



**STANDARD TECHNICAL SPECIFICATION FOR  
RETROFIT OF WET LIMESTONE BASED  
FLUE GAS DESULPHURISATION (FGD) SYSTEM  
IN A TYPICAL 2 x 500 MW THERMAL POWER PLANT**



**CENTRAL ELECTRICITY AUTHORITY  
NEW DELHI**

**December, 2017**



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**P. D. Siwal,  
Member (Thermal)  
Central Electricity Authority**

## **FOREWORD**

Ministry of Environment, Forest and Climate Change (MoEF & CC) vide Notification dated 7.12.2015 has brought out new emission norms for thermal power stations. To meet the new emission norms, installation of flue gas desulphurization (FGD) system has become essential in new as well as existing thermal power plants. There has been a demand from stake holders that CEA, as an apex body in the power sector, should bring out a standard technical specification of FGD system which can be used as a guiding document by the utilities for installation of FGD system in their power plants with reduced time for pre-award activities, design & engineering and equipment manufacturing.

In line with above objective, CEA constituted a committee under Chief Engineer (TE&TD) in July, 2017 with participation from major utilities and manufacturers for developing standard technical specifications for wet limestone based FGD system as majority of thermal power plants in the country are expected to be provided with wet limestone based FGD system.

I am glad that CEA has finalized the document titled, "Standard Technical Specification for Retrofit of Wet Limestone Based FGD System in a Typical 2 x 500 MW Coal Based Thermal Power Plant" with valuable inputs from the committee members. This document can be used for installation of FGD system in a new thermal power plant also. The document reflects pooled experience and knowledge of participating engineers from CEA, utilities and FGD system manufacturers. I hope that the utilities would find the document quite useful for retrofit/implementation of FGD system in thermal power plants in an expeditious manner towards compliance of MoEF & CC notification on new emission norms.

I wish to express my appreciation to all the members of the Committee viz. CEA, NTPC, BHEL, UPRVUNL, TANGEDCO, Toshiba, L&T and Alstom (GE) for sharing their experience and making valuable contribution in bringing out this document.

New Delhi  
December, 2017

**(P. D. SIWAL)**



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## SECTION 1.0

### GENERAL NOTE, APPLICABILITY AND PROJECT SPECIFIC INFORMATION

#### 1.1 GENERAL NOTE

- i) Ministry of Environment, Forest and Climate Change (MOEF &CC) has issued notification no: S.O.3305(E) titled 'Environmental (Protection) Amendment rules, 2015 dated 7.12.2015. The said notification has brought out amendments to Schedule - I of Environment (Protection) Rules, 1986 for the water consumption and emission norms applicable to thermal power stations. As per the amendment, the following emission norms are applicable to the thermal power plants:

Pollutant	TPPs (units) installed up to 31.12.2003*	TPPs (units) installed after 1.4. 2004 up to 31.12. 2016*	TPPs (units) to be installed from 1.1.2017**
Particulate matter	100 mg/Nm <sup>3</sup>	50 mg/Nm <sup>3</sup>	30 mg/Nm <sup>3</sup>
Sulphur Dioxide (SO <sub>2</sub> )	600 mg/Nm <sup>3</sup> (< 500MW capacity units)		100 mg/Nm <sup>3</sup>
	200 mg/Nm <sup>3</sup> (≥ 500MW capacity units)		
Oxides of Nitrogen (NO <sub>x</sub> )	600 mg/Nm <sup>3</sup>	300 mg/Nm <sub>3</sub>	100 mg/Nm <sup>3</sup>
Mercury (Hg)	0.03 mg/Nm <sup>3</sup>		

\*The above emission limits are to be met within two years from date of notification.

\*\* Including all TPPs (units) which have been accorded environmental clearance and are under construction.

After notification of new emission norms, installation of FGD has become essential in all thermal power plants for compliance of stipulated SO<sub>2</sub> emission limits.

- ii) To meet a specific level of SO<sub>2</sub> emission stipulated by MoEF&CC, the SO<sub>2</sub> level to be achieved by the bidder in the treated flue gas under guarantee condition needs to be provided with some margin. The following is proposed guaranteed SO<sub>2</sub> level in the treated flue gas under guarantee condition to be specified in the bid:



SO <sub>2</sub> level stipulated by MoEF& CC	Guaranteed SO <sub>2</sub> level in the treated flue gas under guarantee condition (100% TMCR load)
600 mg/Nm <sup>3</sup>	500 mg/Nm <sup>3</sup>
200 mg/Nm <sup>3</sup>	150 mg/Nm <sup>3</sup>
100 mg/Nm <sup>3</sup>	70 mg/Nm <sup>3</sup>

iii) Partial treatment of flue gas:

The compliance of emission norms of 100 mg/Nm<sup>3</sup> & 200 mg/Nm<sup>3</sup>, the required SO<sub>2</sub> removal efficiency of FGD system to be installed shall be in the range 90- 95%. For compliance of emission norms of 600 mg/Nm<sup>3</sup>, the required SO<sub>2</sub> removal efficiency of FGD system needs to be in the range 60- 70%. The partial bypass of raw flue gas helps in increasing the temperature of the mixed flue gas and increases the buoyancy of exit flue gas leading to its wider dispersion. It also reduces the problem of moisture condensation in chimney. In this specification, partial bypass of raw flue gas has not been envisaged considering complexity of damper control scheme and operational issues involved. Instead, 100% treatment of the flue gas has been considered with required level of SO<sub>2</sub> emission in treated gas to be achieved by the FGD supplier as per his optimization for height of the absorber, limestone slurry feed etc.

However, in case for applicable emission norms of 600 mg/Nm<sup>3</sup>, the purchaser intends to adopt FGD scheme with partial bypass with/ without GGH as per his own assessment, the standard specification shall need to be modified for incorporation of relevant changes as required to this effect.

iv) Gas to gas heat exchanger (GGH)

The use of gas to gas heat exchanger (GGH) in FGD system has got both merits and demerits. The GGH has advantage of reducing the temperature of inlet raw flue gas to the absorber which reduces potential of damage to scrubber internals in case of flue gas excursion and mal-operation etc. Reheating of treated flue gas helps in preventing stack condensation and also increases the buoyancy of flue gas exiting from the chimney resulting in dispersion of pollutants over a wider area and consequently reduced ground level concentration of pollutants. However, GGH requires additional space, results in additional pressure drop, leakage issues apart from adding to the cost. Even with GGH, chimney flue(s) may require additional protection by way of lining or resistive painting. The standard specification has been drawn without GGH.



However, in case the purchaser intends to provide for GGH in the FGD system as per his own assessment, the standard specification shall need to be modified for incorporation of relevant changes as required to this effect.

v) New wet chimney & suggested height:

a) The thermal power plant provided with FGD requires a wet chimney of height smaller than that envisaged prior to MoEF&CC's December 2015 notification. However, the chimney required is to be of wet type with acid resistant lining for the flue(s). The retrofit of FGD in an existing plant would require the existing chimney flue(s) to be provided with acid resistant lining which requires a plant shutdown period of about 5- 6 months. Considering the aspect of huge generation loss associated with this and also huge cost of lining, construction of a new chimney of adequate height, which can be constructed in parallel to FGD, has been considered in this specification. With this, plant shutdown of only about one month or so shall be required for interconnection with FGD system, thus avoiding on huge generation loss.

However, in case the purchaser does not intend to go for a new chimney and decides to use the existing chimney as per his own assessment, the standard specification shall need to be modified for incorporation of relevant changes as required to this effect.

b) For a thermal power plant fitted with FGD, the required height of the chimney is governed by quantum of SO<sub>2</sub> being emitted from the chimney. Vide draft notification dated 16.10.2017, MoEF&CC has specified stack height for thermal power plants with FGD installation for public comments. The stack height required to be provided is indicated as below:

<u>Power generation capacity:</u>	<u>Stack height:</u>
- 100 MW and above	$H=6.902(Q \times 0.277)^{0.555}$ or 100 m whichever is more
- Less than 100 MW	$H=6.902(Q \times 0.277)^{0.555}$ or 30 m whichever is more;

Q = Emission rate of SO<sub>2</sub> in kg/hr  
H = Physical stack height in meter.

Final stipulation on requirement of chimney height is yet to be notified.





Considering that permissible levels of SO<sub>2</sub> emission varies as per unit size/ vintage and that number of units connected to a chimney vary on case to case basis, the calculated height of the chimney does not follow a gradual pattern w.r.t. unit size. Further, chimney height should not be less than boiler height. Based on overall consideration of various factors involved, the suggested appropriate height of the chimney for different size of units installed up to 31.12.2016 is as below:

Unit size	No. of units connected to the chimney	
	1	2
	Suggested height of wet chimney (m)*	
< 250 MW	100	125
≥ 250 MW and < 500 MW	125	150
≥ 500 MW	150	150

The suggested appropriate height of the chimney for different size of units installed from 1.1.2017 is as below:

Unit size	No. of units connected to the chimney	
	1	2
	Suggested height of wet chimney (m)*	
< 250 MW	100	100
≥ 250 MW and < 500 MW	125	125
≥ 500 MW	150	150

\*purchaser is required to check & review for adequacy of indicated chimney height as per final notification of MoEF&CC and accordingly incorporate in the standard specification.

- vi) The provision for complete bypass of FGD system with use of isolation dampers for power plant to operate through existing chimney during unit start-up with oil firing or during any exigency has been considered in this specification.
- vii) The installation of wet limestone FGD system will require space near existing chimney for scrubbers, limestone recirculation pumps, oxidation air blowers, instrument air compressor and new wet chimney, space in plant area for receiving & storage of limestone, space for limestone slurry preparation, and space for gypsum dewatering, handling, storage. The



layout of the FGD system for retrofit in the existing plant shall have to be developed and optimized by the bidder as per pockets of areas available at site and in consultation with the purchaser including for relocation of some plant facilities, if required.

- viii) Various inputs will need to be provided by the purchaser to the contractor for installation of FGD and its interconnection/ integration with the existing power plant. These will vary from plant to plant on case to case basis. The purchaser shall make proper assessment of these requirements and appropriately incorporate in the specification.
- ix) The FGD system and new wet chimney shall be constructed within the scheduled time without affecting operation of the existing plant/ units. The plant shutdown will be taken only for interconnection of the FGD system as per quoted/ mutually agreed period for the same in the contract. The bidder shall properly plan and ensure that the work of structural/ mechanical/ electrical/ C&I interconnection with the existing plant systems is completed within the scheduled shutdown period. In case time taken is more, liquidated damages shall be applicable for each day of delay as indicated elsewhere in the specification.
- x) Auxiliary power consumption, limestone consumption and shut down period for FGD interconnection have been included under Category- I guarantees and SO<sub>2</sub> emission in exit flue gas has been included under Category- II guarantees. Typical liquidated damages (LD) values have been specified for Category- I guarantees. These need to be specified as per relevant inputs applicable on case to case basis. Further, bid evaluation factors for items of category-I guarantees are suggested to be kept such that LD value is at least 1.5 times the respective bid evaluation factor.
- xi) Limestone supply and crushers:  
  
The basic FGD scheme is as per limestone supply of size (-) 250 mm to the plant. In case crushed limestone of size (-) 25 mm is supplied, the limestone crushers shall not be required to be provided and limestone conveyors after pent house shall be directly led to limestone bulk storage silos. Further, the specification indicates the purity of gypsum to be produced from dewatering system as minimum 90% subject to purity of available limestone. The aspect of limestone supply, its composition including purity needs to be firmed up by the purchaser and incorporated in the standard specification.
- xii) Mode of limestone receipt:  
  
The basic FGD scheme is for receipt of limestone at power plant is by road trucks. The alternative mode of receipt of limestone by rail may also



be selected by the purchaser based on his own consideration of relevant factors viz. large requirement of limestone, feasibility of modifications in existing plant for limestone unloading, transfer & storage etc. and necessary changes to this effect shall be appropriately incorporate in the standard specification.

xiii) Gypsum Storage:

The specification envisages collection of gypsum cake from discharge of vacuum belt filters into the storage area of 5 days capacity on ground floor beneath the floor of filters for further transportation by trucks. The alternative for collection and transportation of gypsum cake by conveyor belts to a separate storage building in the plant for further transportation by trucks has also been included in the specification.

The option for location of gypsum storage area in the plant needs to be firmed by the purchaser and incorporated in the standard specification considering relevant aspects such as quantum of gypsum likely to be produced, storage area required, space availability as per plant layout, transportation for utilization/ disposal of gypsum.

xiv) Absorber lining material:

The clause 4.3.1 (vii) specifies the absorber tower, oxidation tank, absorber internals & other parts, absorber outlet duct to be provided with minimum 2 mm thick lining/ cladding of SS 317 LMN / Alloy 31/ Hastelloy C22/ C 59/ C276 or equivalent. The purchaser, as per his own assessment and considerations, may decide to go in for other applicable materials also such as rubber lining (minimum 4 mm thick), flake glass lining (minimum 3 mm thick). In such case, necessary changes shall need to be incorporated in the relevant sections of the standard specification.

xv) Chimney lining material:

The clause 4.20 (i) specifies the chimney flue liner cladding to be made of 2 mm thick Titanium (Grade 2 as per ASME SB265) or C-276 alloy over 8 mm thick (minimum) mild steel base metal of flue liner. The purchaser, as per his own assessment and considerations, may decide to go in for other applicable materials also such as C22 alloy, Borosilicate Block lining. In such case, necessary changes shall need to be incorporated in the relevant sections of the standard specification.

xvi) 220 V DC supply system:

The specification envisages 220 V DC supply system to meet 220 V DC load requirement of the FGD system. In case DC feeders with sufficient capacity are available in the existing DC system of the plant, the same can be used for FGD system and no separate DC system need to be



provided for the FGD system. This needs to be checked and firmed up by the purchaser and incorporated in the relevant part of the standard specification.

## 1.2 APPLICABILITY

This standard technical specification for retrofit of FGD system has been prepared considering a thermal power plant comprising of 2x500 MW units installed prior to 1st January, 2017 for which notified SO<sub>2</sub> emission limit is 200 mg/Nm<sup>3</sup>. The document covers only technical part of the specification in a comprehensive manner as described herewith in nine (9) sections. The specification can be made applicable for other power plants also having different size & number of units and different notified SO<sub>2</sub> emission limit making suitable corrections for indicated technical parameters and other aspects as felt necessary by the purchaser.

## 1.3 BRIEF DETAILS ABOUT POWER PLANT

### i) Site Data

1	Project Name & Address	---
2	Owner	---
3	Project Location	District ---, ---State
4	Longitude	---- E
5	Latitude	---" N
6	Nearest Railway Station	---and is at a distance of --- km
7	Nearest Villages	---
8	Nearest Town	---
9	Nearest City	---
10	Nearest Port	--- Port Trust (--- km)
11	Nearest Air Port	---, --- km
12	Access Road	State Highway connecting NH--- to--- town
13	Altitude	Proposed Finished Ground Level (FGL) is --- m above mean sea level.
14	Seismic data	As per IS: 1893-2002
	(a) Seismic intensity	---
	(b) Zone	---
	(c) Importance factor	---
15	Ambient Temperature	
	(a) Max Dry bulb Temp.	---°C
	(b) Highest Monthly mean of daily max temperature	---°C
	(c) Design Ambient Air temperature for electrical equipment	---°C



16	Design relative humidity	....%
17	Wind Data	.....
		.....
		.....

ii) **Coal**

M/s --- has received firm linkage of --- million tonnes of coal per annum from ---mines of --- coalfields of M/s ---.

iii) **Water**

The ---thermal power plant has allocation of --- m<sup>3</sup>/h of water from ----- river/canal/reservoir of ---state for meeting the fresh water requirement of plant.

**1.4 METEOROLOGICAL DATA <sup>1</sup>**

Detailed Meteorological Data for the site and the wind directions are given in enclosed Exhibits.

**1.5 SALIENT TECHNICAL DATA OF EXISTING POWER PLANT <sup>2</sup>**

Salient Technical parameters of Plant/ equipment, typical characteristics of fuel, flue gas and water provided at ---- TPS and limestone to be used for FGD plant are given below for the information of the bidder:

i) Plant data

a) Boiler

Make : BHEL,  
 Type : Pulverised coal fired,  
 Balanced draft, Dry bottom  
 BMCR : 1590 t/hr,  
 Steam pressure at SH outlet : 179 kg/cm<sup>2</sup>  
 Steam temperature at SH outlet: 540<sup>o</sup>C  
 Steam temperature at RH outlet: 568<sup>o</sup>C

b) Steam Turbine

Make : BHEL, KWU Design  
 TMCR : 500 MW  
 Max. load under VWO : 525 MW  
 Main steam parameters : pressure 170 kg/cm<sup>2</sup>  
 Temperature 537<sup>o</sup>C/565<sup>o</sup>C

<sup>1</sup> To be provided by purchaser

<sup>2</sup> To be provided by purchaser



c) Electrostatic Precipitator

Make	:	BHEL
Efficiency	:	99.91 %
No. of gas paths/boiler	:	4
No. of fields/gas pass	:	8
Outlet SPM emission	:	< 100 mg/Nm <sup>3</sup>

ii) Fuel

a) Coal Analysis

Sl. No.	Description	Symbol	Normal Coal	Worst Coal	Best Coal
<b>A.</b>	<b>Proximate Analysis(As received basis)</b>				
1.	Total moisture	%	15.00	16.00	14.10
2.	Ash	%	37.40	45.70	26.40
3.	Volatile matter	%	19.10	18.80	21.30
4.	Fixed carbon	%	28.50	19.50	38.20
<b>B.</b>	<b>Ultimate Analysis(As received basis)</b>				
1.	Carbon	C%	36.80	28.67	45.88
2.	Hydrogen	H <sub>2</sub> %	3.24	3.05	4.09
3.	Nitrogen	N <sub>2</sub> %	0.48	0.45	0.54
4.	Oxygen (By difference)	O <sub>2</sub> %	5.85	5.38	8.42
5.	Sulphur	S%	0.45	0.49	0.4
6.	Carbonates	CO <sub>3</sub> %	0.30	0.21	0.10
7.	Phosphorous	P <sub>2</sub> %	0.28	0.03	0.09
8.	Total Moisture	H <sub>2</sub> O%	15.00	16.00	14.00
9.	Ash	%	37.40	45.70	26.40
10.	Gross Calorific Value	kcal/kg	3900	3300	4900

b) Heavy Fuel Oil (HFO) Specification- used for startup/low load only

Standard	IS -1593/1971 Grade HV/LSHS
Flash Point minimum, (Pansky-Martens closed cup)	66 °C
Viscosity maximum	370 CST at 50°C
Total sulphur maximum	4.5 % by weight
Gross heating value	10,000 kcal/kg.

c) Light Diesel Oil (LDO) Specification- used for startup/low load only

Standard	IS 1460/1974 Grade LDO
Flash point minimum (Pensky Martens closed cup)	66°C
Viscosity maximum	15.7 CST at 38°C
Total sulphur maximum	1.8 % by weight
Gross heating value	10300kcal/kg.



iii) Water

The raw, cooling, cooling and DM water analysis are given at Annexure-I to IV respectively of the specification.

iv) Limestone

Lime stone is being procured from ...mines of size..... and shall be brought to plant by trucks. The analysis is given at Annexure-V of the specification.

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## SECTION 2.0

### GENERAL

#### 2.1 INTENT OF SPECIFICATION

2.1.1 This specification is intended to cover the design, engineering, manufacture, procurement, inspection and testing at manufacturer's works, supply, packing and delivery at project site, unloading & storage at site, in-plant transportation and handling at site, fabrication, erection, interconnection with existing units, pre-commissioning, testing, successful commissioning, performance testing and handing over of complete wet limestone based FGD system together with a wet flue chimney including electrical and C&I systems for 2x500MW coal fired thermal units of ..... TPS of M/s ..... along with all auxiliaries & accessories, special tools & tackles, mandatory spare parts and associated civil works as specified herein.

2.1.2 Scope of the proposal shall cover following activities and services in respect of all the equipment and works specified in various sections of this specification:

- i) Basic Engineering of all equipment and equipment systems;
- ii) Detailed design of all the equipment and equipment system(s) including civil works;
- iii) Providing engineering drawings, data, instruction manuals, as built drawings and other information for purchaser's review, approval and records;
- iv) Compliance with statutory requirements and provide support to purchaser for obtaining clearances from statutory authorities, wherever required;
- v) Complete manufacturing including shop testing;
- vi) Packing and transportation from the manufacturer's works to the site including customs clearance, port charges, if any;
- vii) Receipt, movement to proper storage, storage, preservation and conservation of equipment at the site, movement from storage area to interim/ final foundation location;
- viii) Fabrication, pre-assembly, if any, erection, testing, pre-commissioning and commissioning and putting into satisfactory operation all the equipment including successful completion of initial operation;
- ix) Performance guarantee/acceptance tests within a period of one month after successful completion of initial operation;





- x) Guaranteeing equipment performance for a period of 12 months from the date of commercial operation;
- xi) Supply of mandatory spares as per specified list and recommended spares for three years of normal operation on FOR site basis;
- xii) Supply of any other equipment including special tools and tackles, commissioning spares and services required for satisfactory completion of the project and operation and maintenance of the same;
- xiii) Training of purchaser's personnel nominated by the purchaser during erection, testing and commissioning, and for operation and maintenance;
- xiv) Reconciliation with customs authorities, in case of imported equipment;
- xv) Satisfactory conclusion of the contract;
- xvi) All items and equipment though not specifically mentioned in the specification, but needed to complete the system to meet the intent of the specification shall be deemed to be included in the scope of the bidder.

