supply units. Power supply unit shall be redundant for each CPU & I/O rack. PLC system will be interfaced with DDCMIS through OPC dual redundant communication interfacing (to be provided at PLC & DDCMIS end) for important process parameters. PLC shall conform to IEC – 61131.

- 4.05.02.2 Redundant CPUs in hot standby mode shall operate on fault tolerant mode with continuous self and cross monitoring facility. Redundant CPU/controllers shall be placed separately and shall not share the same motherboard.
Failure of the active CPU shall not adversely affect the operation of the plant in any perceptible way. Failure of the active CPU will lead to transfer of the tasks being performed to the other healthy CPU within fastest possible transfer time (i.e. ≤ 50 m sec.) without causing any output to drop during the Transfer period. In the Event of the both the CPU failure, the system shall revert to the Fail-safe mode. The CPUs shall not be loaded over 60% of the Individual capacity even under worst data loading conditions. It shall be possible to switch from the active to the back-up CPU and vice versa from Operating station as well from the CPU front panel. (The worst data condition of PLC means all modules in active mode, printer in operation, OLCS&CLCS logics active and process in running condition). Data bus loading shall not be more than 50%. This configuration shall be applicable for each type of PLC based control system. Engineered solutions for redundancy in CPU & I/O cards are not acceptable.
- 4.05.02.3 The system shall be of modular construction and expandable by adding hardware modules and incorporating them in the address register. Bidder shall provide at least 20% overall with minimum two no. spare channels as hot-on-rail spares in each configured cards / Modules. In addition to this 10% or minimum one no. extra assigned complete spare cards mounted on rails in sub-racks for each type of I/O modules shall also to be provided. The spare channel and cards shall be fully wired up to termination cabinets. Spare Philosophy as detailed in cl. No. 4.03.11 for DDCMIS/DCS system shall be applicable for each PLC based control systems.
- 4.05.02.4 The memory unit of the CPU shall be field expandable. The memory capacity shall be sufficient (min. 8 MB per CPU) for system operation and shall have the capability for future expansion at least to the tune of 40%. The application program / sequence logic etc. shall be stored in non-volatile memory (EPROM). However all the dynamic memories shall be provided with battery back up with at least for 96 hours. Lithium or Ni-cd battery shall be used. The quantities of Hot standby redundant CPU/controllers for each PLC system shall be finalized during detailed engineering by owner depending upon CPU/controller's worst data loading conditions and CPU/controller's functional distribution.
- 4.05.02.5 The max number of Input / Output points per card shall be 32 for digital and 16 for Analog / Thermocouple / RTD. No. of channels may also reduced to meet the I/O cards feature specified in NIT. Individual input channels shall have galvanic isolation. Output points shall also have optical / galvanic isolation. Merely fusing of individual or a group of channels is not acceptable. The I/O cards shall be rack mounted. Failure of Analogue I/O cards, binary cards / modules shall also be displayed on the Engineering cum diagnostic station.

- 4.05.02.6 The data communication system of the PLC including that of its redundant system bus with hot back up and other allied buses such as I/O bus, local bus etc., shall fulfill the following minimum features. The bidder shall furnish all the calculation details of CPU utilization and Bus loading. Bidder shall also furnish communication protocol used for the offered PLC.
- i. Communication links (I/O bus) between CPU and individual Input & Output (I/O) modules rack shall be dual redundant with 10 Mbps speed and 16 bit CRC data protection feature. In no case failure of a link shall affect the control of the plant.
 - ii. The communication system design shall ensure that any single point failure on the system bus / media shall not disrupt more than single message and disrupted message shall be automatically retransmitted after the standby communication link takes over control.
 - iii. Failure of physical removal of any station / modules connected on the system bus shall not lead to any loss of communication.
 - iv. Diagnostics display both at operating workstation and module front end shall be provided for easy fault detection.
 - v. Bus change over from active bus to stand by bus, during failure of active bus shall be performed automatically and bumpless. Such event shall be suitably logged or alarmed.
 - vi. The system communication between PLC controllers and the operators stations shall be conducted at high speed minimum 100 Mbps with Ethernet based open protocol with no collision feature to avoid data jamming / overloading of the system. The communication bus, serial link etc. shall have adequate protection against electrical noise and mechanical damage.
 - vii. System should have open bus structure and should allow further extension facility and connection with any third party system.
 - h. PLC Network shall also be provided with external surge protection system and industrial firewall.
- 4.05.02.7 Man Machine Interface (MMI) shall be industrially ruggedised Operator's station based on latest window based market available software along with its peripherals like LED monitor, printer, mouse. Engineering functions shall normally be carried out from dedicated workstation or operating station as per annexure-A "control system for BOP". In case a dedicated engineering station is provided, EWS shall also be worked as operating station through password / Hardware lock. The monitor refresh time i.e. latency time should be ≤ 2 second.
- 4.05.02.8 The Operator's station shall perform the following minimum requirements.
- a. Selection of Auto / Manual, Open / Close operation, sequence auto, start / stop operation etc.
 - b. Dynamic Mimic display detecting the entire process for control monitoring purpose.