2.1.3 The bidder's scope shall also include dismantling of existing facilities/structures, where so required and their relocation at new area to be indicated by the Purchaser, rerouting of over ground and underground pipes, cables, ducts, etc. as necessary for erection and commissioning of FGD plant. Bidders are advised to visit site to see the space earmarked for FGD installation and make a personal assessment of the facilities/structures required to be shifted and confirm explicitly in the bid that they have, personally or through their representative, assessed all such works required and cost estimates for all such works have been included in the bid price. The Purchaser shall provide to the bidder the drawings etc. of the existing underground structures/ facilities as available with him.

2.1.4 It is not the intent to completely specify all details of design and construction, but only to lay down broad sizing and quality criteria for the major equipment and systems and it is expected that the equipment shall conform in all respects to high standards of engineering, design and workmanship and shall be capable of performing in continuous commercial operation up to the contractor's guarantee in a specified manner acceptable to the purchaser.

## 2.2 TYPICAL BRIEF DESCRIPTION OF THE EXISTING FLUE GAS PATH <sup>3</sup>

Dust laden flue gases from second pass of the boiler are divided into two paths to enter 2x60% capacity rotary regenerative air pre-heaters wherein heat of the flue gases is transferred to primary and secondary combustion air. Flue

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<sup>3</sup> To be provided by the purchaser



gases then enter 2x60% capacity Electrostatic Precipitators (ESPs). The outlet of ESPs is connected to respective I.D. fans and then exhausted through chimney. The ESPs are designed for an efficiency of 99.91% and to maintain 150 mg/Nm<sup>3</sup> of dust emission at ESP outlet when firing worst coal and one of the field being out of operation

The flue gas ducts are divided into two independent streams. However, interconnection with isolating dampers are provided at the inlet and outlet of major important equipment i.e. air pre-heaters, ESPs, ID Fans, to ensure flexibility of operation with any one of the equipment being out of service. Each of the equipment on flue gas path i.e. APH, ESP, ID fan is provided with isolating dampers at its inlet and outlet for on line maintenance. The vendor is expected to maintain similar uniformity in all aspects of the duct work in his scope.

### 2.3 TYPICAL BRIEF DESCRIPTION OF EXISTING CHIMNEY <sup>4</sup>

The twin flue chimney is of 275 m height in RCC construction. The flues inside the RCC chimney are fabricated from structural steel conforming to Grade E250 (Fe410W), quality A (semi killed) of IS:2062 from rolled steel members and plates. Stainless steel used for the top portion of flue conforms to AISI type 304L. Each flue is of hung type (i.e. of tension type) suspended from support floors with expansion joints above support floor.

The rectangular cross section duct is connected to flue inside the chimney by means of bolted flange connections. The duct is supported on steel frame inside and outside the chimney shell. The duct is fabricated out of steel of grade E250 (410W) quality (killed).

### 2.4 DESIGN AND GUARANTEE CONDITIONS <sup>5</sup>

- 2.4.1 i) The FGD plant for each unit of 2x500 MW thermal power station shall be designed to comply with the requirements/ conditions as indicated below:

Sl. No.	Description	Guarantee point	Design point
1.	Boiler load	100% TMCR load	BMCR
2.	Type of coal	Worst coal	Worst coal
3.	Ambient air condition	27°C, 60% RH	45°C, 60% RH
4.	Coal flow	360 t/h	390 t/h
5.	Sulphur content in coal	0.5%	0.5%
6.	Flue gas flow at FGD inlet	2,000,000 Nm <sup>3</sup> /h (wet)	2,200,000 Nm <sup>3</sup> /h (wet)
7.	SO <sub>2</sub> concentration in flue gas at FGD inlet	1800 mg/Nm <sup>3</sup> (wet)	1800 mg/Nm <sup>3</sup> (wet)

<sup>4</sup> To be provided by the purchaser

<sup>5</sup> To be provided by the purchaser



Standard Technical Specification for Retrofit of Wet Limestone Based Flue Gas Desulphurisation (FGD) System in a Typical 2x500 MW Thermal Power Plant  
Section- 2 (General)

8.	Dust concentration in flue gas at FGD inlet	100 mg/Nm <sup>3</sup> (wet)	200 mg/Nm <sup>3</sup> (wet)
9.	Flue gas temperature at FGD inlet	125 <sup>0</sup> C	145 <sup>0</sup> C
10.	Flue gas pressure at FGD inlet, mmwc	10 mmwc	10 mmwc
11.	SO <sub>2</sub> concentration in flue gas at FGD outlet	150 mg/Nm <sup>3</sup> (6% O <sub>2</sub> , dry basis)	150 mg/Nm <sup>3</sup> (6% O <sub>2</sub> , dry basis)
12.	Minimum SO <sub>2</sub> removal efficiency	92 %	92 %

Note: Nm<sup>3</sup> refers to condition 101.325 kPa pressure & 273.15 K temperature.

- ii) The flue gas analysis at FGD inlet (ID fan outlet) shall be considered as below:

Sl. No.	Parameter	Unit	Guarantee Point	Design Point
			100% TMCR load	BMCR
1.	CO <sub>2</sub>	% v/v wet	9.87	9.54
2.	O <sub>2</sub>	% v/v wet	6.26	6.04
3.	SO <sub>2</sub>	% v/v wet	0.063	0.061
4.	N <sub>2</sub>	% v/v wet	70.96	68.56
5.	H <sub>2</sub> O	% v/v wet	12.82	15.77
6.	Inlet SO <sub>2</sub>	mg/Nm <sup>3</sup> -wet	1800	1800
7.	SO <sub>3</sub>	ppm	10.5	10.20
8.	HCL	ppm-wet	45	45
9.	HF	ppm-wet	12	12
11	NO <sub>x</sub>	mg/Nm <sup>3</sup>	750 mg/Nm <sup>3</sup>	750 mg/Nm <sup>3</sup>

- 2.4.2 Bidder shall also guarantee that maximum concentration of SO<sub>2</sub> in treated flue gas at the exit of FGD for each unit shall not exceed 150 mg/Nm<sup>3</sup> (6% O<sub>2</sub>, dry basis) under all operating conditions of the plant in the load range 50% TMCR to 100% TMCR.

## 2.5 GENERAL DESIGN REQUIREMENTS

- i) The Flue Gas Desulphurisation (FGD) System shall be designed to meet all the guaranteed parameters that are required to be satisfied as given in Cl. No 2.13 of the specification.
- ii) The complete FGD system and the associated auxiliaries shall be designed by the standard industrial practices. The FGD system shall be designed to achieve the required SO<sub>2</sub> capture without the use of oxalic acid or any other additives.
- iii) Justification of Proposed Design- The Contractor shall also furnish along with his offer the detailed calculations and data to establish as to how he will meet the performance requirements at specified guarantee point.



- iv) The Bidder shall submit with the offer, comprehensive information on how the L/G ratio, mass balance, spray nozzle cone angle, spray nozzle arrangement, limestone consumption etc. as applicable for the proposed design have been arrived at. The Contractor shall also submit along with the offer, a detailed write up on the proposed design features and control philosophy at varying loads to achieve the desired level/ efficiency of SO<sub>2</sub> removal.
- v) The FGD plant shall be designed for a service life of minimum twenty five (25) years.
- vi) Adequate margins shall be considered in design capacity and head of the pumps and fans over and above the maximum duty conditions in addition to increase in frictional losses over a period of 25 years and 5% fall in the frequency of electric supply.
- vii) Stable capacity/head rising characteristics shall be provided for the pumps and the shut off head shall be minimum 20% over the rated head.
- viii) All pressure vessels shall conform to requirements of IS 2825 or ASME Section VIII. The minimum thickness of pressure vessels shall, however, be 6 mm.
- ix) The design pressure of pressure vessels shall be equal to the algebraic sum of the maximum total head encountered in H.Q. characteristic of the preceding pump stage and the total suction head of the same pump plus 5% margin.
- x) For unlined pressure vessels 2-mm corrosion allowance is to be made. Also 2-mm mill tolerance shall be made for all dished ends.
- xi) For tanks coming in contact with corrosive fluids, no corrosion allowance is required but should be rubber lined at least 5mm thick or flake glass lined with minimum 3 mm thickness as per proven experience of the supplier, unless otherwise specified elsewhere. Rubber lining of vessels shall be as per IS: 4682 (Part I).
- xii) All steel pipelines unless otherwise specified elsewhere carrying corrosive fluids should be rubber lined inside to a thickness of at least 5 mm. FRP material may be considered for smaller diameter pipes where lining is not feasible.
- xiii) All pumps shall have discharge pressure gauges (with isolating valves) suitable to handle the particular fluid for which they are intended for.
- xiv) All centrifugal pumps shall have suction and discharge gate/ butterfly valves, and check valves on the discharge side unless otherwise stated.
- xv) All tanks and sumps handling slurry shall be provided with adequate number of agitators.
- xvi) Sampling connections, as required, shall be provided at different stages of the FGD plant.
- xvii) All valves which a normal person cannot operate standing on the floor should be provided with chain operation.



- xviii) The water velocities in pressure lines shall not exceed 2.4 m/sec. and pump suction line velocities shall not exceed 1.0 m/sec. except otherwise specified elsewhere in this specification.
- xix) The maximum temperature of ambient air for the purpose of designing the capacities of fans and motors shall be taken as 50degC.
- xx) All metallic valves coming in contact with corrosive fluids shall be rubber lined metallic valves or of proven material suitable for the duty involved.
- xxi) The contractor shall supply all essential instrumentation and other accessories required for satisfactory and reliable performance of the FGD plant.
- xxii) Wherever motors are specified to be TEFC weather proof or TEFC weather protected, it shall mean that they will be TEFC suitable for outdoor installations. All motors shall comply with specific technical requirements given in this specification.
- xxiii) All instruments shall be provided with isolating globe/needle valves (foot valves) of suitable material.
- xxiv) Wherever applicable, all level gauges, shall be provided with isolating and drain valves.
- xxv) The size of overflow pipes of all storage tanks shall be one size higher than inlet pipe sizes of these tanks.
- xxvi) For buried pipelines, three (3) coats of heavy duty bituminastic paint shall be applied on the cleaned surface. Finally, it shall be wrapped with minimum 3 mm thick bitumen impregnated tar-felt. The lap joint of the felt should be touched with paint.
- xxvii) Heavy duty hume pipes of adequate size shall be provided for road crossing etc. of the buried pipe lines.
- xxviii) Pipelines at interface terminal points shall be provided with blank flange arrangement, unless otherwise specified.
- xxix) Recirculation lines shall be provided for each centrifugal pump, unless otherwise specified.
- xxx) Each equipment/motor shall be earthed with two Nos. distinct and independent earthing electrodes.
- xxxi) Construction Material and Internal anticorrosive Protection:
  - a) In general, the material selection is the Bidder's responsibility, but the quality of material for pressure vessels, piping, etc., however, must meet the requirements of the relevant IS/ASME standards. The Bidder shall specify in his bid the material quality and the standards applied to each equipment, piping system, etc.
  - b) Suitable corrosion and erosion allowances shall be provided commensurate with service conditions of the equipment. The corrosion allowances shall be determined by the Bidder on the basis of his experience/standard practice. Corrosion allowances considered for various equipment and piping system etc. shall be indicated in the bid. Similar data shall be given for erosion allowances.



- c) Where necessary, an internal anticorrosive protection based on the Bidder's proven experience shall be applied. Bidder shall include a comprehensive list of anticorrosion protection including equipment on which respective corrosion protection has been provided. Reference information on the application, reliability and suitability of the proposed anticorrosion protection as per the equipment supplied by the bidder and operating successfully for a long period shall also be furnished. Life of anti-corrosion protection, necessary repairs required, their frequency and time demands shall also be indicated.
- xxxiii) The annual maintenance period and capital maintenance frequency of the FGD plant shall match with those of the units which is given here under <sup>6</sup> and will not call for any extension of the maintenance and repair period:
- Annual maintenance period of the Units: 15 days
  - Capital maintenance period of the Units: 45 days (every 5 years)

## 2.6 OPERATIONAL PERFORMANCE REQUIREMENTS

- i) The FGD plant for each unit shall be designed to achieve minimum 92% (to be provided by Purchaser) SO<sub>2</sub> removal efficiency at all operating conditions from 50% to 100% of Unit MCR.
- ii) The FGD plant shall be capable of base load operation at minimum 95% availability. The bidder shall also furnish details of availability records in plants stated in his experience list.
- iii) System shall be capable of safe shut down in case of unit tripping and/or station black out. Customer shall try to provide emergency AC supply for FGD system from station emergency AC supply. However, if in case it is not feasible to do so, bidder may be required to include emergency AC supply for FGD equipment needing such supply in case of unit tripping /station black out in his scope and shall have to provide DG sets of adequate capacity. Bidder may indicate price for providing emergency AC supply separately in the price bid.
- iv) The normal flue gas temperature at inlet to FGD shall be about 120-135°C. However, in case of APH failure the flue gas temperature may rise to about 250°C for 15 minutes and the FGD system shall be designed to suitably withstand such operation without any damage to the system. All duct work/duct lining, dampers etc. shall be designed to withstand above temperature conditions.
- v) The provision shall be made for complete bypass of FGD system during unit start-up with oil firing (LDO)/ HFO) or during any plant operational exigency with use of isolation dampers to enable power plant operation through existing chimney.

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<sup>6</sup> To be provided by the purchaser



- vi) In order to be compatible for operation in conjunction with existing units, the design of the plant must guarantee a rapid availability during start-up, a fine and favorable characteristic during load changes and are reliable and stable mode of continuous operation at conditions encountered during the power plant operation.
- vii) The FGD plant shall be suited to an unlimited operation at any load point between the minimum and maximum load point being guaranteed. The plant shall be capable of being put into service (both warm and cold start-up) without the necessity of extensive and unusual activities or preparations.
- viii) The FGD plant shall be able to handle the load imposed on the FGD plant by the boiler, including rate of load changes, minimum load and the anticipated daily and annual load schedules. Furthermore, the FGD plant shall be able to be put in operation, while the boiler is in operation at any load, without any disturbance in the operation of the Units.
- xiv) The operation and supervision of the FGD plants and the ancillary facilities shall be carried out fully automatically by its own dedicated PLC system. When necessary, it shall be possible for the control room staff to intervene and control the plant. Start-up and shut-down procedures shall be possible by means of semi-automatic operations which shall be released and supervised by the control room.
- xv) In case of a failure of an item of equipment (e.g. pumps, etc.) the stand-by unit has to be activated and put into service automatically without delay and without interruption of the plant operation and audio-visual alarm to such effect shall be provided in the control room.
- xvi) In case of a power failure, all items of equipment which could possibly suffer irreversible damage shall be connected to the emergency power supply.
- xvii) In case of failure of the boiler and ancillary equipment, the associated FGD plant shall be brought automatically to the off-load operation without restriction by the current loading.
- xviii) In case of shutdown and outage periods of the plant, drains and flushings of respective items of equipment which require such a treatment e.g. lime slurry preparation and supply, pipes, binds, etc. shall be possible without restriction and without necessity of extensive or unusual preparation and activity. Drains and flushings required even during short time outages or an emergency shut-down shall be started automatically and by remote control. This requirement shall be applicable to limestone slurry and gypsum slurry pipe work and all other items being in contact with lime stone or gypsum slurry in any case. Acid flushing equipment shall also be provided if necessary for flushing these items of equipment. The system shall be complete with storage tank, pumps, pipe work, fittings, etc. The system shall work automatically, locally activated by a local control unit.



- xix) All items of equipment which are known to be subject to wearing, abrasion or failure (e.g. nozzles, pumps, pipe work etc.) and thereby affecting availability of FGD plant shall be designed and installed so as to facilitate easy replacement, repair and maintenance, even if installed redundantly.

## 2.7 LAYOUT REQUIREMENTS

The Contractor shall offer the optimum design and layout to accommodate the flue gas system, absorber system, limestone handling & storage system and gypsum handling & storage system and a new wet flue chimney within the confines of the space available.

The absorber and its auxiliaries and wet stack shall preferably be located around/ near the existing chimney. Bulk limestone storage (covered shed) shall be provided at a suitable location within the plant boundary from where limestone shall be transported to limestone crushing area by dumper/ trucks. The limestone grinding, slurry preparation and storage system shall be housed together. Gypsum dewatering, gypsum storage and effluent treatment plant shall be housed in multi story building at a suitable location nearest to the absorber. Gypsum storage area shall preferably be provided on ground floor, below the vacuum belt filters, for easy Gypsum handling and transportation.

The general layout requirements are as under:

- i) Proper approach shall be provided for access to all equipment during normal operation and maintenance. Unless otherwise specified, platforms, staircase and ladders shall follow the stipulations specified elsewhere in this specification.
- ii) Equipment requiring monitoring during regular operation shall be approachable from the ground floor through staircase. Staircase with minimum width of 1200 mm shall be provided for approach to elevated structures at 5m height from the nearest platform. Below this height a vertical ladder with minimum clear width of 600 mm may also be acceptable.
- iii) Platform with a minimum clear width of 1000 mm shall be provided all around the lowest absorber spray levels and mist eliminators. Similar platforms shall be provided at subsequent elevations if they are more than 3000 mm apart from each other. An adequately sized manhole with platform shall be provided above each spray level. Ladders/staircase shall be provided for the access to the platform.
- iv) The absorber slurry recirculation pumps (for spray tower systems), gypsum bleed pumps and limestone feed pumps shall be mounted on the ground level. Suitable approach and platforms shall be provided for all the valves required during regular operation.





- v) Adequate working space shall be provided around all operating equipment and drives.
- vi) Platform with a minimum width of 1200 mm shall be provided all around the mills and feeders. Approach along with suitable platforms shall be provided for ball loading hoppers.
- vii) A 1000 mm wide platform with suitable approach shall be provided around each hydro-cyclone.
- viii) A 2000 mm wide floor/platform shall be provided all around each belt filter.
- ix) The Contractor shall provide adequate handling facility with motorized hoist, runway beams etc. for handling/ maintenance of heavy components. Motorized hoists shall be provided for handling all components exceeding 500 kg.
- x) The regular basement and local pits/trenches etc. shall be avoided as far as possible.
- xi) Handling arrangement of milling system, Booster fans, Slurry recirculation pumps, oxidation blower, belt feeder system etc. complete with crane/ monorail along with removal space for maintenance shall be provided by the Contractor.
- xii) Approach for removal of equipment for maintenance shall be provided.
- xiii) All other safety requirements as per the CEA Regulation, Factories Act, Indian Electricity Rules and other applicable codes/standards etc. shall be complied with while developing Layout.
- xiv) Cable trenches/slits, if unavoidable, shall be provided with adequate cushioning of sand and the same shall be covered with PCC.
- xv) Each Equipment room shall be provided with alternate exits in case of fire/ accidents as per requirements of Factories Act and Statutory bodies/ insurance companies.
- xvi) Minimum Headroom (free height) under all floors, ducts, walkways and stairs shall be 2 m.
- xvii) Inter-connecting pipes/cables between various facilities of FGD plant shall be routed on the steel trestles. The clear head room for the same shall be minimum 8 m.
- xviii) In case of any specific space constraint at site, the layout, clearance, approach etc. shall be mutually agreed and subject to approval of the purchaser.



## 2.8 GENERAL TECHNICAL REQUIREMENTS

- 2.8.1 All equipment, systems and works covered under these specifications shall be in accordance with all the latest applicable statutes, regulations, codes and standards specified as well as all such standards, statutes, regulations and safety codes applicable in the locality where the equipment will be installed. Bidders may familiarize themselves with all such requirements before preparation of bids. FGD plant design including piping, valves and fittings shall completely meet or exceed all the requirements of the latest versions of Indian Standards/ASME codes. In all other cases where IS/ASME does not govern, Japanese, American, British, German or other international standards established to be equivalent or superior to IS/ASME shall be acceptable with the approval of the purchaser at the time of detailed engineering. In the event of any conflict between the requirements of equivalent codes and standards, and the requirements of IS/ASME code, the latter shall govern unless specified elsewhere in the specifications.
- 2.8.2 The responsibility of safe, efficient and reliable operation of the equipment and system supplied shall rest on the supplier and the approval of the drawings/documents shall not in any way relieve the manufacturer of this and obligation to meet all the requirements stipulated in the specification or of the responsibility for correctness of the drawings/documents.
- 2.8.3 It will be the responsibility of the contractor to furnish the requisite documentation as required by the Purchaser/Consultant for ascertaining the adequacy of the design/ soundness of the materials of construction/manufacturing methods adopted etc.
- 2.8.4 The wet limestone FGD system offered by the bidder shall be in line with the specified scheme of FGD process. However, minor variations are permissible for optimization of the process based on bidder's experience. These variations shall, however, not change the basic essence or configuration of the process specified. Specific advantages of such variations shall be indicated by the bidder in his bid. All modifications/variations proposed from the process specified shall be subject to approval from the purchaser. Description of the process which has been offered by the Bidder must be submitted in detail indicating clearly the function of each equipment.
- 2.8.5 The materials of construction for all exposed metal/ concrete surfaces shall be so chosen as to withstand the prevailing environment at plant site. Also suitable weather protection shall be provided to all exposed surfaces as required. The equipment and the auxiliaries shall be designed for maximum reliability and availability; operability and maintainability. The bidder shall specifically state the design features incorporated to achieve the high degree of reliability and availability.



- 2.8.6 Adequate maintenance facilities shall be provided as required, for assembly, disassembly, handling during maintenance and alignment work of all important equipment and auxiliaries.
- 2.8.7 Complete thermal, mechanical and electrical functions of the station are to be remotely controlled from the unit control desk/ Panel (located in common control room) during normal as well as emergency operating conditions.
- 2.8.8 Wherever oil coolers of any equipment are provided, these shall be of 3x50% or 2x100% capacity to facilitate cleaning without shutting down the equipment. All coolers/jackets shall be designed to take care of the operating pressure of the cooling medium.
- 2.8.9 All stand-by auxiliaries shall be designed for auto start up, on failure of running auxiliaries with minimum time delay and without runback on unit load.
- 2.8.10 The bidder shall endeavor to supply the equipment (motors, valves, actuators, instruments etc.) of same type and make to the extent possible so as to reduce the spare parts inventory. However, this must not affect the functioning and operational reliability of the given equipment.
- 2.8.11 All the electric motor driven equipment shall give their rated performance even at a power supply frequency of 47.5 Hz (minimum). All equipment and auxiliaries shall be suitable for continuous operation in the frequency range of 47.5 Hz to 51.5 Hz.
- 2.8.12 The plant and its units shall be designed to operate with all the specified margins for continuous operation without any limitations under any of the conditions indicated in the Technical Specification.
- 2.8.13 All materials used for the construction of the equipment shall be new and shall be in accordance with the requirements of this specification. Materials utilised for various components shall be those which have established themselves for use in such applications. It would be the responsibility of the bidder to furnish the relevant information in this regard, as required, at the time of detailed engineering,
- 2.8.14 Equipment/works offered shall be designed for high availability, low maintenance and ease of maintenance. The Bidder shall specifically state the design features incorporated to achieve high degree of reliability/availability and ease of maintenance. The FGD plant shall be designed for minimum need for inspection. The time between inspection for absorber internals and major equipment shall correspond to capital overhaul period of units (once in 5 years). The FGD plant must operate without the replacement of the most important equipment and devices for 25 years at least. The quality of material, internal anticorrosion protection and whole performance must correspond to



this requirement. The bidder shall enumerate the special measures incorporated in the designs to meet these requirements. The following details on maintenance requirements for each major equipment shall be furnished:

- i) Maintenance requirements for the equipment given in hours per year.
- ii) Special methods used in maintenance and in performing repairs.
- iii) Recommended maintenance model and proposal of the organization of repairs.
- iv) Special aids and devices necessary for performing repairs and maintenance including stationary lifting devices or possibly other mechanisms necessary for vertical as well as horizontal transport of parts to be replaced.
- v) A brief description of main works, handling, transport, etc. performed during the plant operation and connected with maintenance performance.

2.8.15 Roller bearings provided on pumps, fans, air compressors, GGH, agitators and other equipment shall have a life of at least 10 years with maximum loading conditions. Journal bearings provided should have operational life equal to the life of the equipment

2.8.16 The bidder shall develop detailed layout drawings with his equipment sizes and confirm the adequacy of the space available for housing FGD equipment. Layout should facilitate access for operation, maintenance and inspection of any one or more equipment/components at a time, without disturbing the operation or installation of balance of plant. The offers not fitting into the space allocated for the purpose are liable to be rejected.

2.8.17 All heavy parts of the plant must be provided with some convenient arrangement for aligning and for handling during erection and overhaul. Any item of plant required to be stripped or lifted during period of maintenance and weighing one tons or more shall be marked with its approximate weight. All equipment shall be designed to run satisfactorily without any undue noise and vibrations. Corresponding parts throughout shall be made to gauge and shall be interchangeable wherever possible. No welding, filling or plugging of defective parts shall be allowed without the permission in writing of the purchaser.

2.8.18 Each main and auxiliary item of plant shall have permanently attached to it in a conspicuous position, a rating plate of non-corrosive material upon which shall be engraved manufacturer's name, equipment, type or serial number together with details of the ratings, service conditions under which the item of plant in question has been designed to operate, and such diagram plates as may be required by the Engineer. The inscriptions on the name plates as also the material and design of the name plates shall be approved by the Engineer.

2.8.19 The contractor shall intimate the purchaser in writing of any changes proposed in design, manufacturing methods or materials from those included or implied in his tender giving reasons, for purchaser's approval. The changes shall be



allowed only after written approval of the purchaser. The purchaser recognizes the importance of including the latest principles and design information in the final design of any plant.

2.8.20 The Bidder shall do everything to standardize the equipment as far as possible. It is recommended to use the equipment of the same type and of the same manufacturer, for example for pumps, valves, motors, etc. However, this must not affect the functioning and operational reliability of the given equipment. The equipment with same rating shall be of the same manufacturer so as to reduce spare parts inventory.

#### 2.8.21 **Process Safety**

- ii) The process proposed must be free of any danger for personnel handling the equipment, for related operations and for the surroundings. This requirement applies for normal operation as well as for starting up & shut down.
- iii) Automated protection as well as alarm systems must be installed at the places where emergency conditions could occur due to a failure. These systems must be "fail safe" i.e. they must be triggered in the case of an electric voltage or pressure air outage.

#### 2.8.22 **Valves, Drains etc.**

- i) All valves shall be suitable for the service conditions i.e. fluid flow, temperature and pressure under which they are required to operate and those performing similar duties shall be interchangeable with one another unless otherwise approved.
- ii) All gate valves shall be of the full way type unless otherwise approved and when in the full open position, the bore of the valve shall not be obstructed by any part of the gate. Globe valves shall have curved or spherical seating and the discs shall be free to revolve on the spindle.
- iii) All non-return valves shall have an arrow cast or embossed on the side of the valve body to indicate the direction of flow. For severe service conditions, cushioned check valves are preferred to obviate valve clatter. In case of the swing check valves, the body seat shall be inclined at such an angle to the vertical so as to facilitate closing and prevent clatter.
- iv) The internal diameter of all valve ends to be connected to pipes shall be the same as the internal diameter of the pipe to which they are joined so as to minimize use of reducers/expanders.
- v) Where applicable valves shall be of the outside screw and yoke type.
- vi) Wherever necessary, valves shall be fitted with indicators so that percentage of valve opening can be readily determined.



- vii) Manually operated valves shall be operable by a single man capable of exerting 35 kg force (max) at the valve. Wherever more force is required to operate the valve, gear mechanism shall be provided.
- viii) All sampling and root valves furnished shall be of integral body bonnet type.
- ix) Where necessary for the safe and efficient operation of the plant, valves shall be provided with both hand and actuator operating gear. The valves shall be complete in all respects including actuator and necessary limit switches, torque limit switch linkages etc.
- x) Each motorized valve shall be supplied with two sets of position operated adjustable limit switches each for open and close positions for signaling and interlocking. In addition, two numbers torque limit switches (one for fully open position and the other for fully closed position) shall be provided.
- xi) In case of regulating valves, provision shall also be made for suitable two numbers resistance position transmitters for remote position indication.
- xii) All gate and globe valves shall have bonnet-back seating arrangement to facilitate easy replacement of packing with the valves in service.
- xiii) All gate, globe and check valves shall be designed for reconditioning of seating surfaces and replacement of stem and disc without removing the valve body from the line.
- xiv) Wherever there is a provision for local control of valves, position indicator shall be readily visible from the operation position.
- xv) All valves and specialties shall bear tag numbers for identification.
- xvi) The scheme/arrangement of valves and fittings shall be such that it shall be possible to do the maintenance of the control/regulating valves and spare/standby equipment without shutting down the FGD plant. All the control valves in the system shall be of 2x100 % capacity with proper isolating valves upstream and downstream of control valve for maintenance. The valves located in the inaccessible positions shall be motorized even if not required functionally.
- xvii) Necessary drain lines with valves of adequate size for draining the system and to achieve low pressure loss and low noise level shall be provided. All the drain lines shall be led to the nearest waste water treatment plant. The air release valves shall be fitted with an inverted 'U' pipe on the outlet and drain piping to the nearest drain. All drain and air release valves shall be located in positions convenient for operation. No drain line shall be sized below 25 mm ID. All drain lines shall be provided with two isolating globe valves in series.



- 2.8.23 Hangers, anchors, guides, clamps, stops and supports, auxiliary structures etc. Required for the proper installation supports of the piping shall be provided.
- 2.8.24 The isolators and dampers provided in the gas ducts shall be 100% leak proof (zero leakage type) so as to completely isolate and permit the maintenance of FGD plant and accessories, with the unit in operation with FGD bypassed
- 2.8.25 Noise level should not be more than 85 dB at a distance of 1 meter and at a height of 1.5 meter from any equipment except for limestone crushers and limestone wet ball mills for which noise level shall not exceed 90 dB each. If necessary, suitable noise reduction covers shall be provided. For short term exposure, noise levels shall not exceed the limits as stipulated in the Occupational Safety & Health Administration Standard (OSHAS). Compliance to noise level shall be demonstrated by the bidder.
- 2.8.26 All the electric motor driven auxiliaries shall be sized to give their rated performance even at a power supply frequency of 47.5 Hz. (minimum).

**2.8.27 Lubrication**

Provision shall be made for lubricating the parts wherever necessary to ensure smooth operation and freedom from undue wear. Gear boxes and oil bath shall be provided with filling and drain plugs of adequate size and shall be provided with level indicators. Provision shall be made for efficient lubrication of all bearings including ball and roller bearings by the use of separate grease cups, self-sealing nipples or oil bath. Housing of ball and roller bearing shall be packed with the lubricant at the time of assembly. Lubrication opening of nipples shall be so arranged that it should be possible to carryout lubrication from a gangway or landing and without the removal of or insertion of the hand into the guarding. Necessary provision shall be made for preventing dust ingress into lubricated parts. The contractor shall supply schedule drawing showing all lubricating points and recommended lubricants to be used. First fill of the lubricants wherever required and all lubricants till handing over of FGD system, shall be supplied by the contractor.

**2.8.28 Safety Guards**

Wire mesh or steel plate guards of suitable design shall be provided for all drives as well as exposed revolving parts of equipment. Oil drip pans shall be provided wherever required. Guards and pans should be of removable construction to provide access to the machine. Guards may consist of railing and tee boards placed at least at a gap of 300 mm from the parts to be covered. Suitable machinery covers shall also be provided.

**2.8.29 Special Cleaning, Protection and Painting**

- i) Suitable protection method shall be adopted for protecting all material, plant and equipment during all stages of manufacture, transportation, storage and erection.



- ii) All coated surfaces shall be protected against abrasion, impact, discoloration and any other damages. All exposed threaded portions shall be suitably protected with either metallic or a non-metallic protection device. All ends of all valves and piping and conduit equipment connections shall be properly sealed with suitable devices to protect them from damage. The parts which are likely to get rusted, due to exposure to weather, should also be properly treated and protected in a suitable manner.
- iii) All exposed metallic surfaces subject to corrosion shall be protected by application of suitable coatings. All surfaces which will not be easily accessible after the shop assembly, shall beforehand be treated and protected for the life of the equipment. All surfaces shall be thoroughly cleaned of all mill scales, oxides and other coatings and prepared in the shop. The surfaces that are to be finish-painted after installation or require corrosion protection until installation, shall be shop painted with at least two coats of primer.
- iv) All the surfaces of equipment and structures of the proposed FGD plant to be painted at site have to be sand blasted at site and painting with one coat of primer and two coats of epoxy paint to achieve the minimum DFT of 200 microns. Shop painting of equipment shall also conform to this requirement.
- v) Shop primer for all steel surfaces which will be exposed to operating temperature below 95 deg C shall be selected by the Contractor after obtaining specific approval of the Purchaser regarding the quality of primer proposed to be applied. Special high temperature primer shall be used on surfaces exposed to temperature higher than 95 deg C and such primer shall also be subject to the approval of the Purchaser. All other steel surfaces which are not to be painted shall be coated with suitable dust preventive compound subject to the approval of the Purchaser.
- vi) All equipment/ piping/ pipe services are to be painted by the Bidder in accordance with Owner's standard colour coding scheme, which will be furnished to the Bidder during detailed engineering stage.
- vii) The control panels and annunciation panels shall be given final painting before shipment and shall be touched up at site, if necessary.
- viii) Final painting of approved colour of purchaser's choice shall be arranged by the contractor at site.

#### 2.8.30 Site Specific Safety

The structure of the FGD plant shall be adequately designed taking into account the local seismic factors and wind conditions prevailing at site. A project design manual indicating design data and detailed design criteria for civil and structure steel work shall be submitted for the approval of the consultant/purchaser. In case of coastal climatic conditions, the special measures adopted to protect reinforced concrete and structural steel shall be included in the design criteria.





### 2.8.31 Maintenance Tools and Tackles

- i) The Contractor shall supply with the equipment, one complete set of all special tools and tackles required for the erection, assembly, disassembly and maintenance of equipment. These special tools will also include special material handling equipment, jigs and fixtures for maintenance & calibration/readjustment, checking & measurement aids etc. A list of such tools and tackles will be submitted by the Bidder along with the offer. Detailed description of each tool/tackle, its function along with the equipment/part for which it is meant for and the price of each tool/tackle shall be indicated in the offer. However, the price of all tools and tackles shall be included in the bid price and unit price shall be separately indicated for information purpose only. The bidder shall also ensure that these tools and tackles are not used by him during erection, commissioning and trial operation.
- ii) The tools shall be supplied in separate containers clearly marked with the name of equipment for which they are marked.
- iii) The bidder shall furnish a list of such tools included under the scope of supply with the proposal.

### 2.8.32 Laboratory Equipment

The FGD plant supply must contain as its integral part, the equipment for laboratory/analysis for control of desulphurisation process, including quality control of input and output products. The power plant laboratory is equipped for standard chemical control of the steam water system, fuels and oils. All other analytical/laboratory instruments and chemicals required for analysis/quality control of inputs to FGD viz. chemicals and limestone and outputs from FGD viz. flue gas, waste water, solid waste etc. shall be provided. Also, special instruments required for inspection and maintenance of FGD plant shall be provided.

2.8.33 All manholes and inspection openings shall be hinged and shall be suitable for easy opening/closing. All inspection openings and manholes shall be provided with maintenance platforms for easy access. Dust catchers shall be provided in order to prevent discharge of dust when opening the doors and manholes.

2.8.34 Every equipment or parts of equipment that must operate under certain conditions of maximum pressure, temperature, speed, position etc. should have devices to prevent such limits from being exceeded and, if necessary, to stop the operation of the machine. (Safety valves, limit switches, thermal switches, etc.).

### 2.8.35 Rating Plates, Name Plates & Labels

- i) Each item of plant shall be provided with nameplate or label designating the service of the particular equipment. Each main and auxiliary item of plant including instruments shall have permanently attached to it in a

conspicuous position, a rating plate of non-corrosive material upon which shall be engraved manufacturer's name, equipment, type or serial number together with details of the ratings, service conditions under which the item of plant in question has been designed to operate, and such diagram plates as may be required by the Owner.

- ii) Items of plant such as valves, which are subject to handling, shall be provided with engraved chromium plated nameplate or label with engraving filled with epoxy. The name plates for valves shall be marked in accordance with MSS standard SP-25 and ANSI B 16.34 as a minimum.
- iv) All segregated phases of conductors or bus ducts, indoor or outdoor, shall be provided with coloured phase plates to clearly identify the phase of the system.

#### **2.8.36 Material and Workmanship**

- i) All materials used in the manufacture of the equipment shall be free from defects and imperfections. The purchaser will reject components and equipment with bad workmanship and the supplier shall have to re-supply equipment of right workmanship at no additional cost to the purchaser.
- ii) Materials not specifically described shall conform to latest revised specification of IS or equal. The equipment shall conform in every respect to high standards of engineering design and workmanship. The supply of equipment shall be such that the maximum facility for interchangeability of parts is provided.
- iii) The materials used in the fabrication of the components shall be new and shall have such composition, grade and properties which match and suit the duties to be performed and the conditions of operation to which these components will be subjected. Site-specific conditions shall be especially taken care of in the choice of materials proposed to be adopted.
- v) The bidders shall furnish schedule of materials giving standards, compositions, properties etc. for major/ important components of all the equipment. The bidder shall also furnish the specifications of materials on the respective component drawings.
- vi) All parts shall be manufactured true to drawing dimensions. All tolerances shall be defined on the contractor's drawings for both manufacturing and installation purposes.



### 2.8.37 Operation and Maintenance Manuals

- i) The bidder shall furnish 10 copies of instruction manuals prepared on good quality paper securely bound in durable folders for assembly, installation, adjustment, operation and maintenance of the equipment furnished by him and his sub-contractors. The manuals shall be specific to the equipment furnished and not of general nature. The instructions for assembly and installation shall show the identification of part numbers of the dismantled apparatus or equipment. Instructions for initial commissioning, short duration and long duration shut down
- ii) Instruction for operation, routine inspection and maintenance including preventive maintenance, recommendation for inspection points, method of inspection and period of inspection, information on detection, cause and rectification of troubles and faults and instructions on normal repairs and overhaul etc. shall be included in the manual.
- iii) Necessary drawings, curves and other illustrations shall be included or copies of appropriate approved drawings shall be bound in the manuals, Tests, adjustment and calibration information, as appropriate, shall be included. Safety and other warning notices and instructions, maintenance and operating cautions shall be emphasized.

### 2.9 SPARE PARTS

The bidder shall include in his scope of supply all the necessary mandatory spares, start up and commissioning spares and recommended spares and indicate these in the relevant schedules. The requirements pertaining to the supply of these spares is given below:

- i) **Mandatory Spares**
  - a) The list of mandatory spares considered essential by the purchaser is enclosed with this specification. The bidder shall indicate the prices for each and every item (except for items not applicable to the bidder's design) in the 'Schedule of mandatory spares' whether or not he considers it necessary for the purchaser to have such spares. If the bidder fails to comply with the above or fails to quote the price of any spare item, the cost of such spares shall be deemed to be included in the contract price. The bidder shall furnish the population per unit of each item in the relevant Schedules. Whenever the quantity is mentioned in "sets" the bidder has to give the item details and prices of each item. The bidder is informed that the total prices quoted for the listed mandatory spare parts will be used in tender evaluation.
  - b) Whenever the quantity is indicated as a percentage, it shall mean percentage of total population of that item in the station (project) unless specified otherwise, and the fraction will be rounded off to the next higher whole number. Wherever the requirement has been specified a 'set' it will include the total requirement of the item for a



unit, module or the station or as specified. Where it is not specified a 'set' would mean the requirement for the single equipment/system as the case may be. Also the 'set' would include all components required to replace the item; for example, a set of bearings shall include all hardware normally required while replacing the bearings.

- c) The assembly/ sub- assembly which have different orientation (like left hand, right hand, top or bottom), different direction of rotation, mirror image positioning or any other reason which result in maintaining two different sets of spares shall be considered as different type of assembly/ sub- assembly.
- d) The purchaser reserves the right to buy any or all the mandatory spare parts.
- e) The prices of mandatory spares indicated by the bidder in the Bid Proposal shall be used for bid evaluation purposes.
- f) All mandatory spares shall be delivered at site at least two months before scheduled date of initial operation of the first unit. However, spares shall not be dispatched before dispatch of corresponding main equipment.
- g) Wherever quantity is specified both as a percentage and a value, the bidder has to supply the higher quantity until and unless specified otherwise.

ii) **Recommended Spares**

- a) In addition to the spare parts mentioned above, the Contractor shall also provide a list of recommended spares for three (3) years of normal operation of the plant and indicate the list and total prices in relevant schedule. The list shall take into consideration the mandatory spares specified and should be independent of the list of the mandatory spares. The purchaser reserves the right to buy any or all of the recommended spares. The recommended spares shall be delivered at project site at least two months before the scheduled date of initial operation of first unit. However, the spares shall not be dispatched before the dispatch of the main equipment.
- b) Prices of recommended spares will not be used for evaluation of the bids. The price of these spares will remain valid up to execution of the contract. However, the Contractor shall be liable to provide necessary justification for the quoted prices for these spares as desired by the purchaser.

iii) **Start up and Commissioning Spares**

Start up and commissioning spares are those spares which may be required during the start-up and commissioning of the equipment/system till the commercial operation of the Plant. The Contractor shall provide



all such start up and commissioning spares and keep an adequate stock of the same to be brought by him to the site for the plant erection and commissioning. These must be available at site before the equipment are energized. The unused spares, if any, should be removed from there only after commercial operation of the plant. All start up spares which remain unused at the time shall remain the property of the Contractor.

iv) **General Requirements**

- a) The Contractor shall indicate the service expectancy period for the spares parts (both mandatory and recommended) under normal operating conditions before replacement is necessary.
- b) All spares supplied under this contract shall be strictly interchangeable with the parts for which they are intended for replacements. The spares shall be treated and packed for long storage under the climatic conditions prevailing at the site e.g. small items shall be packed in sealed transparent plastic with desiccator packs as necessary.
- c) All the spares (both recommended and mandatory) shall be manufactured along with the main equipment components as a continuous operation as per same specification and quality plan.
- d) The contractor will provide purchaser with cross-sectional drawings, catalogues, assembly drawings and other relevant documents so as to enable the purchaser to identify and finalise order for recommended spares.
- e) Each spare part shall be clearly marked or labeled on the outside of the packing with its description. When more than one spare part is packed in a single case, a general description of the content shall be shown on the outside of such case and a detailed list enclosed. All cases, containers and other packages must be suitably marked and numbered for the purposes of identification.
- f) All cases, containers or other packages are to be opened for such examination as may be considered necessary by the purchaser.
- g) The Contractor will provide the purchaser with all the addresses and particulars of his sub-suppliers while placing the order on vendors for items/ components/ equipment covered under Contract and will further ensure with his vendors that the purchaser, if so desires, will have the right to place order for spares directly on them on mutually agreed terms based on offers of such vendors.
- h) The Contractor shall warrant that all spares supplied will be new and in accordance with the Contract documents and will be free from defects in design, material and workmanship.