- c. Alarm monitoring, report generation, logs, calculations and printing of logs, reports, trends etc.
- d. Online / historical trending, historical storage and retrieval of data.

4.05.02.9 Software provided shall be latest, modular, upgradable and industrially proven. It shall have capability for multi tasking, multi programming, multi user operation in real time environment and support for third party system. Bidder shall provide the following minimum requirements:

- 1. Required software for fulfilling the complete implementation of the control logics, operation displays, logs, data storage, retrieval, diagnostic and other functional requirements as indicated in this specification.
- 2. Detail documentation on all programming software's and this shall be part of the O & M manual.
- 3. Supply of Licensed version of all software both in edit and run mode with multi – user license. All the third party softwares should be latest and market available.

4.05.02.10 a. Bidder shall provide and connect suitable communication hardware / software/ cables and other accessories required for connecting all numerical relays as per IEC – 61850 of auxiliary in PLC / SCADA where PLC with OWS.

b. Bidder shall provide firewall (hardware) in various layers to protect PLC from other network as per ISA – SP – 99. Communication to any third party system shall be via industrial grade anti spam, anti virus Firewall only.

c. Bidder shall provide redundant software/hardware link with “online” in Motion Bridge computer and other belt weight system with CHP PLC system to calculate coal flow to indicate following status:

- i. Daily and cumulative coal unloaded by track hopper.
- ii. Daily and cumulative coal sent to stockpile.
- iii. Daily and cumulative coal sent to boiler bunker.
- iv. Amount of coal available in stockpile.

d. Remote indication in centralized control room (DDCMIS) for total coal unloaded in 24 hours from ECHS shall be provided.

e. A pneumatic control valve shall be provided at the interconnection line between service air header and instrument air header before air dryer unit. When instrument air header pressure falls below set value, the control valve will start opening and maintain the instrument header pressure at specified level in line with plant requirement. A gain when instrument air header pressure goes above specified level in line with plant requirement the control valve will fully close automatically. Complete system shall be in bidder scope.

4.05.02.11 PLC shall specifically meet the following requirements:

- (a) PLC shall have extensive self-diagnostic capability. Self diagnostics shall include both module level diagnostics as well as channel level diagnostics
- (b) PLC shall have hot standby redundant processors/controllers. This shall mean the fulfillment of the following requirements:

- (i) Automatic synchronisation of primary processor/controller of PLC with secondary processor/controller
- (ii) Bumpless switchover to secondary processor/controller of PLC when the primary fails.
- (c) Automatic program and data equalisation in the event of any on-line program / edit executed in the primary processor/controller of PLC.
- (d) Automatic “Forcing Bit” update in the secondary processor/ controller of PLC when any “ Forcing is applied in the primary processor/controller of PLC.

4.05.03 **SYSTEM REQUIREMENT & SPECIFICATION**

- 4.05.03.1 The system shall have high MTBF and shall be hot maintainable. The system hardware shall be designed to be fault avoidant by selecting high grade components of proven quality and properly thermally de-rated design. The system shall have extensive fault monitoring, self surveillance & on-line self diagnostic capability so that failure up to module / card level is immediately detected. Each of the modules shall have its self – diagnostic system. The operator station located at the area control room shall be used for fault data presentation and monitoring purpose.
- 4.05.03.2 The system shall have capability to automatically check & correct gain & drift for ADCs on-line.
- 4.05.03.3 All data exchanged in a bus shall be fully monitored & checked for validity.
- 4.05.03.4 Loop Cycle time in PLC shall be equal to or less than.
- a. OLCS : 100 ms or less
 - b. CLCS : 250ms or less
- 4.05.03.5 Following operations will be performed on I/Os, as required:
- 1. Square root extraction
 - 2. Pressure & Temperature compensation
 - 3. Responsibility check of all inputs (analog specially), validate and quality tagging like good, bad, suspects etc
 - 4. Channel wise engineering unit conversion.
 - 5. Contact bounce filtering with adjustable time constant.
- 4.05.03.6 All controllers shall be freely configurable with respect to requisite control algorithms. An extensive library of macros shall be included for the purpose adequate software capability shall be provided to implement closed loop control functions as follows:
- i) P, PI, PD and PID control and their variations.
 - ii) Open loop (On- Off, sequence control)
 - iii) Cascade control
 - iv) Ratio control
- 4.05.03.7 For open Loop Controls, the system shall have, as a minimum, the following features:

- a) Logic functions like AND/OR/NOT gates, timers (on-delay, off-delay), shift registers, counters, latches, flip-flops, mono – shots, tantalizers etc.
- b) The automatic sequence control to ensure sequential start up and shut down of auxiliaries / equipment. Sequence control shall be performed in groups initiated by command from operator's console. A sequence shall be made of steps executed in predetermined order according to logic criteria. For each step there shall be a provision for 'waiting time' and 'monitoring time', and it shall output an action on the process. System shall have the capability to bypass one step if desired by the operating personnel by forcing an input or output from the operator's station. Such action however will be registered as an exception or alarm.
- c) Increase the reliability and availability of the plant as a whole, for example, by timely and correct switchover to standby drives etc.
- d) Basic interlock and protection logic related to safety of individual drive and plant equipment. All inputs required for protection system shall be on high priority basis. In the event of either loss of control power or control signal input to the drive, the drive shall remain in its last position unless specifically required otherwise. The system shall be designed such that no upset occurs either to process or to the drive when the power is restored.

4.05.03.8 Interface of the PLC system with AC Solenoids & DC Solenoids shall be in the form of potential free contacts via interposing relay modules mounted in the interposing relay cabinet. 20% additional interposing relay modules shall be provided as installed spare. For AC solenoids and contactors directly driven from output cards, arc suppressors & MCB shall be provided across the coil.

4.05.03.9 **Displays**

4.05.03.9.1 The operator's station shall be responsible for handling all commands as well as in generating desired displays, logs, reports, alarms and printouts. Security in different levels shall be provided to prevent unauthorized access to the system.

4.05.03.9.2 Programming shall also be permissible by drawing Ladder or Boolean diagram or through any easily understandable language. Single programming instruction / command shall be sufficient to delete a program rung from memory. Similarly, any rung can be inserted into the existing program. The active and the standby CPU programs shall equalize automatically, once the new program is permitted to 'RUN'.

4.05.03.9.3 Updating time and reaction time (system's response to an operator's command) shall be provided for operator station as follows:

- a. Calling up a mimic : 1 sec or better
- b. Updating status signal in mimic : 1 sec or better
- c. Updating variables in a mimic : 1 sec or better.
- d. Issuance of command to output : 2 sec. or better
(without considering travel time and process lag)

4.05.03.9.4 Programmable Controller shall be responsible for real time process Parameter monitoring, storage and display. Basic requirements are (i) Operator Interface, (ii) Basic

Calculation, (iii) Alarm Monitoring & Reporting, (iv) Display generation, (v) Logs, (vi) Trend Recording & (vii) Historical Storage & Retrieval.

4.05.03.9.5 The displays at the operator console shall be classified into overview Display, group display, point display, alarm display and trend display.

- a) Overview display – This display is to enable the operator to set an overview of the entire plant section.
- b) Group display – The group display page shall display several sub-sections & present status information.
- c) Point display – Along with the specified parameter value, this page should indicate historical trend of the parameter.
- d) Trend display – This display include real time/historical trend display facility including Dynamic Graphic Display & Bar Graph Display.
- e) Alarm Message Display – It shall be possible to display process as well as system and diagnostic alarms for operator's attention and action. Alarm shall appear immediately on the operator station as and when they occur on priority basis. In addition to alarms appearing on displays, the system shall also be able to display alarm summary and alarm history listing the date and time of occurrence, tag number, point description, type of alarm (absolute value or deviation), serial number of alarm in the sequence of occurrence etc. Alarm shall disappear from display only when they are acknowledged and cleared. Any abnormal condition in any sub-system or any other function devices shall be displayed as system alarm message on the operator console irrespective of display selected.

4.05.03.9.6 The system shall print the following logs as minimum as defined in the Following clauses. The printing of these logs shall be initiated automatically at prescribed time intervals, or initiated on demand by the occurrence of predefined events.

Shift/Daily Log

A Shift/daily log shall be provided to furnish data for routine analysis of plant performance. This log shall be automatically printed at specified time each day and on demand at any time.

4.05.04 **Salient hardware / software features of the PLC system**

The salient hardware / software features of the PLC system for I/O handling shall be as follows.

- 1. Input filters to attenuate noise.
- 2. SWC of 500v DC common mode and 500V AC peak to peak
- 3. Comm. Mode Noise rejection for analog inputs of 120dB at 50 HZ
- 4. Normal mode noise rejection for analog inputs of 60 dB at 50 HZ
- 5. LED indicators on each card to show status of input
- 6. All the outputs shall be with individual fuse.
- 7. K type thermocouple mV input where applicable.
- 8. Pt-100 three wire resistance thermometer input where applicable.