- i) In addition to the recommended spares listed by the Contractor, if the purchaser further identifies certain particular items of spares, the Contractor shall submit the prices and delivery quotation for such spares within 30 days of receipt of such request for consideration by the purchaser and placement of order for additional spares if the purchaser so desires.
- j) The Contractor shall guarantee the long term availability of spares to the purchaser for the full life of the equipment covered in the Contract. The Contractor shall guarantee that before going out of production of spare parts of the equipment covered under the Contract, he shall give the purchaser at least 2 years advance notice so that the latter may order his bulk requirement of spares, if he so desires. The same provision will also be applicable to Sub-contractors. Further, in case of discontinuance of manufacture of any spares by the Contractor and/or his sub-contractors, Contractor will provide the purchaser, two years in advance, with full manufacturing drawings, material specifications and technical information including information on alternative equipment makes required by the purchaser for the purpose of manufacture/procurement of such items.
- k) Tenders submitted without mandatory spare parts stated in the specification along with bidder's recommended spare parts shall be treated as incomplete and are liable to be rejected.

## **2.10 QUALITY ASSURANCE PROGRAMME**

- i) All materials, components & equipment covered under this specification shall be tested at all stages of procurement, manufacturing, erection, commissioning as per a comprehensive Quality Assurance Programme. The detailed Quality plans for manufacturing and field activities should be drawn up by the bidder and shall be submitted along with the bid which shall be finally accepted by the Employer/ authorised representative after discussions before the award of the contract. The quality assurance program shall be generally in line with ISO-9001/IS-14001 and shall generally cover the following:
  - a) Contractor's organization structure for the management and implementation of the proposed quality assurance program
  - b) Quality System Manual
  - c) Design Control System
  - d) Documentation and Data Control System
  - e) Qualification and experience data for bidder's key personnel.
  - f) The procedure for purchase of materials, parts, components and selection of sub-Bidder's services including vendor analysis, source inspection, incoming raw-material inspection, verification of materials purchased etc.
  - g) System for shop manufacturing and site erection controls including process, fabrication and assembly.



- h) System for quality audits, control of non-conforming items and system for corrective actions and resolution of deviations.
  - i) Inspection and test procedure both for manufacture and field activities.
  - j) Control of calibration and testing of measuring testing equipment.
  - k) System for Quality Audits.
  - l) System for identification and appraisal of inspection status.
  - m) System for authorising release of manufactured product to the Owner.
  - n) System for handling, storage and delivery.
  - o) System for generation and maintenance of inspection and test records.
- ii) All materials, components & equipment covered under this specification shall be tested at all stages of procurement, manufacturing, erection, commissioning as per the agreed Quality Assurance Program.
- iii) Manufacturing Quality Plan will detail out for all the components and equipment, various tests/inspection, to be carried out as per the requirements of this specification and standards mentioned therein and quality practices and procedures followed by Bidder's/ Sub-Bidder's/ sub-supplier's Quality Control Organisation, the relevant reference documents and standards, acceptance norms, inspection documents raised etc., during all stages of materials procurement, manufacture, assembly and final testing/performance testing. The Quality Plan shall be submitted on electronic media e.g. CD or E-mail in addition to hard copy, for review and approval. After approval the same shall be submitted in compiled form on CD-ROM.
- iv) Field Quality Plans will detail out for all the equipment, the quality practices and procedure etc. to be followed by the Contractor's site Quality Control Organization, during various stages of site activities including receipt of materials/equipment at site, preservation and storage, pre-assembly, erection, pre-commissioning & commissioning.
- v) The bidder, along with quality plan, shall also furnish copies of the reference documents/plant standards/acceptance norms/test & inspection procedure etc./ referred by him in Quality Plans. These Quality Plans and reference documents/standards etc. will be subject to purchaser's approval and will form a part of the contract. In these approved Quality Plans, purchaser shall identify customer hold points (CHP), indicating tests/checks which shall be carried out in presence of the Purchaser's engineer or authorized representative and beyond which work will not proceed without consent of Purchaser's Engineer/ authorized representative in writing.
- vi) No materials/equipment shall be dispatched from the manufacturer's works before the same is either accepted subsequent to pre-dispatch final inspection including verification of records of all previous tests/inspections by Purchaser's Engineer /authorized representatives and duly authorised for dispatch by issuance of Material Dispatch Clearance Certificate (MDCC) or such pre-dispatch final inspection is waived by the purchaser and dispatch is authorized after review of test reports.



- vii) All materials used or supplied shall be accompanied by valid and approved material certificates and test and inspection reports duly approved by the purchaser. These certificates and reports shall indicate the acceptable identification number of the material they proposed to certify. The material certified shall also have the identification details stamped on it.
- viii) All material used for equipment construction including castings and forgings etc. shall be of tested quality as per relevant codes/standards. Details of results of the test conducted to determine the mechanical properties, chemical analysis and details of heat treatment procedures recommended and actually followed shall be recorded on certificates and time temperature chart. Tests shall be carried out as per applicable material standards and/or agreed details.
- ix) All welding and brazing shall be carried out as per welding procedure drawn and qualified in accordance with requirements of ASME Section IX/ BS-4870 or other International equivalent standard acceptable to the Owner. Welding procedures shall be submitted to the Purchaser for approval prior to carrying out Qualification test in the presence of Purchaser's representative.
- x) All welders/welding operators employed on any part of the contract either in the Supplier's works or at site or elsewhere shall be qualified as per ASME Section-IX IX/ BS-4871 or other equivalent International Standards acceptable to the Owner.
- xi) Test results of qualification tests and specimen testing shall be furnished to the Purchaser for approval. However, wherever required by the purchaser, tests shall be conducted in presence of Purchaser's Engineer/ authorized representative.
- xii) Unless otherwise proven and specifically agreed with the Owner, welding of dissimilar materials and high alloy materials shall be carried out at shop only.
- xiii) No welding shall be carried out on cast iron components for repair.
- xiv) All the heat treatment results shall be recorded on time temperature charts and verified with recommended regimes.
- xv) All non-destructive examination shall be performed in accordance with written procedures as per International Standards, The NDT operator shall be qualified as per SNT-TC-IA (of the American Society of non-destructive examination). NDT shall be recorded in a report, which includes details of methods and equipment used, result/evaluation, job data and identification of personnel employed and details of co-relation of the test report with the job.





- xvi) All plates of thickness above 40mm & all bar stock/Forging above 40mm dia shall be ultrasonically tested. For pressure parts, plate of thickness equal to or above 25mm shall be ultrasonically tested.
- xvii) Quality audit/surveillance/approval of the results of the tests and inspection will not, however, prejudice the right of the Owner to reject the equipment if it does not comply with the specification when erected or does not give complete satisfaction in service and the above shall in no way limit the liabilities and responsibilities of the Bidder in ensuring complete conformance of the materials/equipment supplied to relevant specification, standard, data sheets, drawings, etc.
- xviii) For all spares and replacement items, the quality requirements as agreed for the main equipment supply shall be applicable.
- xix) Repair/rectification procedures to be adopted to make the job acceptable shall be subject to the approval of the Purchaser/ authorised representative.
- xx) All the sub-vendors proposed by the Bidder for procurement of major bought out items including castings, forgings, pumps, fans, heat exchangers, semi-finished and finished components/equipment- (list of which shall be drawn up by the Bidder along with his offer and finalized with the purchaser) shall be subject to Purchaser's approval.
- xxi) All the purchase specifications for the major bought out items, list of which shall be drawn up by the Contractor and finalized with the purchaser, shall be furnished to the Purchaser for comments and subsequent approval before orders are placed as per those specifications.
- xxii) Purchaser reserves the right to carry out quality audit and quality surveillance of the systems and procedures of the Contractor and their sub-vendors for quality management and control activities. The Contractor shall provide all necessary assistance to enable the purchaser carry out such audit and surveillance.

## **2.11 TESTING AND INSPECTION**

### **2.11.1 General**

- i) The Contractor shall undertake an inspection and testing programme during manufacture in his works and that of his sub-contractors to ensure the mechanical accuracy of components, compliance with drawings, conformance to functional and performance requirements, identification and acceptability of all materials, parts and equipment. In addition to tests as per the approved Quality Plan, the Contractor shall also carry out all tests/ inspection required to establish that the items/ equipment conform to requirements of this specification and the relevant codes/ standards specified in this specification.



- ii) The word 'Inspector' shall mean the Purchaser/ Engineer and/or his authorized representative and/or an outside inspection agency acting on behalf of the Owner to inspect and examine the materials and workmanship of the works during its manufacture or erection.
- iii) The Purchaser/ Engineer and/or his duly authorised representative shall have at all reasonable times access to the contractor's premises or works and shall have the power at all reasonable times to inspect and examine the materials and workmanship of the works during its manufacture or erection and part of the work being manufactured or assembled on other's premises or works. The contractor shall obtain for the Engineer and his duly authorised representative the permission to inspect as if the works were manufactured or assembled on the contractor's premises or works.
- iv) The contractor shall give the Engineer/Inspector fifteen (15) days written notice of any material being ready for testing. Such tests shall be to the contractor's account except for the expenses of the Inspector. The Engineer/Inspector unless the inspection of the tests is virtually waived, shall attend such tests within fifteen (15) days of the date on which the equipment is notified as being ready for test/inspection, failing which, the contractor may proceed with the test which shall be deemed to have been made in the Inspector's presence and he shall forthwith forward to the Inspector duly certified copies of tests in triplicate.
- v) The Engineer or Inspector shall within fifteen (15) days from the date of inspection as defined herein give notice in writing to the contractor of any objection to any drawings or any equipment and workmanship which in his opinion is not in accordance with the contract. The contractor shall give due consideration to such objections and shall either make the modifications that may be necessary to meet the said objections or shall confirm in writing to the Engineer/Inspector, giving reasons therein that no modifications are necessary to comply with the contract.
- vi) When the factory tests have been completed at the contractor's or sub-contractor's works, the Engineer/Inspector shall issue a certificate to this effect within fifteen (15) days after completion of test. If the tests are not witnessed by the Engineer/Inspector, the certificate shall be issued within fifteen (15) days of the receipt of the contractor's test certificate by the Engineer/Inspector. Failure of the Engineer/Inspector to issue such a certificate shall not prevent the contractor from proceeding with the works. The completion of these tests or the issue of the certificate shall not bind the owner to accept the equipment, should on further tests after erection, the equipment is found not to comply with the contract.
- vii) In all cases where the contract provides for tests whether at the premises or works of the contractor or of any sub-contractor, the contractor, except where otherwise specified, shall provide free of charge such items as labour, materials, electricity, fuel, water, stores, apparatus and instruments as may be reasonably demanded by the Engineer/Inspector or his authorised representative, to accomplish testing.



- viii) Quality audit/ surveillance/ approval of the results of the tests and inspection will not, however, prejudice the right of the purchaser to reject the equipment if it does not comply with the specification when erected or does not give complete satisfaction in service and the above shall in no way limit the liabilities and responsibilities of the Contractor in ensuring complete conformance of the materials/equipment supplied to relevant specification, standards, data sheets, drawings etc.
- ix) All inspection, measuring and test equipment used by Contractor shall be calibrated periodically depending on its use and criticality of the test/measurement to be done. The Contractor shall maintain all the relevant records of periodic calibration and instrument identification, and shall produce the same for inspection by the Purchaser/ Inspector. Wherever asked specifically, the Contractor shall re-calibrate the measuring/test equipment in the presence of Purchaser/ Inspector.
- x) The cost of all the tests shall be borne by the Contractors.

#### 2.11.2 Material Tests

Wherever tested quality material is specified and wherever called upon by the design code, the test pieces are to be prepared and tested to the Purchaser's satisfaction. The Purchaser may, at his discretion, after being furnished with certified particulars of tests which have been carried out by the suppliers of material, dispense with the testing of test pieces.

#### 2.11.3 Shop Tests

- i) Shop tests shall include all tests to be carried out at Contractor's works, at the works of his sub-contractor and at works where raw materials supplied for manufacture of equipment is manufactured.
- ii) Works tests are to include electrical and mechanical performance and hydraulic tests in accordance with relevant IS, ASME or any other approved standard and/or any other tests called for by the Purchaser under these specifications to ensure that the plant being supplied fulfils the requirement of the specifications. For equipment not covered by any IS or other approved standards, the tests to be carried out shall be in accordance with Contractor's quality assurance programme to be agreed to between the Contractor and the Purchaser.
- iii) All pipes, valves, steam traps, are to be subjected to hydraulic test as called for under IS, BS or other approved codes. Copies of certificates covering all the hydraulic tests shall be submitted to the purchaser. The following shop tests shall be conducted, as applicable according to the approved manufacturer's test Procedures:
  - a) Material Analysis
  - b) Radiographic test at welds.
  - c) Magnetic particle examination



- d) Dye penetrate examination
  - e) Hydro static test.
  - f) Dimension check
  - g) Ultrasonic test (as required)
- iv) All pumps and fans are to be tested at manufacturer's works. Complete performance tests are to be carried out on each pump/ fan to verify its output (flow) against total head, power input, efficiency and suction head. Head vs. Volume, Suction head vs Volume, Volume vs Efficiency and power input curves corrected for site conditions are to be provided.

#### 2.11.4 Site Tests

Contractor shall carry out the tests at site to prove to the purchaser that each equipment of the plant complies with all the requirements specified. Before the plant is put into commercial operation, the Contractor will be required to conduct tests to demonstrate to the Purchaser that each item of the plant is capable of correctly performing the functions for which it was specified. These tests may be conducted concurrently with those required under commissioning sequence. The tests required shall specifically include the following:

- i) Checks on the operation of dampers including tests of gas tightness/ leak proofing.
- ii) Check on operation of all fans to ascertain level of noise and vibration.
- iii) Test running of pumps and motors.
- iv) Check free rotation of gas heater and adjust seals, if necessary when heater is up to working temperature.
- v) Check operation of soot blowers and retraction gear and the sequence control.
- vi) Check run on the Mills, where applicable.
- vii) Check operation of all variable speed drives throughout their respective ranges on lime stone feeders etc. where applicable.
- viii) Check operation of all motorized isolating valves both locally and from the FGD control room.
- ix) Check operation of all individual control loops in the FGD control system.
- x) Check inter-relation between each separate control loops.
- xi) Calibration of instruments before commissioning as required.
- xii) Gas tightness test on FGD system.



- xiii) Calibration tests of monitoring, instrumentation and control system/ devices (permanent one) to be used for tests.

Other tests shall be conducted if required by the Purchaser to establish that the plant equipment are in accordance with requirements of specifications.

## 2.12 TRIAL OPERATION

The FGD plants after completion of the above tests shall be put on trial operation for a period of fifteen (15) days during which all necessary adjustments etc. shall be made while operating over full load range enabling the unit/ plant to be made ready for performance guarantee test.

- i) During the Trial Operation period, the FGD Plant / System shall be operated continuously for 360 hours (15 days) at various operating loads as provided by the Purchaser and at various operating modes when firing with the specified range of coal in the Boiler. Reliability Run of 72 hours of un-interrupted operation at full load or near full load as may be provided by the Purchaser shall be conducted during the Trial Operation period. If there is any interruption in this 72 hours period of Reliability Run, the same shall have to be attempted and demonstrated for guaranteed 72 hours of un-interrupted running. In case of any interruption of up to 4 hours in period of 360 hours (15 days) operation (other than 72 hours of full load or near full load operation of Reliability Run as described above), the period of interruption must be added to 360 hours; however, if cumulative period of interruption is more than 4 hours, then 24 hours will be added to 360 hours. In case the cumulative period of interruption / down time of FGD Plant / System during Trial Operation is more than 48 hours, then the Trial Operation shall be considered as unsuccessful and the Contractor shall be asked to demonstrate Trial Operation again, including the Reliability Run.
- ii) The trial operation shall be considered successful, provided that each item / part of the FGD Plant/System can operate continuously at the specified operating characteristics, for the period of Trial Operation with all operating parameters within the specified limits and at or near the predicted performance of the equipment/Plant. The Contractor shall intimate the Purchaser about the commencement of Trial Operation and shall furnish adequate notice to the Purchaser in this respect.
- iii) A Trial Operation report comprising of observations and recordings of various parameters to be measured in respect of the above Trial Operation shall be prepared by the Contractor. This report with details of the various observations made during Trial Operation, details of interruptions occurred, adjustments made, and any minor repairs done, shall also include the dates of start and finish of the Trial Operation and shall be signed by the representatives of Purchaser and Contractor. Based on the observations, necessary modifications/repairs to the FGD Plant / System shall be carried out by the Contractor to the full satisfaction



of the Purchaser to enable the latter to accord permission to carry out the Performance Guarantee tests on the FGD Plant / System. However, minor defects which do not endanger the safe operation of FGD Plant / System, shall not be considered as reasons for withholding the aforesaid permission.

## **2.13 PERFORMANCE GUARANTEES AND ACCEPTANCE TESTS**

### **2.13.1 General Requirements**

- i) The contractor shall guarantee that the equipment offered shall meet the ratings and performance requirements stipulated for various equipment covered in these specifications.
- ii) The guaranteed performance parameters furnished by the bidder in his offer, shall be without any tolerance values and all margins required for instrument inaccuracies and other uncertainties shall be deemed to have been included in the guaranteed figures.
- iii) The Contractor shall demonstrate all the guarantees covered herein during functional guarantee/acceptance test. The various tests which are to be carried out during performance guarantee/acceptance test are listed in this Sub-section. The guarantee tests shall be conducted by the contractor at site in presence of purchaser on each unit individually.
- iv) All costs associated with the tests shall be included in the bid price.
- v) In case during tests it is found that the equipment/system has failed to meet the guarantees, the contractor shall carry out all necessary modifications and/or replacements to make the equipment/system comply with the guaranteed requirements at no extra cost to the purchaser. However, if the contractor is not able to demonstrate the guarantees, even after the above modifications/ replacements within ninety (90) days or a reasonable period allowed by the purchaser, after the tests have been completed, the purchaser will have the right to either of the following:

a) For Category-I Guarantees

Reject the equipment/ system/ plant and recover from the contractor the payments already made.

OR

Accept the equipment/system/plant after levying liquidated damages (LDs) as specified hereunder. The liquidated damages for shortfall in performance shall be levied separately for each unit. The liquidated damages shall be prorated for the fractional parts of the deficiencies.

The performance guarantees coming under this category shall be called 'Category-I Guarantees'.



b) For Category-II Guarantees

Reject the equipment/ plant/ system and recover from the Contractor the payments made.

The performance guarantees under this category shall be called 'Category-II Guarantees'. Conformance to the performance requirements under Category-II is mandatory.

c) For Category-III Guarantees

Reject the equipment/ system and recover from the contractor the payments already made.

OR

Accept the equipment/system after assessing the deficiency in respect of the various ratings, performance parameters and capabilities and recover from the contract price an amount equivalent to the damages as determined by the purchaser.

The performance guarantees coming under this category shall be called 'Category-III Guarantees'.

**2.13.2 Guarantees under Category- I**

The performance guarantees which attract liquidated damages are as follows:

- i) Guaranteed maximum auxiliary power consumption of for FGD System with each units operating at 100% unit MCR load with corresponding conditions specified at clause no. 2.4.1 of the specification.
- ii) Guaranteed maximum limestone consumption of FGD System with each units operating at 100% unit MCR load with corresponding conditions specified at clause no. 2.4.1 of the specification.

**2.13.3 Guarantees under Category-II**

SO<sub>2</sub> removal in treated flue gas: Bidder shall guarantee that maximum concentration of SO<sub>2</sub> in treated flue gas at the exit of FGD for each unit shall not exceed 150<sup>7</sup> mg/Nm<sup>3</sup> at 6% O<sub>2</sub> on dry basis at 100% TMCR load with corresponding conditions specified at clause no. 2.4.1 of the specification.

**Conformance to the performance requirements under Category-II is mandatory as compliance of limiting the SO<sub>2</sub> emission from the plant is a statutory requirement. If the stipulated guarantee is not met, the Purchaser at his discretion will reject the FGD Plant/ System and recover from the Contractor the payments made for the entire contract.**

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<sup>7</sup> To be specified by purchaser in line with stipulated limit of MoEF&CC.



#### 2.13.4 Guarantees under Category-III

The parameters/ capabilities to be demonstrated for various systems/ equipment shall include but not be limited to the following:

1. Minimum SO<sub>2</sub> removal efficiency of each scrubber corresponding to the design conditions of the FGD plant\* :
2. Maximum mist content in the treated flue gas at the exit of the FGD corresponding to the guarantee conditions of the FGD plant\* :100 mg/Nm<sup>3</sup>
5. Maximum pressure drop of flue gas across the FGD system, corresponding to the guarantee conditions of the FGD plant\*, mmwc (g) :
6. Permissible range of plant load variation for design SO<sub>2</sub> removal efficiency of the FGD plant (MW or % of unit MCR) :
7. Permissible maximum SO<sub>2</sub> concentration in the inlet flue gas for design SO<sub>2</sub> removal efficiency of the FGD plant, mg/Nm<sup>3</sup>. :
8. SO<sub>2</sub> removal efficiency with one spray level out of service corresponding to guarantee conditions of FGD plant\*(for multi spray tower systems) :

\*Design and guarantee point conditions of FGD plant refers to the conditions and requirements indicated at clause no. 2.4.1 of the specification.

#### 11. Gypsum Purity

- i) Minimum purity of gypsum produced (dry basis) : \*
- ii) Maximum chloride content : 100 ppm
- iii) Maximum moisture content : 10%

\*Bidder shall demonstrate the quoted gypsum purity for range of specified coal and range of specified limestone.

#### 12. Noise

- i) All the plant, equipment and systems covered under this specification shall perform continuously without exceeding the noise level of 85 dB (95 dB for limestone crushers and 90 dB for wet ball mills) over the entire range of output and operating frequency.
- ii) Noise level measurement shall be carried out using applicable and internationally acceptable standards. The measurement shall be carried out with a calibrated integrating sound level meter meeting the requirement of IEC 651 or BS 5969 or IS 9779.





iii) Sound pressure shall be measured all around the equipment at a distance of 1.0 m horizontally from the nearest surface of any equipment/ machine and at a height of 1.5 m above the floor level in elevation.

iv) A minimum of 6 points around each equipment shall be covered for measurement. Additional measurement points shall be considered based on the applicable standards and the size of the equipment. The measurement shall be done with slow response on the A – weighting scale. The average of A-weighted sound pressure level measurements expressed in decibels to a reference of 0.0002 micro bar, shall not exceed the guaranteed value. Corrections for background noise shall be considered in line with the applicable standards. All the necessary data for determining these corrections, in line with the applicable standards, shall be collected during the tests

13. Wet Ball Mills:

- i) Limestone fineness :
- ii) Minimum life of mill wear parts :
- iii) Maximum consumption of grinding balls :  
per ton of limestone throughput

Notes

- The limestone shall be of all available quality from specified range.
- The limestone capacity shall be demonstrated with originally installed grinding elements in nearly worn out condition.
- The contractor shall indicate the minimum ball diameter below which the balls shall be replaced.

15. Pumps, Fans, Compressors and Blowers etc.

Satisfactory operation of booster fans, compressors and blowers without undue noise and vibration while operating in isolation or in parallel with other fans shall be demonstrated at site.

16. Passenger cum Goods Elevators (for absorbers)

Over load tests, travel and speed checks, functional tests, performance tests, safety inspection etc. as per relevant standards and codes shall be demonstrated at site.

17. Cranes, Monorails etc.

Over load test, Travel and speed checks, functional tests, performance tests, safety test as per relevant Indian standards and codes shall be demonstrated at site.

19. Operating time of different dampers

Operation	Damper identification						
Closing							
Opening							



### 2.13.5 Auxiliary Power Consumption

2.13.5.1 The auxiliary power consumption shall be calculated using the following relationship:

$$P_a = P_{tg} + T_L$$

$P_a$  = Guaranteed auxiliary power consumption

$P_{tg}$  = Power consumed by the auxiliaries of the unit under test

$T_L$  = Losses of the transformers

While guaranteeing the auxiliary power consumption, the bidder shall necessarily include all continuously operating auxiliaries. The auxiliaries and their duty factor to be considered shall include but not be limited to the following:

Sl. No.	Description	Duty factor
1.	Booster fans and their integral auxiliaries	1
2.	Gas to gas heat exchangers and their integral auxiliaries (if provided)	1
3.	Absorber limestone slurry recirculation pumps(for spray tower system)	1
4.	Absorber oxidation air blowers/ compressors	1
5.	Absorber tank slurry agitators	1
6.	Absorber limestone slurry feed pumps	0.3
7.	Mist eliminator wash pumps (if applicable)	0.3
8.	Absorber gypsum bleed pumps	1
9.	Limestone gravimetric feeders	0.5
10.	Wet ball mills and their integral auxiliaries	0.5
11.	Limestone slurry tank agitators	1
12.	Limestone slurry transfer pumps	0.3
13.	Process water pumps	1
14.	Gypsum bucket elevator	0.5
15.	Hydro-cyclones	0.5
16.	Vacuum filters	0.5
17.	Vacuum pumps and their integral auxiliaries	0.5
18.	Belt filter wash water pumps	0.5
19.	Hydro- cyclone waste water sump pumps	0.5
20.	Waste water transfer pumps	0.5



21.	Limestone vibrating feeders	0.3
22.	Limestone crusher and its integral auxiliaries	0.3
23.	Limestone conveyor belts and bucket elevators etc. (single stream)	0.3
24.	Air conditioning and ventilation system	0.5
25.	230 VAC UPS Power supply system	0.5
26.	Power consumption of any other continuously operating equipment required for operation of the system	1
27.	Power consumption of any other intermittent operating equipment required for operation of the system	0.3

2.13.5.2 The power consumption of continuously operating equipment/ drives i.e. with duty factor 1 shall be corresponding to the plant operation at 100% TMCR condition.

2.13.5.3 The power consumption of intermittently operating equipment/ drives i.e. with duty factor less than 1 shall be corresponding to the rated design capacity of these equipment/ systems.

#### 2.13.6 Method of Computing Plant Availability

- i) The Contractor shall guarantee 95% availability of FGD plant for a continuous period of 120 days. An availability guarantee test shall be conducted to assure this level of availability for a period of 120 days as per the procedure indicated below.

Availability 'A' in %:

$$\frac{T_c \times 100\%}{T_k}$$

Where,  $T_c$  — recorded time of FGD operation, expressed in hours, and

$T_k$  — recorded time of boiler operation, expressed in hours,

However, it is required that:

In order to calculate the FGD availability, operation hours will be counted normal operation of boiler excluding start-up and shutdown periods. Operation hours counting of the FGD plant will start on the moment of shut down of all oil burners.

- (ii) If FGD is out of operation during the boiler operation time as a result of the Employer's decision, this time will not be counted as boiler operation time for calculating the FGD availability,
- (iii) Boiler operation hours will be counted based on the recorded boiler operation hours and the recorded data will be made available to the Contractor by the Employer.



### 2.13.7 Acceptance Test

- i) It is the responsibility of the Contractor to perform the performance guarantee/ acceptance test as specified in this sub-section. The performance guarantee tests will be performed using only the normal number of purchaser supplied operating staff. Contactor, vendor or other subcontractor personnel shall only be used for instructional purposes or data collection. The Contractor shall make the plant ready for the performance guarantee tests.
- ii) All instruments required for performance testing shall be of the type and accuracy required by the relevant codes and prior to the test, the contractor shall get these instruments calibrated in an independent test Institute approved by the purchaser. All test instrumentation required for performance tests shall be supplied by the contractor and shall be retained by him upon satisfactory completion of all such tests at site. All costs associated with the supply, calibration, installation and removal of the test instrumentation shall be included in the bid price. All calibration procedures and standards shall be subjected to the approval of the purchaser. The protecting tubes, pressure connection and other test connections required for conducting guarantee test shall conform to the relevant codes. Any test chemicals, test apparatus, additional instruments or measuring points essential shall be provided by the Contractor.
- iii) Prior to the test, the contractor shall submit for purchaser's approval the detailed performance test procedure containing the following:
  - a) Object of the test
  - b) Various guaranteed parameters and tests as per contract
  - c) Method of conductance of test and test code
  - d) Duration of test, frequency of readings and number of test runs.
  - e) Method of calculation
  - f) Correction curves
  - g) Instrument list consisting of range, accuracy, least count and location of instruments.
  - h) Scheme showing measurement points
  - i) Sample calculation
  - j) Acceptance criteria
  - k) Any other information required for conducting the test.
- iv) The performance guarantee/ acceptance test shall be carried out in accordance with ASME PTC 40 (1991) code. The PG test procedure including demonstration tests shall be submitted by the bidder during detailed engineering for approval of the purchaser.
- v) In the event of a test interruption resulting from an event of force-majeure or purchaser caused delay, contractor shall be entitled to relief as provided in the contract, provided that (except for certain interruptions of an Availability Test as specified below), the interrupted Performance Test must be started again and test data that were collected during the interrupted test must be ignored.



- vi) In the event of test interruptions as a result of force- majeure or purchaser caused delay during an availability test, if (a) the total cumulative interrupted time during the test is more than twenty-four (24) hours and/or (b) the total number of interruptions during the test is more than four (4), the test shall not be deemed as successful performance guarantee test.

Except as provided above, the interrupted test resulting from force- majeure or purchaser caused delay shall be extended by an amount of time equal to the length of the interruptions, including time to return to steady-state operation; the test data for the period of interruptions shall be excluded from analysis; and the test data that were collected both before and after the interruptions shall be included in the analysis.

- vi) The performance test shall generally be conducted in accordance with the ASME Power Test Code 40. However, details of tests shall be mutually agreed upon. The contractor shall specify areas of responsibility and the items that specifically require preparation and agreement before the tests can be carried out. The test shall be arranged in a manner that the purchasers' operation is not disrupted. The test shall be carried out at the operating conditions as near the specified conditions as possible. The duration of the performance test shall be four hours.

- vii) The following correction curves shall be applicable for correction of test results during the performance test:

- Gas flow v/s SO<sub>2</sub> removal efficiency
- Inlet SO<sub>2</sub> concentration v/s SO<sub>2</sub> removal efficiency
- Gas flow v/s auxiliary power consumption
- Inlet SO<sub>2</sub> concentration v/s auxiliary power consumption
- Gas flow v/s reagent consumption
- Inlet SO<sub>2</sub> concentration v/s reagent consumption
- Gas flow v/s pressure drop

The bidder shall furnish the correction curves preferably along with the bid covering the expected ranges of variations for all these parameters for the range of coal and limestone specified.

- viii) After the conductance of performance guarantee test, the contractor shall submit the test evaluation report of performance test results to purchaser promptly but not later than fifteen (15) days from the date of conductance of performance guarantee test. However, preliminary test reports shall be submitted to the purchaser after completing each test run.

- ix) Performance guarantee/ acceptance tests on the equipment/ systems not covered in this Sub-Section shall be carried out as per the procedure/test codes/specified in respective detailed specifications/sub-sections.



## 2.14 INTEGRATION OF FGD SYSTEM WITH THE POWER PLANT UNITS

In case, for reasons not attributable to the purchase, the time period taken by the bidder for integration/ interconnection of FGD plant/ system with existing thermal power units/ plant is more than the quoted/ mutually agreed plant shutdown period, then liquidated damages shall be applicable for additional shutdown period involved. The liquidated damages for each day of delay beyond quoted/ mutually agreed period shall be applicable separately for each unit as indicated under clause 2.15 below:

## 2.15 LIQUIDATED DAMAGES (LD)

If the guarantees specified under Category- I guarantees are not achieved by the contractor within 90 days or a reasonable period allowed by the purchaser after notification by the purchaser, the purchaser may at his discretion reject the equipment/system and recover the payment already made or accept the equipment/system only after levying liquidated damages listed herein against the contractor and such amounts shall be deducted from the contract price:

Sl. No.	Parameters	Amount of Liquidated Damages for shortfall in Performance Parameters (or part thereof)	Acceptable shortfall limit with Liquidated Damages
	Auxiliary Power Consumption at 100% of FGD load at Unit MCR	Rs. 2,00,000/- <sup>8</sup> for every one kW increase in the auxiliary Power consumption from the guaranteed value	(+) 5% of the guaranteed auxiliary power consumption
	Limestone Consumption rate at 100% of FGD load at Unit MCR	Rs. 1,50,000/- <sup>9</sup> for every one kg/hr increase in limestone consumption from the guaranteed value.	(+) 10% of the guaranteed limestone consumption
	Shut down period for integration of FGD Plant	Rs. 1,00,00,000/- <sup>10</sup> for each Unit for every one day delay from guaranteed period.	-

### Notes:

- i) Each of the liquidated damages specified above shall be independent and these liquidated damages shall be levied concurrently as applicable.
- ii) Contractor's aggregate liability to pay liquidated damages for shortfall in guaranteed performance parameters, scheduled integration of FGD system with existing thermal power plant and delay in completion of the project shall not exceed twenty five percent (25%) of the contract price.

<sup>8</sup> To be provide by the purchaser

<sup>9</sup> To be provide by the purchaser

<sup>10</sup> To be provide by the purchaser



## SECTION 3.0

### SYSTEM DESCRIPTION AND SCOPE

#### 3.1 GENERAL DESCRIPTION OF WET LIMESTONE FGD SYSTEM

##### 3.1.1 Flue Gas System

For each 500 MW unit, the hot flue gas tapped from outlet of existing induced draft (ID) Fans shall be led to 2x60% FGD booster fans followed by the wet limestone absorber. Treated flue gas from outlet of the absorber shall be discharged to atmosphere through a new wet chimney of height 150 m (purchaser to check for adequacy as per MoEF&CC's requirement). During unit start-up with oil firing or during any exigency, the FGD system shall be bypassed and untreated flue gas shall be discharged to atmosphere through existing chimney.

##### 3.1.2 Absorber System

Each unit shall be provided with a separate Limestone Forced Oxidation (LSFO) type absorber system designed to handle 100% of the flue gas flow at boiler maximum continuous rating (BMCR) for the complete range of specified coal / flue gas. Flue gas shall enter the absorber from the bottom and shall come in intimate contact with spraying limestone slurry in the absorber. The flue gas inlet shall be so designed to ensure that flue gas is well distributed over the entire absorber cross-section. The limestone slurry shall be sprayed into the absorber to saturate the gas and remove the SO<sub>2</sub>. In case of multiple spray level design absorber, one spray level shall be kept as spare. Each spraying level including spare spray level shall be served by one individual limestone slurry recirculation pump. In case of single spray level type absorber, multiple numbers of identical slurry recirculation pumps shall be provided with one number recirculation pump kept as standby pump. The spray type absorber to be supplied by the bidder i.e. multiple spray level type or single spray level type shall be as per his proven and standard practice.

Other type of limestone wet absorber system viz. gas bubbling through the slurry shall also be acceptable provided it is proven and standard scheme of the bidder and same shall be subject to approval of the purchaser.

The absorber sump/ oxidation tank shall be adequately designed to give the limestone enough time for formation of calcium sulphate and crystal growth. Absorber sump shall be provided with adequate number of agitators for agitating the slurry to ensure consistent concentration of absorbent and to prevent settlement of solids.

Fresh limestone slurry shall be added into the sump by dedicated limestone slurry transfer pumps to compensate for calcium carbonate consumed in the absorber tower and the sump.



Minimum two levels of mist eliminators/ separators shall be provided in vertical/ horizontal position at the outlet of the absorber to separate flue gas from any remaining absorbent suspension droplets as per suitability for type of absorber offered. A wash water system shall be provided for cleaning of mist eliminators at regular intervals.

The emptying of the absorber shall be done by the gypsum bleed pumps into the emergency storage tank for the purpose of inspection and maintenance. Return pumps shall be provided for the refilling of absorber.

### 3.1.3 Limestone Unloading, Crushing & Storage System

The limestone unloading, storage, crushing shall be common for both units of the station. The limestone shall be received at power plant in trucks and shall be unloaded and stored under covered shed at some convenient place in the power plant. From storage yard, limestone to the FGD area shall be supplied by trucks/ dumpers.

In the FGD area, there shall be two underground hoppers and limestone shall be unloaded from trucks/ dumpers on underground hoppers/ paved area near the hoppers. Adequate space shall be provided for movement of pay loaders/ bulldozers to facilitate dropping of limestone into unloading hoppers.

Limestone from unloading hoppers shall be fed to two sets of conveyor belts through two vibrating feeders, one each placed under each unloading hopper, and then to two limestone crushers via pent house. The crushed limestone shall be supplied via belt feeders placed below crusher floor and bucket elevators to the 2 Nos. crushed limestone bulk storage silo.

**In case crushed limestone of size (-) 25 mm is supplied to the plant, limestone crushers shall not be provided and limestone conveyors after pent house shall be directly led to limestone bulk storage silos.**

### 3.1.4 Limestone Grinding, Slurry Preparation and Storage System

The limestone grinding, slurry preparation and storage system shall be common for both units of the station. The crushed limestone from 2 Nos. bulk storage silos shall be supplied to 2x100%capacity wet ball mills through gravimetric feeders for wet grinding of limestone. The limestone slurry of required fineness available from the wet ball mill system shall be stored in two limestone slurry tanks of total 24 hour requirement of the plant. From limestone slurry tank, the limestone slurry shall be pumped to individual absorber by means of dedicated 2x100% capacity limestone slurry transfer pumps.

Adequate numbers of agitators shall be provided for each limestone slurry tank to ensure consistent concentration of absorbent and to prevent settlement of solids.





### 3.1.5 Gypsum Dewatering, Handling System

The gypsum dewatering and handling system shall be common for both units of the station. Absorber bleed slurry from absorber sump shall be fed into gypsum dewatering system through 2x100% capacity gypsum bleed pumps. Gypsum slurry coming from two FGD units shall be fed into common 2x100% capacity primary hydro cyclones where it shall be classified and separated into a solid enriched under flow and over flow with reduced solid content. The underflow which contains the coarser gypsum particle shall be fed to 2x100% capacity vacuum belt filters. The overflow shall be collected in a reclaim tank and then taken to secondary hydro cyclone. The underflow of secondary hydro cyclone shall be collected in a filtrate tank and then taken to the wet ball mill/ gypsum recovery system. Water from vacuum receiver tank(s) shall also be recycled to the wet ball mill/ gypsum recovery system. The overflow from secondary hydro-cyclone, as waste water, shall be collected in a waste water tank.

Alternative scheme for gypsum dewatering & handling system as per proven and standard practice of the bidder shall also be acceptable subject to approval of the purchaser.

The gypsum from discharge of vacuum belt filter shall be collected in the common storage area on ground floor beneath the floor of filters for further transportation by trucks.

**Alternatively, gypsum from discharge of vacuum belt filters shall be collected by transfer belts and conveyed to a separate gypsum storage area from where it shall be further transported by trucks by the purchaser.**

### 3.1.6 Waste Water Treatment & Disposal System

The waste water collected in the waste water tank of FGD system shall be provided with adequate treatment and then disposed to existing ash handling system.

### 3.1.7 Water Supply for FGD System

Clarified water/ CW blow down water required for FGD plant shall be taken by the bidder from the identified terminal point indicated in the specification. Water shall be collected in a MS tank with epoxy painting of adequate capacity from which process water requirement of the FGD system for various applications shall be met through horizontal pumps provided with adequate redundancy.

### 3.1.8 Equipment Cooling Water System

For meeting equipment cooling water requirement of FGD system, the DM cooling water shall be tapped by the bidder from DM cooling water piping of both the existing units from suitable terminal points in the main plant area to



be identified by the Purchaser. The return hot water from FGD system shall be terminated by the bidder at suitable terminal points on hot water sections of DM cooling water piping.

### 3.2 SCOPE OF SUPPLY

The FGD system to be supplied by the bidder shall comprise of one FGD plant for each unit with common facilities for limestone receiving, unloading, storage, grinding, slurry preparation and gypsum handling & dewatering system for both the units. A new wet chimney shall be provided for discharge of treated flue gas into the atmosphere. Necessary modifications required in the existing power plant systems for interconnection and integration of FGD plant with the existing units/facilities are also included in the bidder's scope.

The detailed scope of work is defined broadly hereunder but any equipment/facilities/ services etc. not specifically defined herein but required for successful completion/ commissioning of system shall be deemed to have been included in scope of supply of bidder without extra cost to the purchaser. The bidder's scope of work shall include, but not limited to, the following:

#### 3.2.1 Scope - Mechanical Works

##### i) Ducting and flue gas path

- a) Dismantling of existing facilities/ structures, where so required and their relocation at new area to be indicated by the Purchaser, rerouting of over ground and underground pipes, cables, ducts, etc. as necessary for erection and commissioning of FGD system.
- b) Flue gas duct work for each FGD plant, from existing ID fan discharge duct to inlet of booster fans, from discharge of booster fans to inlet of absorber and from outlet absorber to the new wet stack. Ductwork shall be complete with all structural supports, stiffeners, quick opening access doors, flanged duct connections, corrosion protection lining for duct downstream of the absorber & for wet flue(s), thermal insulation, test connections, etc.
- c) Necessary isolation dampers required for interconnection of FGD plants with existing flue gas path, for by-pass of flue gas to existing chimney and dampers at inlet and outlet of booster fans along with 2 x100% seal air fans.

##### ii) Booster Fans

For 500 MW unit, two (2) nos. axial booster fans each of capacity 60% with constant speed motor drive and blade pitch control for each FGD plant along with oil cooling system comprising of lube oil tank, 2 x 100% lube oil pumps, coolers, duplex oil filters etc. and other accessories as required.

iii) **Absorber System**

- a) Each unit shall be provided with one (1) wet limestone absorber tower made of carbon steel provided with lining/ cladding of SS 317 LMN / Alloy 31/ Hastelloy C22/ C 59/ C276 or equivalent high nickel alloys of suitable thickness. The absorber shall be complete with limestone spray nozzles, packing, mist eliminators, water distribution systems, wash water nozzles, oxidation air grid, headers and nozzles, agitators, inlet/outlet connections for flue gas ducting and manholes, ladders, maintenance scaffolding platforms, hand railing and fittings etc. and all internal systems integral to the satisfactory working of absorber.

In case the bidder offers an absorber with single spray level or with gas bubbling through the slurry as per his or his collaborator's proven and standard practice, the components as per his design shall be applicable.

- b) Each absorber tower shall be provided with multiple limestone slurry spray levels (minimum 4 nos.) or a single spray level as per bidder or his collaborator's proven and standard practice. In case of multiple spray level design absorber, each spraying level shall be provided with one individual limestone slurry recirculation pump. One spray level shall be kept as spare to meet 100% availability of the FGD plant in case of failure of any one slurry recirculation pump or one spray level. In case of single spray level design absorber, multiple numbers of identical slurry recirculation pumps shall be provided with one number recirculation pump kept as standby pump. In case of bubbling type absorber with flue gas bubbling through the limestone slurry, gas distribution system to the slurry and 3x50% gas cooling water pumps shall be provided to cool and saturate the incoming hot flue gas.
- c) One (1) mist eliminator wash water tank along with 2 x 100% mist eliminator wash pumps (if applicable).
- d) One (1) no emergency slurry storage tank (common for both units to store slurry content of one absorber. The emptying of the absorber sump shall be done by the gypsum bleed pumps. Tank shall be suitably lined, provided with agitators and 2 x 100% slurry transfer pumps to pump slurry back to absorber in 8 hour (max).
- e) Emergency quenching system including dedicated water tank of adequate capacity, 2 x 100% capacity pumps and associated piping to cool the flue gas inlet to the absorber in case of sudden rise in flue gas temperature.
- f) Forced oxidation equipment comprising of 2 x 100% blowers/ compressors for each absorber, complete with all accessories and silencers.



g) Two (2) x100% gypsum bleed pumps for each absorber taking suction from the absorber sump.

iv) **Limestone Unloading, Crushing & Storage System**

The limestone of size (-) 250 mm shall be received at power plant in trucks and shall be unloaded and stored at some convenient place in the power plant. The storage area of RCC with covered shed shall have capacity for 15 days limestone requirement of the power plant. Limestone to the FGD area shall be supplied by trucks/ dumpers.

In the FGD area, two streams of limestone unloading, feeding, crushing and silo storage facility common for both units shall be provided. 100% capacity (per hour) of each stream feeding and belt conveyor system shall be equal to 6-hour requirement of both the units (minimum 60 t/h for 2x500 MW units). Each stream shall consist of one underground receiving hopper of adequate size, vibrating feeder, conveyer belt (110 % capacity) with telescopic chutes, 2 x 100% crushers (common for both streams), bucket elevators, two crushed limestone silos each of storage capacity of 24 hours requirement of the FGD system.

**In case crushed limestone of size (-) 25 mm is supplied to the plant, 2x100% limestone crushers and bucket elevators shall not be provided and limestone conveyor belts after pent house shall be directly led to crushed limestone silos.**

v) **Limestone Grinding, Slurry Preparation and Storage System**

a) Two streams of Limestone slurry preparation system common for both units shall be provided. The 100% capacity (per hour) of each stream shall be equal to 3 hour requirement of two units (minimum 30 t/h). Each stream shall be fed limestone from crushed limestone silo and shall consist of gravimetric feeder, wet ball mill (110% capacity), hydrocyclone, mill circuit tank & 2x100% pumps, limestone slurry storage tank (12 hours requirement of both the units). The limestone slurry storage tanks of two units shall be interconnected and shall be provided with 2 x 100 % slurry feed pumps for each absorber unit.

b) Lube oil system for ball mills comprising of lube oil tank, 2 x 100% lube oil pumps, coolers, duplex oil filters.

vi) **Gypsum Dewatering & Handling System**

a) Two streams of complete gypsum dewatering & handling system, common for both units, shall be provided. Each stream shall comprise of 1 x 100 % primary hydro-cyclone, 1x100 % vacuum belt filter along with 2x 100% vacuum pump with vacuum receiver of adequate capacity, 2 x 100% belt wash pumps. The gypsum from discharge of vacuum belt filter shall be collected in the common storage area of RCC on ground floor beneath the floor of filters for further

transportation by trucks. **Alternatively, gypsum from discharge of vacuum belt filters shall be collected by transfer belts and conveyed to a separate gypsum storage area from where it shall be further transported by trucks.** The gypsum storage area shall have capacity to store gypsum production of both the units for five (5) days. The system shall be capable of producing gypsum with residual moisture not more than 10 %, chloride content less than 100 ppm and purity not less than 90 % (depending upon purity of available limestone).

- b) The overflow from the primary set of hydro-cyclone shall be taken to reclaim water tank of minimum one hour capacity of both the units. Reclaim water tanks shall be provided with agitator and 2x100% pumps along with piping for transferring water to 2x100% secondary hydro-cyclones. The underflow from secondary hydro-cyclone shall be collected in a filtrate tank of minimum one hour capacity. 2 x 100% pumps shall be provided for transferring filtrate to wet ball mill/ gypsum recovery system. The overflow from secondary hydro cyclone, as waste water of FGD plant to restrict its chloride level, shall be collected in 2x100% waste water tanks each of two (2) hour capacity of both the units.

Alternative scheme for gypsum dewatering & handling system as per proven and standard practice of the bidder shall also be acceptable subject to approval of the purchaser.

vii) **Waste Water Treatment & Disposal System**

Waste water treatment system for neutralization of FGD waste water by lime dosing shall be provided and treated waste water shall be led to existing ash water handling system.

3.2.2 **Scope – Civil & Structural Works**

- i) The Civil & Structural works to be performed under this specification consist of construction of all the structures, buildings, foundations and facilities as required for successful completion and commissioning of FGD plant including construction of a new wet chimney. The scope also includes supply and transportation of all the construction material, labour, scaffolding, construction equipment, tools and plants, and all other incidental items not shown or specified but reasonably implied or necessary for successful completion of the work including necessary technical supervision during construction in strict accordance with the approved drawings, technical specifications, applicable Indian Standard Codes, directions of owner, etc.
- ii) As the present work involves retrofitting of FGD plant, it shall be the responsibility of the contractor to modify, rectify and strengthen the existing structures at the interface with the new FGD plant as per the requirements.



- iii) The nature of work shall generally involve demolition, excavation, dewatering, shoring, back filling around completed structures, plinth protection, disposal of surplus earth, plain & reinforced concrete work, form work, precast concrete work, brickwork, damp proofing, fabrication and erection of structural/miscellaneous steel, steel inserts, anchor/foundation bolts, steel gratings, various types of flooring, false ceiling works, architectural works, water supply & sanitary works, drainage work, road works, other building works etc. as per the requirements for successful commissioning of FGD plant.
- iv) The scope of civil, structural and architectural works for retrofit of wet limestone FGD plant shall include the following but not limited to:
  - a) Detailed design and engineering including preparation of all civil/ structural/ fabrication/ Architectural drawings for the complete FGD Plant;
  - b) Geotechnical investigations, site clearance including grubbing, removing of shrubs, trees etc., survey, earth cutting & filling, plant leveling and grading including micro grading, area paving, gravel filling etc. as per requirement of actual site.
  - c) One twin wet flue chimney of RCC construction of height 150 m (for 2x500 MW units) with flue liner at downstream of FGD system along with rake & pinion type elevator and wet chimney condensate collection system etc. Purchaser to check for adequacy of the indicated height as per MoEF&CC's requirement. Alternately, in case existing chimney is to be used, the scope of work shall include retrofitting works of providing corrosion protection lining on chimney flues and wet chimney condensate collection system, etc. as required.
  - d) Bulk limestone receiving, unloading & storage area made up with concrete paving and RCC columns, pedestal and beams with covered shed made up of steel structure and G.I. sheets to be suitably provided in the power plant area. The limestone storage area shall be suitably dyked with brick walls for preventing spilling of the limestone in the adjoining area.

In the FGD area, the unloading facilities with underground receiving hoppers of required capacities shall be provided as specified in mechanical scope of work. The hoppers shall be of MS construction with stainless steel lining.

- e) Conveyor galleries from receiving hopper to the crushers. These galleries shall be partly underground and partly over ground. The underground portion of galleries shall be RCC construction and over ground portion shall be of structural steel with suitable sheet cladding



& roofing. The underground portion of conveyor galleries shall have proper ventilation & drainage arrangement.

- f) The crushed limestone storage silos as specified in mechanical scope of work. These shall be of mild steel construction with stainless lining for protection against abrasion and chemical attack by reagent.
- g) Construction of buildings in different areas for housing limestone feeding, crushing (if applicable), grinding facilities, limestone slurry preparation facilities, limestone slurry pumps, slurry recirculation pumps, air blowers, air compressors, gypsum dewatering and handling system, waste water treatment system, miscellaneous pumps, FGD control room, MCCs in different areas.

The buildings shall be of RCC with brick wall cladding. The buildings shall have adequate circulation space for inspection & maintenance purposes and shall have separate rooms for various facilities and other civil amenities like office room, store, toilets etc. as per the requirements of the system. The buildings shall have suitable hoisting arrangement for handling the equipment during erection and maintenance as required.

The gypsum dewatering and handling system shall be common for both units of the station. The gypsum from discharge of vacuum belt filter shall be collected in the common storage area of RCC on the ground floor beneath the floor of filters for further transportation by trucks.

- h) Reinforced concrete pedestals/foundation as required for supporting various equipment.
- i) Construction of foundations including piling works (if required) for absorber, booster fans, various tanks, pumps, air blowers, hydro cyclones and other associated equipment as per scheme defined in the mechanical scope of supply. The foundations shall be of reinforced concrete construction.
- j) Construction of all cable trenches, pipe & cable racks, trestles and their foundations, RCC culverts and concrete pipes for underground facilities.
- k) Construction of necessary approach roads/paths for connecting with the existing roads/paths of the plant for providing the access to the facilities of FGD Plant.
- l) Construction of necessary drainage facilities for new structures/buildings of FGD plant and their inter-connection with existing plant drainage system.



- m) Providing water supply & sanitary facilities and their inter-connection to existing system required for various buildings of FGD Plant.
- n) Any other civil & structural work required or necessary for successful commissioning of the FGD Plant.

### 3.2.3 Scope - Electrical works

There will be mainly four areas of the FGD equipment system viz. limestone unloading & crushing; limestone slurry preparation; absorber area and gypsum dewatering/ handling systems. The purchaser shall provide two (2) nos. 11/6.6kV supply feeders (as applicable) from his switchgear (preferably from two different sources). Further distribution at 3.3/0.415kV level shall be done by the bidder for entire FGD plant. Tentatively, the scope of electrical works shall include but not limited to the following:

- i. HT Switchgears:
  - a) HT switchgear of adequate rating consisting of two incomers and one bus coupler which shall cater to all the HT/ LT loads of FGD system. This switchgear shall be located in switchgear room for FGD plant. The two (2) no. incomer feeders for this switchgear shall be provided by the purchaser from his 11/6.6kV station board(s) (preferably from two different sources from reliability point of view). However, the bidder shall supply, lay and terminate these incoming cables in his 11/6.6kV switchgear. Further distribution for various HT loads for entire FGD system shall be in scope of the bidder.
  - b) Each HT switchgear to be provided by the bidder in different areas viz. absorber area, limestone preparation area, gypsum handling area shall be having two incomers and one bus coupler which shall cater to all the HT loads of that area.
- ii. Transformers:
  - a) Two (2) no. 11/0.433kV or 3.3/0.433kV or 6.6/ 0.433 kV cast resin dry type/ Oil filled transformers of adequate rating located at absorber area of FGD Plant.
  - b) Two (2) no. 11/0.433kV or 3.3/0.433kV or 6.6/ 0.433 kV, cast resin dry type/ Oil filled transformers of adequate rating located at "Limestone unloading, storage & crushing facilities"
  - c) Two (2) no. 11/0.433kV or 3.3/0.433kV or 6.6/ 0.433 kV, cast resin dry type/ Oil filled transformers of adequate rating located at "Limestone slurry preparation facilities".
  - d) Two (2) no. 11/0.433kV or 3.3/0.433kV or 6.6/ 0.433 kV, cast resin dry type/ Oil filled transformers of adequate rating located at "Gypsum handling facilities."





- e) These transformers shall get its incoming supply from bidder's 11/6.6/3.3kV switchboard mentioned above.
  - f) Any other transformer required for completeness of the system.
- iii. 415 V Switchgear:
- a) One no. 415V switchgear of adequate rating consisting of two sections coupled through circuit breaker shall be provided for FGD plant and located in switchgear room. This switchgear shall get its supply from 11/6.6/3.3kV switchgear through 2x100% rating transformers and shall feed power to various LT loads of absorber area of FGD Plants.
  - b) One no. 415V switchgear of adequate rating consisting of two sections coupled through circuit breaker shall be provided for "Limestone unloading, storage & crushing facilities" located in switchgear room. This switchgear shall get its supply from bidder's 11/6.6/3.3kV switchgear through 2x100% rating transformers and shall feed power to various LT loads of "Limestone unloading, storage & crushing facilities".
  - c) One no. 415V switchgear of adequate rating consisting of two sections coupled through circuit breaker shall be provided for Gypsum Dewatering Handling system and located in switchgear room. This switchgear shall get its supply from 11/6.6/3.3kV switchgear through 2x100% rating transformers and shall feed power to various LT loads of Gypsum Dewatering Handling facilities.
  - d) One no. 415V switchgear of adequate rating consisting of two sections coupled through circuit breaker shall be provided for limestone slurry preparation system and located in switchgear room. This switchgear shall get its supply from 11/6.6/3.3kV switchgear through 2x100% rating transformers and shall feed power to various LT loads of limestone slurry preparation facilities.
  - e) Any other 415V switchgear/ MCC/ Distribution board required for completeness of the system.
- iv. As the present work involves retrofitting of FGD plant, the power supply arrangement (transformers/ 415V switchgear) for different areas can be clubbed together provided both the areas are located nearby depending upon the layout.
- v. All electrical drives for equipment.
- vi. Local push button stations for all drives and local motor starters for ventilation fans.



vii. Connections

- a) Connections from 11/6.6 kV source of supply (purchaser) to 11/6.6 kV switchgear located in switchgear room for FGD Plant shall be through 11/6.6 kV Cables.
- b) Connections from 11/6.6/3.3kV switchgears to 11/0.433 and 3.3/0.433kV or 6.6/0.433kV transformers shall be through Cables/ Bus ducts.
- c) Connections from 11/0.433kV and 3.3/0.433kV or 6.6/0.433kV transformers to 415V LT switchgears shall be through LT Bus ducts.
- d) 11/6.6/3.3kV cables shall be XLPE insulated, FRLS PVC sheathed.
- f) LT power cable shall be 1.1kV grade XLPE/ PVC insulated and FRLS PVC sheathed and control cables shall be 1.1kV grade PVC insulated and FRLS PVC sheathed

viii. Supply, laying and termination of all required power, control and instrumentation cables, conductor and LT bus duct.

ix. Complete cable facility including cable laying along with cabling accessories, cable trays with supporting, structures, termination and joining kits, cable trenches, overhead trestles, etc. as required for the cables.

x. 220 V DC system

220 V DC, lead acid (Plante)/ Ni-Cd battery (Pocket plate High discharge type) with two (2) nos. float cum boost chargers and associated DC distribution board to be provided (separately, if required) for absorber area of FGD plant, "limestone unloading, storage & crushing facilities", "limestone slurry preparation facilities" and "Gypsum handling facilities".

(Note: In case DC feeders with sufficient capacity are available in the existing DC system of the plant, the same may be used with purchaser's approval. However, supply, laying & termination of cables shall be in bidder's scope of work)

xi. Lighting system :

Complete illumination system as required for complete internal and external lighting of associated plant, building, including wet chimney and roads. Aviation lighting for chimney shall also be in bidder's scope of work.

xii. Safety grounding of all electrical and other equipment and lightning protection along with earth grid and its interconnection to the nearest earth grid.

(Note: In case 6.6kV supply is not available in the plant, the 11kV or 3.3kV HT supply shall be considered as per requirement and availability).



### 3.2.4 Scope- Control & Instrumentation Works

Bidder shall design, engineer, manufacture, supply, erect and commission the complete Control & Instrumentation (C&I) systems including all necessary field instruments, vibration transmitters, analysers, sensors, safety switches, local/ remote monitoring, control and protection system required for safe and efficient operation of FGD system. Programmable logic controller (PLC) based control system with hot redundant controller, redundant power supplies, I/O cards and redundant communication modules for FGD plant of each unit and common systems. The control room shall be common for both the units. The scope of supply shall include but not limited to following:

- i) Two (2) 24" operator work stations, one for scrubber system of each unit.
- ii) One (1) 24" operator work station for common facilities.
- iii) One (1) 24" redundant server based engineering work station common for both units.
- iv) One (1) engineering laptop with master software.
- v) One A4 size coloured laser jet printer and One no. A3 sized Dot matrix Printer
- vi) Local Control Panel in limestone unloading and feeding plant area for control of conveyors, vibrating feeders, crushers etc. with interface to FGD PLC.
- vii) Local instruments, such as pressure/ temperature/ level/ flow gauges, switches, transmitters etc.
- viii) Special instruments viz. SO<sub>2</sub> measuring instrument/ analyser at FGD inlet & outlet, vibration analyser, calibration instruments, pH measuring instrument/ analyser.
- ix) Continuous emission monitoring system (CEMS) comprising of analysers and associated items for measurement of SO<sub>x</sub>, NO<sub>x</sub>, CO<sub>2</sub>, Mercury, Particulate emission (dust density/ stack opacity) monitor, stack flue gas ultrasonic flow meter etc. for chimney emission monitoring.
- x) Interlock, and Protections.
- xi) Closed loop control system.
- xii) Hardwired and soft link interfacing with the existing unit DCS as required to ensure safe, reliable and integral operation of the FGD system along with the respective Unit operation.
- xiii) Instrument hook up material, erection hardware, impulse tubing/ piping, fitting, racks, stanchions, enclosures, junction boxes etc. for bidder supplied instruments/ analyzers/ devices etc.



- xiv) All interconnecting I&C cables, communication cables, special cables between bidder supplied equipment, devices and for interconnection/integration with existing unit DCS/ DDCMIS.
  - xv) All accessories, special tools, testing instruments, all erection hardware etc.
  - xvi) 230 V AC Parallel redundant UPS with SVS and 1x100% Ni Cd battery bank. Parallel redundant 230 V AC to 24 V DC convertor shall be provided for 24 V DC power supply.
- 3.2.5 One (1) no. process water tank common for both units (4 hours capacity) along with 2 x 100 % process water pumps along with associated piping valves & fittings.
- 3.2.6 2x100% DM booster pumps for DM water cooling of FGD system equipment.
- 3.2.7 All drain sump pits along with 2x 100% sump pumps for absorber area (with agitators, if required), gypsum dewatering area, lime stone slurry preparation area etc.
- 3.2.8 2x100% seal water pumps, if required.
- 3.2.9 Complete slurry line flushing system including surge tanks and 2x100% booster pumps.
- 3.2.10 The limestone conveying system and gypsum conveying system (if applicable) including conveyor drives, idlers, belting, pulleys and necessary protection devices.
- 3.2.11 Two (2) nos. limestone sampling units, one for uncrushed limestone before crusher system and one for crushed limestone after crusher system complete with all accessories and auxiliaries etc.
- 3.2.12 2x100% indoor, reciprocating air compressors and 2x100% air dryers, common for both units, of suitable capacity and discharge pressure complete with accessories shall be provided to cater the requirement of instrument air for valves etc. The service air for various buildings and facilities of FGD system shall be taken from existing service air system, tapped from a terminal point identified by the purchaser.
- 3.2.13 The structural steel work for mechanical equipment such as conveyor support frame, deck plates, chutes.
- 3.2.14 All hoisting equipment, tools and tackles required for removal and maintenance of rotating and non-rotating equipment of entire FGD system. This shall include structures, gantries, hoists, trolleys and supporting steel structure.
- 3.2.15 Complete service and instrument air distribution system for the entire FGD system.



- 3.2.16 Complete wash down hose system for entire FGD system with 15m hoses along with connections.
- 3.2.17 Thermal insulation of all flue gas ducting, gas to gas heat exchangers, booster fans and scrubbers etc. as applicable.
- 3.2.18 One (1) number passenger cum goods elevator of minimum capacity 1000 kgs for each absorber for easy access & movement of men & material.
- 3.2.19 Interconnecting piping, fittings, valves, nuts and bolts, mountings, gaskets, supporting arrangement, pipe anchors, pipe hangers, trestles, vibration isolation arrangement, anchor bolts, foundation plates etc. as required for lime preparation, absorber and gypsum handling area and for completion of the FGD system.
- 3.2.20 Ventilation system for all buildings including conveyor gallery and air-conditioning of FGD control room.
- 3.2.21 Fire detection, protection & alarm system for complete FGD system and its integration with existing system.
- 3.2.22 Service and potable water system for the complete FGD system.
- 3.2.23 Vibration monitoring system for booster fans and crushers including vibration probes, transducers, junction boxes, vibration monitoring racks and interconnecting cables.
- 3.2.24 Mandatory spare parts for trouble free operation of the FGD plants as included in the specification.
- 3.2.25 Supply of commissioning spares and all lubricants, greases and consumables etc. as required during erection, testing, commissioning and till handing over of the FGD system
- 3.2.26 Complete erection hardware for the FGD system.
- 3.2.27 One set of special tools and tackles including testing, calibrating and measuring instruments required for erection, assembly, necessary tools and tackles required for operation and maintenance of all equipment/ systems covered under the scope of bidder shall be supplied. These shall not be used for erection/ commissioning purposes and shall be in unused condition. A list of such special tools and tackles shall be submitted along with the bid. The list shall include wrenches, spanners and screwdrivers, special bolts and or other accessories required for proper assembly, field welding equipment, necessary special wrenches and jigs and tools for disassembly and reassembly of pump rotors, and repacking glands, tools and tackles considered necessary for proper erection, operation and maintenance of the instruments and one (1) repair kit for field patching of cracked rubber lining along with sufficient patching material.



- 3.2.28 Painting/ anticorrosive treatment of complete FGD system.
- 3.2.29 Analytical/laboratory instruments and chemicals required for analysis/quality control of inputs to FGD viz. chemicals and lime stone and outputs from FGD viz. flue gas, waste water, solid waste etc.
- 3.2.30 Training of owner's staff in operation and maintenance of system.
- 3.2.31 Any other item not specifically mentioned in the specification, but considered necessary for safe and efficient operation of the system.

### 3.3 TERMINAL POINTS & EXCLUSIONS

#### 3.3.1 Terminal Points

- |    |  |   |
|----|--|---|
| 1  | Flue gas inlet to FGD plant  | : To be tapped from common outlet duct of existing I.D. Fans.   |
| 2. | Treated flue gas from exit of FGD  | : To be connected to the new wet chimney to be constructed by the bidder with provision for bypass of raw flue gas to the existing chimney. |
| 3. | Water for limestone slurry preparation   | : CW blow down water (clarified water) to be tapped from a terminal point to be identified by owner.  |
| 4. | Clear/clarified water for cleaning of mist eliminators/ demisters, sealing of limestone slurry handling pumps, gypsum dewatering cloth | : To be tapped from a terminal point to be identified by owner.   |
| 5. | Water for fire hydrant system of the FGD plant system  | : To be tapped from a terminal point to be identified by owner.   |
| 6  | Overflow/drain connections and drain channels of various equipment in all areas of FGD plant   | : To be collected in a sump in respective areas for recycling in the system or for transfer to wastewater treatment system.                 |
| 7  | DM cooling water for equipment cooling   | : To be tapped from and returned to suitable terminal points to be identified by owner for two units.                                       |



- |    |   |   |  |
|----|---|---|--|
| 8  | Service water for various plant areas   | : | To be tapped from a terminal point to be identified by owner.                                    |
| 9  | Potable water for various plant areas   | : | To be tapped from existing potable water system.   |
| 10 | Service air for the intermittent cleaning of the equipment in various plant areas | : | To be tapped from the existing service air system.   |
| 11 | Power supply for the equipment located in various plant areas                     | : | Requisite number of 6.6 kV feeders shall be provided by owner at the various required locations. |
| 12 | C&I hardwired signal exchange with existing plant                                 | : | To be connected with Main Plant DCS.   |

### 3.3.2 Exclusions

- i) Firefighting system and Equipment (unless specifically included in scope).
- ii) Station wide LAN.
- iii) Receipt, unloading and storage of limestone at plant site.



## SECTION 4.0

### MECHANICAL WORKS

#### 4.0 TECHNICAL SPECIFICATION- MECHANICAL WORKS

##### 4.1 Flue Gas System and Duct works

###### 4.1.1 General

All gas ducts required within the FGD system and for connection of FGD system to the boiler gas paths shall be provided and shall conform to the requirements specified herein.

- i) Flue gas ducts tapped from discharge duct of existing ID fans to inlet of booster fans and from discharge of booster fans to inlet of absorbers shall be of all welded construction of steel plates of suitable thickness but not less than 7 mm and shall be adequately stiffened by means of rolled sections. Suitable stiffening to prevent sagging, distortion, excessive vibration and pulsation under any operating conditions shall be provided.
- ii) The flue gas duct from outlet of Absorber to the new wet stack shall be made of STEN-I or equivalent of minimum 9 mm thickness. Alternatively, the ducts shall be made of 7 mm thickness carbon steel provided with a flaked glass lining, if the contractor has proven experience of the same.  
  
Lining shall be attached properly to the base to ensure that the base material does not come into contact with the corrosive gases under any circumstance. Sufficient overlap of the lining material shall be provided. Suitable stiffening to prevent sagging, distortion, excessive vibration and pulsation under any operating conditions shall be provided.
- iii) A corrosion allowance of 1.5 mm shall be considered for stress calculation for gas ducts.
- iv) All flue gas ducts shall be designed either for pressure or vacuum of +/- 660 & -150 mmwc (g) respectively at 67% yield strength or for maximum conceivable pressure of Booster fan whichever is higher.
- v) The velocities of flue gas in the ducts shall not exceed 15 m/sec. The design shall ensure equal distribution of flow. Flow distribution vanes shall be provided in ducts wherever required. Bends provided shall be smooth to streamline the flow. Cross section and flow direction changes must not allow creation of dead spaces with possibility of fouling. Model studies of duct work may be carried out for optimum flow distribution with minimum pressure loss.





- vi) Bracing and stiffeners shall be designed to prevent corrosion and erosion.
- vii) Turbulence and resistance should be minimized especially in the proximity of fans/air heaters. Turning vanes/splitter plates shall be provided if required to streamline the flow.
- viii) The duct work upstream of absorber and the quenching/gas cooling zone shall be designed to withstand the temperature rise associated with the failure of air pre-heater at full load operation.
- ix) The design of the duct work and supports shall ensure freedom from vibration and noise.
- x) Bolted joints shall be reduced to the minimum and wherever employed shall be provided with asbestos gaskets or approved equivalent for gas/air tightness.
- xi) Duct work shall be insulated so as to restrict the surface temperature up to 60° C and the duct design shall incorporate adequate fixing cleats for this purpose. The insulation and cladding provided shall conform to the provisions laid down elsewhere in this specification.
- xii) Thermal insulation shall be applied to all air/ gas ducts to comply with the requirements as specified elsewhere in this specification.
- xiii) Acoustic insulation shall be used, if required, in gas ducts to restrict the noise level to specified values.
- xiv) The duct layout shall ensure that there is no accumulation of acid mist on the duct floor. The absorber outlet duct shall not have any horizontal section for this purpose.
- xv) A wash system shall be provided to prevent the accumulation of dried slurry solids/ dissolved slurry solids at wet/ dry interface where hot flue gas is contacted by scrubbing slurry in the Inlet duct of absorber. The wet/dry interface in the quenching area/ gas cooling zone shall be made of solid Alloy 59 or C276 of minimum 6 mm thickness.
- xvi) All ducts shall have a sufficient slope with respect to horizontal so that any chance of accumulation of ash particles or water in the duct can be avoided under all normal/abnormal operating conditions. Drainage facility shall be provided for all ducts where significant quantities of water are liable to collect under emergency conditions. The ducts shall be routed such that satisfactory condensate drainage is ensured. The inlet duct shall have minimum 10 degrees downward slope in the direction of absorber. Any material collected in the inlet duct shall be taken to reaction tank.



- xvii) Drain fittings shall be sized to pass the expected drain flow. Drain fittings shall be fabricated of alloy material (at least Hastelloy C or better) or FRP if surrounding requirements can be fulfilled. Additional drains shall be provided based on results of the flue gas flow model study to be furnished by Contractor. Drains shall be returned to the FGD drain pit or the absorber sump to be constructed by the bidder for the purpose. The drain scheme shall be approved by the purchaser. No drain line shall be sized below 25 mm ID. All drain lines shall be provided with two isolating globe valves in series.
- xviii) Access doors shall be provided to permit access to all duct sections for inspection and maintenance of duct work and ductwork accessories including expansion joints and dampers. They shall be of adequate size, gas tight with bolted closing arrangement and shall be of hinged type. The required ladders/staging for maintenance inside the duct shall be included. Dampers shall be accessible from both directions by way of associated inspection doors in near vicinity.
- xix) The ducting shall be complete with required number of expansion joints, hangers, supports, flanges, gaskets, access platforms, ladders etc. Expansion joints shall, where necessary, be provided with internal plates to prevent and to eliminate the deposition of dust in the joints. A capped nipple type connection shall be provided at the bottom of all expansion joints to facilitate air cleaning.
- xx) A series of test points shall be arranged in the duct work at approved position so that the distribution of gas, can be tested.
- xxi) Instrument measuring connections, and sampling devices shall be provided to permit a full range of measurements in raw and clean gas ducts. Measurements of total gas flow, pressure, temperature and concentrations of SO<sub>2</sub> shall be provided.
- xxii) Particular attention shall be given to thermal expansion of the ducts and steel structure, in order to avoid inadmissible forces to connected equipment. Thermal expansion shall be accommodated by means of expansion joints with an internal guided plate. The ingress of fly ash and FGD by-product into the expansion joint shall be prevented. Sliding bearing supports shall be provided as required to permit the thermal expansion of ductwork. The material chosen for expansion joints shall be suitable for the duty conditions and the corrosive atmosphere of the FGD system and shall be field proven for similar applications. The expansion joint shall have a minimum guaranteed life of not less than 20000 hrs. of operation.
- xxiii) All ductwork provided by Contractor shall have external stiffeners only. No internal stiffeners or bracing are allowed. External ductwork stiffeners shall be spaced uniformly.



#### 4.1.2 Dampers

All necessary isolating and regulating dampers shall be provided. As a minimum, following dampers shall be included for each FGD plant:

- a) Inlet tap off point for FGD (1no.)
- b) At inlet and outlet of each booster fan (4 Nos. dampers)
- c) FGD bypass (raw flue gas to existing chimney) damper (1no.)

Alternative arrangement of dampers viz. inlet tap off to individual booster fan, as per proven and standard practice of the bidder, shall also be acceptable subject to approval of the purchaser.

The bidder shall furnish a list of dampers with their purpose and size, which are provided with servo-drives for remote control. All damper shall be motorized and provided with actuators and the complete link mechanism connecting the dampers and their actuator. Such dampers shall also have provision for manual operation during maintenance.

- i) The dampers shall be of balanced, heavy duty isolating gate type, of reputed make with their bearings sufficiently insulated to protect against overheating. However, FGD bypass damper and dampers at inlet to FGD system shall be required to open/close rapidly to ensure fast isolation/bypass of FGD system to prevent unit tripping in case of emergencies in FGD system/unit. Keeping the above requirement in view, double louver type dampers with sealing air system shall be provided for these applications. Such dampers shall also be acceptable for inlet & outlet of booster fans, if flow regulation of fans is proposed through dampers. The principal consideration for damper selection shall be zero leakage (100% leak tight with seal air fans under operation) and fast action (opening/closing). The zero leakage property of the dampers shall be demonstrated by the bidder at manufacturer's works and at site. Bidders shall indicate opening/closing time for each damper in bid data sheets. The bypass damper shall be capable of quick opening during emergency conditions within a time of 10-20 secs.
- ii) The dampers shall be of reputed make. The blades and frames of the dampers provided at the inlet and outlet of Booster fan shall be made of carbon steel.
- iii) The operation of dampers shall be suitably interlocked with booster fans, ID fan and existing controls of the unit to prevent mal operation leading to damage of the unit or FGD system.
- iii) Gas dampers shall be capable of being operated and be tight in the closed position under the maximum differential pressures without bending/warping or seizure, and shall be fitted with locking devices in the fully open and closed positions. The Bidders shall state the special features provided to make them gas tight to enable maintenance of equipment whilst the steam generator is in service.



- v) Special attention shall be given to the design of sealing arrangement of dampers to ensure that they provide a positive leak proof shut off when closed. Each damper shall be provided with its own arrangement for sealing air. The seal air system for each damper shall consist of an operating seal air blower and a stand by seal air blower. The blowers shall be designed with sufficient volume and pressure head, with seal air pressure always at least 50 mmwc(g) higher than maximum flue gas pressure.
- vi) All dampers shall be of non-lubricating type bearings in principle. However, in case lubricating type is applied, grease lines of stainless steel shall run from all the greasing points on each damper to a convenient and easily accessible location adjacent to the respective dampers and terminated with suitable clamps and grease nipples on a steel frame to facilitate easy lubrication. The bearings shall be outside of the duct.
- vii) All dampers shall be so arranged to facilitate local manual operation from a gallery or floor level. The operating gear shall be fitted with a graduated indicator and shall be designed such that the damper may be retained in any position. The force required for manual operation of the gate shall not exceed 35 kg (max.) at the rim of the hand wheel. The isolating dampers shall, in addition, be fitted with a locking device in the fully open and close position. All powered dampers shall also have provision for manual operation during emergency and maintenance along with graduated local position indicator.
- viii) Dampers shall close tightly and operate easily and smoothly without bending or fluttering under all operating conditions.
- ix) The actuator shall be equipped with positioning switches for both end positions, torque switches for both function directions, hand wheels for emergencies and mechanical interlock for maintenance work. In addition to this limit switches shall be provided with all dampers to indicate fully open and fully closed positions. These limit switches shall be independent of those provided with the drive units. Limit switches shall be provided at each end of travel and shall directly indicate the blade position.
- x) All the dampers shall be so located in flue gas paths that buildup of grit behind the damper blades is reduced to a minimum.
- xi) Weather hood to prevent rain water entry and accumulation shall be provided at damper top.
- xii) All dampers shall be easily accessible from both outside and inside of the ducts. For this purpose, Contractor shall furnish access platform (s) at each damper and its drives such that all components are fully and safely accessible by stairs. Drives shall move with dampers as the unit



expands and contracts. Platform size and location shall be based on the damper manufacturer's recommendation subject to owner's acceptance. The access from insides of the ducts shall be done by providing inspection doors at the gas ducts in close vicinity to the dampers from both sides.

#### 4.2 **Booster Fans**

Two gas booster fans, suitable for producing adequate draft for flow of flue gases through FGD system under all operating conditions, shall be provided for each FGD plant. The Booster Fans located downstream of the ID Fans in the inlet duct to Absorber shall be capable of handling the pressure drop in the FGD system & ducting and maintain required pressure at inlet to the new chimney over the entire load range with any one or both Booster fans in operation in conjunction with one or both ID fan in operation while firing the specified range of fuels. Fans shall be complete with drive motor, coupling, base plates fixing bolts and nuts. The booster fans shall meet the following requirements:

- i) Capacity of each fan shall correspond to 60% BMCR flow. Over and above value thus calculated, following margins shall also be applied for sizing the fan:

Margin on volume flow rate : 20%  
Margin on pressure corresponding to rated flow : 44%

However, the best efficiency point for the fans shall be at unit MCR. The bidder shall furnish the fan sizing calculations for approval of purchaser during detail engineering.

- ii) The gas booster fans for 500 MW size unit shall be constant speed, axial flow centrifugal type. The maximum speed of the fans shall be limited to 750 rpm. The booster fans shall be capable of fully meeting the pressure drop of the FGD plant and the associated ducting/dampers/fitting under all loading conditions. Booster fan shall provide for sufficient positive pressure at the inlet of wet chimney so as to facilitate effective discharge of wet flue gases into the atmosphere through the wet chimney.
- iii) The design shall incorporate such materials as to ensure reliability and high availability of the fan service under adverse conditions of corrosion in the flue gases. The dust concentration in flue gases is expected to be in the range 50- 200 mg/Nm<sup>3</sup>. The fan casing and impeller blades shall be provided with suitable renewable wear resistant liners of proven design. Suitable proven arrangements shall be provided for prevention of corrosion of fan components.
- iv) The design of fans shall ensure prevention of corrosion of areas coming in contact with flue gases, prevention of buildup on blades and erosion of blades and prevention of entrance of flue gas and condensate into interior of rotor and hub. All stationary parts coming in contact with flue



gases shall be provided with suitable lining or made from corrosion resistant materials. The rotor shall be made from high alloy stainless steel. The material of the construction of fan components shall be so chosen as to give long life to obviate frequent repairs and replacement of parts. Fan casing material shall be abrasion and wear resistant, high BHN steel having thickness minimum 8.0 mm or 12mm mild steel with liner of thickness 10mm (min.).

- v) Booster fan components such as blades, hubs, casing etc. shall be able to encounter the high dust burden of the order of  $200 \text{ mg/Nm}^3$ . The minimum wear life of Booster fan components shall not be less than 25000 hours of operation from the date of commissioning.
- vi) Water injection system shall be provided to prevent build up on blades and suitable drain system for draining of condensate shall be provided.
- vi) Fans shall be suitable for conditions of temperature excursions specified for FGD plant.
- vii) The fans shall be suitable for parallel operation with equal load sharing. Unbalance during operation shall be signaled through suitable indication/alarm. The fans shall be suitable for stable operation continuously at all loads from 30% to 100% of the fan capacity.
- viii) The fans shall be capable of operating satisfactorily in series with existing ID fans without any problem for complete range of operation
- ix) The following characteristic curves of the fan shall be submitted:
  - a) Flow v/s Total pressure
  - b) Flow v/s power consumption
  - c) Flow v/s efficiency

The system-resistance point at different loads shall be indicated in the above performance curves.

- ix) Fans shall be provided with blade pitch control regulation mechanism. The flow control shall be suitably interlocked/ integrated with existing boiler controls.
- x) Fan components along with blade pitch control mechanism shall be designed to withstand and continuously operate with the maximum air or flue gas temperature that these fans will be required to handle. Fan component shall also be designed to withstand the excursions in flue gas temperature up to 300 degrees Celsius, which may persist for about 15minute duration. Such temperature excursion will not inhibit the safe and smooth operation of fans or cause any damage or increased maintenance.



- xi) The fan shaft shall be designed in such a way that critical speed shall not fall within 125% of the operating speed. The fan should be statically and dynamically balanced.
- xii) Fan induced duct vibration due to flow pulsations shall be avoided through suitable design.
- xiii) Overhang type impeller designs shall not be accepted. Shaft shall be carried in bearings on either side of impeller and shall be independent of casing.
- xiv) Adequate temperature detectors and indicators shall be provided for remote and local monitoring of the bearing metal temperature of fans, motor and hydraulic coupling, (if any). Suitable vibration sensor devices shall be provided for monitoring the fan/motor bearing vibrations from FGD Control Room.
- xv) Noise shall be limited to maximum 85 dbA for all equipment (except of 90 dBA for wet balls mill and 95 dBA for limestone crushers) as measured at a distance of 1m and at a height of 1.5 meter
- xvi) For forced oil lubrication arrangement (if envisaged) for fans and drive motors, the complete pumping system with storage tanks, thermostats, coolers, strainers, filters, sight glasses, pressure gauges and separate pressure switches, flow gauges, differential pressure switches, dial thermometers and separate temperature switches, flow control valves etc. shall be furnished. The lube oil pumps and filters shall be 2x100% capacity with proper isolating valves etc. The system shall also include controls, starters, ammeters for lube oil pump motors, interlocks and protection for motors etc. for each fan and motor.
- xvii) Fan bearing shall be provided with oil bath to prevent damage in case of complete loss of plant auxiliary power when the fans must coast down without power. Adequate numbers of duplex Pt-RTD (100 ohms at 0 degree Celsius) or thermocouples and one no. temperature indicator shall be provided for each bearing.
- xviii) Fully wired interlocks and control panels common for both the fans shall be provided to the approval of purchaser. All necessary annunciations shall be provided for common annunciation on the FGD OWS for any trouble in the system.

#### 4.3 Wet Limestone Absorber System

##### 4.3.1 Absorber

- i) Two (2) nos. wet limestone absorber shall be provided (one for each unit) for absorption of SO<sub>2</sub> from the flue gases. The absorber shall be designed for 100% BMCR conditions with worst coal. The maximum flue gas flow



rate of each absorber shall be  $2,200,000^{11}$  Nm<sup>3</sup>/h having input SO<sub>2</sub> concentration of minimum  $1800^{12}$  mg/Nm<sup>3</sup> (wet). The SO<sub>2</sub> removal efficiency of each absorber shall be not be less than 92% for all loads from 50% to 100% Unit MCR. The guaranteed SO<sub>2</sub> concentration in flue at outlet of absorber under 100% TMCR condition shall not exceed  $150^{13}$  mg/Nm<sup>3</sup> at 6% O<sub>2</sub> on dry basis. The parameters of the inlet flue gas (at exit of existing I.D. fans) to be considered for the design of the FGD system have been indicated in Cl. No.1.4 of the specification. The spray type absorber shall be designed considering flue gas velocity not more than 4 m/s at design point.

- ii) The absorber can be circular or rectangular in cross-section. The offered shape of absorber by the bidder shall have proven and operating experience. Each absorber shall comprise of absorber sump, spray absorption section, spray level section(s). Minimum 10% spare nozzles shall be provided at each level.

In case the bidder offers an absorber with gas bubbling through the slurry as per his or his collaborator's proven and standard practice, the absorber shall be provided with flue gas distribution system to the slurry and 3 x 50% gas cooling water pumps shall be provided to cool and saturate the incoming hot flue gas. The cooling water pump discharge piping and spray water header shall be made of alloy 59 or C 276 or equivalent and nozzles shall be made of silicon carbide or ceramic or equivalent having minimum guarantee life of 20,000 hours.

- iii) Adequate nos. (minimum 4) of limestone solution agitators shall be provided for absorber sump. The contractor shall offer and demonstrate mixing arrangement such that n-1 number of agitators are sufficient to avoid the slurry settlement in the absorber tank in case of one agitator under breakdown.
- iv) The absorber internal shall be minimum to avoid the occurrence of scaling in absorber. There shall not be any diversion internals in the gas-liquid stage. Mist separator/ demister section shall be provided at the top of the absorber to trap any remaining absorbent suspension droplets.
- v) The absorber shall be of outdoor type construction to form a gas tight, liquid leak proof envelope. All penetrations to the shell shall be sealed and made leak proof. The absorber must be designed for the severe corrosive and abrasive environment and its influence on used materials. The absorber including the supporting parts of internals shall be made from materials suitable for the given environment at the temperature and pressure corresponding to the technological process.
- vi) Sufficient protection shall be provided for the base of the tank to prevent mechanical damage, particularly during maintenance. The material of

<sup>11</sup> To be provided by the purchaser

<sup>12</sup> To be provided by the purchaser

<sup>13</sup> To be specified by the purchaser.





process equipment of flue gas desulphurization system shall be appropriate for the chloride content and pH level at which the process is to operate.

- vii) The absorber and oxidation tank shall be made of minimum 7 mm thick carbon steel. The absorber tower, oxidation tank, absorber internals & other parts, absorber outlet duct shall be provided with minimum 2 mm thick lining/ cladding of SS 317 LMN / Alloy 31/ Hastelloy C22/ C 59/ C276 or equivalent. Special precautions shall be taken to prevent failures due to blistering, debonding and wear due to abrasive slurry which enables to keep time interval for necessary inspection and/or repairs in compliance with the duration of overhauls (period 5 years).
- viii) The absorber slurry tank shall be designed for 6 minutes retention based on the design absorber slurry flow rate.
- ix) Absorber built-in structures shall be of non-flammable materials.
- All interior baffles, braces and supports shall be designed so as not to trap dirt, sludge on scale and shall have convenient access for cleaning.
  - Sieve plates shall be installed at the vessel outlets to protect the circulation pumps and all other pump connected.
  - All necessary local and remote measurements shall be included viz. absorber level, pH-value, absorber temperature, differential pressure. Sufficient test measuring points for level, pressure and temperature shall be supplied.
  - Absorber internals slurry systems shall be designed to uniformity distribute the required spray flow. The flow through each spray level shall be fed singly by one circulation pumps.
  - Spray headers shall be designed to provide uniform distribution of slurry within the headers and branch piping to the slurry spray nozzles.
- x) The absorber shall be designed to operate without scaling or build ups in any part and clogging of nozzles/internals. Special features of the design to prevent such problems shall be clearly brought out in the bid. The operating and design philosophy indicating pH rangers in various zones under different loading conditions shall be indicated along with control mechanism. The bidder shall also indicate necessary safeguards provided to prevent catastrophic failures due to improper control and operation.
- xi) The bidder shall guarantee the operation of scrubber along with mist eliminators without fouling or plugging continuously for the period of 20,000 hours without cleaning which requires FGD shutdown. Access for possible inspections of the mist eliminator section shall be provided.
- xii) Provision shall be made for automatic spray of quenching water at the inlet to the absorber, in case the gas temperature exceeds the design



temperature due to failure of upstream equipment. For this purpose an emergency water tank shall be provided for each absorber along with 2 x 100% pumps (if required). Alternatively, separate emergency water tanks may not be provided if dedicated storage for emergency quenching requirement is kept in mist eliminator wash water tanks.

- xiii) The absorber sump shall be located above ground level so that its content can be completely discharged. Suitable provision shall be made for complete transfer of slurry in absorber sump to the common emergency slurry tank.
- xiv) The design of and materials selected for all nozzles shall be such that Rapid wear, encrustation and plugging is avoided. Hollow cone or spiral spray nozzles made of silicon carbide or equivalent shall be used.
- xv) The design of the external steel structure of the absorber must allow access to the whole surface of the absorber sheet, including the spaces beyond the service platforms (possibility of suspensions etc.).
- xvi) Mist elimination system
  - a) The mist elimination system shall comprise of minimum two sections of mist eliminators, one coarse and one fine. The mist elimination system shall be designed to limit the mist content of exit flue gas not to exceed 100 mg/Nm<sup>3</sup>.
  - b) The first mist eliminator (bottom) shall be located at least 5 feet above the last slurry recycle header (top) in the absorber module. For vertical mist eliminators, the spacing between the top of the first and bottom of the second mist eliminators should be at least 6 feet. The superficial gas velocity in the mist eliminator area should not exceed 10 ft/sec for vertical gas flow mist eliminators and 18 ft/sec for horizontal gas flow mist eliminators.
  - c) The type of chevrons used for both the first and second mist eliminators shall have continuous blades (baffle type mist eliminators with separated blades are not acceptable). The exit section of the first mist eliminator chevron shall be constructed with a straightening section and/or oriented such that the flue gas leaves in the essentially the same direction as it entered the mist eliminator.
  - d) The mist eliminator shall be FRP or polypropylene, of proven design and shall be capable of meeting ASTM E84 flammability standards. The mist eliminator chevrons shall be capable of withstanding the chemical and thermal environment in the absorber. They shall also be capable of being periodically washed with manual high pressure wash systems (3000 psig) without damage or failure.
  - e) The mist elimination wash system shall consist of a fixed grid of headers and nozzles that are capable of washing the front and back sides (upstream and downstream, respectively) of the first mist eliminator and the front side of the second mist eliminator. The



nozzles used in the wash system shall be full cone spray nozzles with no more than a 90 (degrees) spray angle, and they shall not use any moving parts to achieve the spray pattern. The overlap from adjacent wash nozzles shall provide a minimum of 150 percent coverage (on average) of the mist eliminators. The wash nozzles shall be located no more than 36 inches from the mist eliminator surface.

- f) Mist eliminator cleaning using clarified water/ CW blowdown water shall be performed automatically with provision for manual operation. Each mist eliminator face shall be automatically washed for a duration of at least one minute every hour. However, only one mist eliminator face of a given mist eliminator shall be washed at a time; the back side (top) of the first mist eliminator and the front side (bottom) of the second mist eliminator face may be washed at a time. The mist eliminator wash control system shall be capable of being easily reprogrammed to change the wash sequence, frequency, and duration. The wash system design shall ensure that the mist eliminators are cleaned thoroughly and it shall allow the operator to change the dwell time (length of time not washing), and the duration of wash of each segment.
- xvii) In case the multi spray absorber, limestone slurry required for absorption of SO<sub>2</sub> shall spray in the tower at the spray levels provided, with minimum distance of 1.5 m between each level, through suitable nos. of inlet connections. The spray system consisting of headers, laterals and nozzles etc. shall be designed to provide for uniform distribution of limestone slurry across the entire cross-section of the tower. The nozzles shall be designed to provide satisfactory spray pattern over a wide range of limestone slurry loading in the tower. The nozzles shall be of non-clogging type, and their design shall be suitable to handle limestone slurry solution.
- xviii) A wall wash system shall be provided to prevent the accumulation of either dried slurry solids or dissolved slurry solids where hot flue gas is contacted by scrubbing slurry wet/dry interface in the absorber inlet duct. The wet/dry interface in the quenching area / gas cooling zone and the absorber shall be made of solid Alloy 59 or C276 of minimum 6 mm thickness. All spray headers inside the quenching area/gas cooling zone and the absorber shall be made of C276.
- xix) The absorber tower shall be designed as to allow for easy inspection, to the cleaning and repair. Adequate number of viewing ports with flushing arrangement shall be provided to view the condition of absorber internals and process taking place during operation. Due consideration shall be given to the wind loading and appropriate stiffening shall be provided on the tower to prevent failure or bucking when empty or when subject to vacuum as per relevant Indian/equivalent standards.
- xx) The absorber tower shall be provided with manholes, ladders, maintenance scaffolding, hand railing etc. Each absorber shall have access door above each spray level, between the mist eliminator section, in the inlet duct and outlet duct. The supporting structure for limestone

slurry system and clear water distribution systems, mist eliminators shall be designed to ensure unrestricted upward flow of flue gas and downward flow of water. Supporting structure shall also be made of corrosion resistant materials. Lightning arresters and grounding connection shall be provided on each tower.

#### 4.3.2 Mist Eliminator Wash Water Supply System

- i) Clarified water shall be used for cleaning of mist eliminators and the system shall be provided unit wise. One no. service water/ clarified water storage tank and 2x100% capacity horizontal centrifugal pumps shall be provided for intermittent cleaning of demisters/ mist eliminators of each absorber. The capacity and head of the pump shall be as per spray cleaning requirement of the mist eliminators with adequate margins.
- ii) The storage capacity of the tanks shall be as per requirement of service water for intermittent cleaning of the mist eliminators. Input water to the storage tanks shall be supplied from process water tank. The tanks shall be made of mild steel and their design shall conform to Indian Standard or equivalent. The tanks shall be complete with inlet/outlet connections, overflow and drain piping connections, level indicator, manholes, air vents, and ladder etc. Level switches/ instruments shall be provided on the tanks for alarm annunciation and control interlock of demister cleaning pumps. Continuous water level reading of the tank shall be provided in the FGD control room.
- iii) The demister cleaning pumps shall be of centrifugal type having horizontal design and shall be suitable for outdoor installation. However, protection sheds shall also be provided for these pumps.
- iv) The pump casing, gland and stuffing box shall be of 2.5% Ni Cast Iron to IS:210 Grade FG 260 or equivalent. The impeller, wearing rings (as applicable) shall be of Stainless Steel316 grade and shaft & shaft sleeves shall be of SS-410 grade.
- v) The materials of construction of piping, valves and fittings etc. shall be of proven type as per duty involved and shall be subject to approval of the purchaser during detail engineering. The pump discharge piping up to the top of the scrubbers shall be of mild steel.

#### 4.3.3 Slurry Pumps

- i) Each absorber shall be provided with adequate number of limestone slurry recirculation pumps with minimum 1 standby pump, 2 x100% gypsum bleed pumps for supply of gypsum slurry to gypsum dewatering system, two (2) x 100% make up slurry pumps for each absorber, 2x100% emergency slurry transfers pumps (if required) and 2 x 100% slurry recirculation pumps for each mill. Other pumps required as per system requirement shall also be included.
- ii) The pumps shall be of horizontal type and designed for continuous operation. The pump shall be single stage centrifugal type capable of delivering the rated flow at rated head with margins as specified in the



respective clauses. The slurry concentration in the pump shall not exceed 30% by weight.

- iii) The slurry pumps shall be provided with design margin of minimum 10% in the rated flow and minimum 10% in the rated head calculated at duty point of the pump.
- iv) All the slurry pumps shall be provided with motorized suction and discharge valves. In addition, flushing water lines with motorized valves shall be provided for each pump for automatic flushing of the pump after each shut down. The flushing water for the pumps shall be taken from the process water supply.
- v) The pump casing should be radially split to allow easy removal of impeller.
- vi) The materials of construction of various components of the slurry pumps shall be of proven type as per duty involved. For absorber recirculation service a silicon carbide impeller with casing having Silicon carbide lining can also be supplied as per proven practice of the contractor.
- vii) All the pump wear parts in contact with the slurry shall be provided with replaceable rubber/elastomer liners suitable for the fluid handled. The material and thickness of the liners shall ensure a minimum service life of 2 years before replacement. All the wear parts of the pump shall be guaranteed for a minimum wear life of not less than 14000 hrs.
- viii) The pump shall be provided with seals of proven type and shall be designed for minimization of seal water consumption. The shaft shall be supported on heavy duty ball/roller bearings.
- ix) The design and construction of the various pumps shall meet the requirements of the horizontal centrifugal pumps described elsewhere in the specification.

#### 4.3.4 Oxidation Air blowers

- i) The air blowers shall be provided to supply the oxidation air for oxidizing calcium sulphite ( $\text{CaSO}_3$ ) to more stable and harmless compound calcium sulphate ( $\text{CaSO}_4$ ). 2x100% capacity oxidation air blowers shall be provided for supplying oxidizing air for oxidation of limestone slurry in the absorber sump tank of each FGD Plant. Minimum redundancy of 10% on oxidation air nozzles/ spargers shall be provided. Air supply headers shall be made of FRP or Carbon Steel with rubber lining (minimum 10 mm natural rubber lining), corruptions and erosion resistant in the inner and outer side (Silicon Carbide coating on metal/FRP surface exposed to slurry).
- ii) The oxidation air blowers/ compressors shall be of centrifugal/rotary/ positive displacement type and supplied with base frame with shock absorbers and mounting bolts, intake filter with hood, silencers, safety



valves and check valves etc. The blowers shall be of sturdy construction with various components made of suitable corrosion resistant material.

- iii) The air blowers shall be sized to supply at least 2.5 times the stoichiometric air requirement for spray tower process & at least 4.0 times the stoichiometric air requirement for Bubbling Type process or the actual requirement whichever is higher under design condition with 10% choking/ blockage each of the oxidation air nozzles. Further, a margin of 10% each on capacity and head of the blower shall be considered under above condition.
- iv) The air blower shall be compact and simple in design requiring minimum number of spare parts. The blower shall be designed for continuous operation and shall be of water-cooled/air cooled type. The rotor shall be ground all over and accurately machined. The rotor blades shall be made of chrome steel or equivalent and shall move freely and smoothly in the rotor slots. The shaft shall be of hot rolled steel or equivalent accurately ground, polished and keyed to the rotor. It shall run in precision heavy duty roller bearings. Lubrication system provided shall be designed such that visual checking of lubricant level is possible. The blower shall be provided with water jackets for cooling the bearings and the casing and prevent excessive heating of parts. The casing shall be of grey cast iron conforming to IS:210 grade 25 designed for the duty specified. The cooling water jackets shall be readily accessible for maintenance purposes. Provision shall be made to shut off the blower automatically should the level of the lubricating oil falls below the design value. The blower shall also shut-off automatically whenever the pressure of the cooling water supply line falls below a preset value. The first fill of the lubricant shall be given by the supplier.
- v) The roots blower shall be of twin lobe type with grey iron casing with alloy steel heat treated and lobes. The shaft shall be of high carbon steel accurately ground running in roller bearings. The bearing on both drive and end gear end and gears shall be oil lubricated. Both shafts shall have lip and labyrinth seals to prevent leakage of oil and air respectively.
- vi) The base plate for the blower, driver V- belt, pulleys, coupling, guards, pressure relief valves, air filter and silencer shall be included.
- vii) The blower shall be driven by an electric motor either directly coupled via flexible coupling or through v-belt drive. The bidder shall quote for both the alternatives. The belting system in the case of v-belt drive shall be provided with a heavy screen guard for ensuring safety and the motor shall be mounted on slide rails for adjustment of belt tension.
- viii) One cleanable, dry, air intake filter cum silencer to prevent dust and other atmospheric impurities from entering the blower shall be provided for each blower. The silencer shall reduce the noise level to 85 decibels at a distance of 1 meter from the blower. The filter area shall be at least



twice that of the inlet pipe area. The filter shall be suitable for removing dust particles down to 5 microns size.

#### 4.3.5 Agitators

Each limestone slurry handling tank and sump shall also be provided with adequate number of agitators including for redundancy.

In case bidder offers side entry agitators, minimum four (4) number agitators shall be provided for each absorber slurry sump to promote mixing, maintain a uniform slurry concentration. All agitators shall have minimum 6mm rubber lining on shaft and impeller. The contractor shall demonstrate that n-1 number of agitators are sufficient to avoid the slurry settlement in the absorber tank in case of one agitator under breakdown (n-total no. of working agitators).

The agitators shall be motor operated, robust in construction and capable of agitating limestone slurry and solid from time to time to prevent settlement of the slurry in the tanks. Protective devices shall be provided to prevent over loading of the agitators in case of increased slurry specially during start-up. The agitator must be able to mix up the contents of the tanks even after 24 hours operation break. Mechanical seals of the agitator shall be replaceable from outside of the tank in operation with minimum fluid leakage from the tank.

For horizontally mounted agitators, pressurized shaft sealing and shaft supports shall be provided. Seal water leakage shall be collected and piped to a drain.

#### 4.3.6 Process Water Storage Tanks & Pumps

- i) From the terminal point for process water/ clarified water (or any other type of water), the bidder shall draw water to separate water storage tank(s), designed to store 4 hours of total water required for the entire FGD process (including absorber system, mist eliminator wash system, limestone grinding and slurry preparation system and gypsum dewatering system etc.) for the FGD plant. The storage tank shall be of mild steel and shall be designed, fabricated, erected and tested in accordance with the IS:803, latest edition unless otherwise stated.
- ii) Process water shall be pumped from these tanks using 2 x 100% pumps to cater to the water requirement of the entire FGD system. The capacity of the pumps shall be such that total capacity of working pumps shall meet the process water requirement of the unit operating at maximum load with 10% margin.
- iii) The design and construction of the various pumps shall meet the requirements of the horizontal centrifugal pumps described elsewhere in the specification.

#### 4.3.7 Other Tanks

- i) The minimum number of tanks to be provided shall be as mentioned below:



- Two (2) x 100% (one for each unit) limestone slurry storage tanks.
- One (1) no. (common to both units) emergency slurry tank
- Two (2) nos. (one for each unit) emergency quenching water storage tank
- Two (2) nos. (one for each mill) slurry recirculation tank for wet ball mills
- One (1) no. (common to both units) reclaim water tank
- One (1) no. (common to both units) filtrate tank
- Two (2) no. (common to both units) waste water tanks

Any other tank(s) required as per process requirement and for completion of the FGD system shall be provided by the contractor without any extra cost to the purchaser.

- ii) All tanks except those specified otherwise shall be of mild steel. These shall be lined with suitable material capable of satisfactorily withstanding the respective fluids to be handled by these tanks. Each tank handling limestone slurry shall be complete with stainless steel (SS) motor driven agitators, dilution water inlet and limestone dosing connection. All tanks furnished by the Bidder shall be designed to be suitable for operating conditions. The tanks shall be provided with inlet and outlet connections, hand holes, manholes, connections for level gauges, vents, drain and overflow, etc. as may be required. All the tanks including chemical solution tanks shall be provided with drain valves and piping, overflow piping and the same shall be led to the nearest drain sump. All the non-pressure tanks shall be provided with removable hinged type top covers in two halves.
- iii) For volume/ sizing calculation of limestone slurry storage tanks, the solid concentration (by weight) in the slurry shall be considered not more than 20% or actual required whichever is lower.
- iv) The slurry handling storage tanks shall be equipped with sufficient number of agitators, to avoid settling of limestone, as per the proven practice of the supplier. The agitators shall be designed to meet the requirements stipulated elsewhere in the specification.
- v) The emergency limestone slurry tank shall be sized to contain the complete slurry of one absorber tank at its maximum level.
- vi) All tanks/ pressure vessels shall be designed and tested to withstand 1.5 time the design pressure. Pressure vessels shall conform to IS: 2825 and storage tanks to IS: 803/BS: 2594.

#### 4.3.8 Seal Water Pumps

- i) Horizontal centrifugal pumps in 2x100 % capacity configuration shall be provided to cater the requirement of seal water for absorbent





recirculation pump, feed pump, gypsum extraction pumps for each FGD plant.

- |                              |                |   |   |
|------------------------------|----------------|---|---|
| a)                           | Type           |   | Horizontal centrifugal  |
| b)                           | Capacity & TDH |   | As required by the system being offered with margin in capacity & head as specified elsewhere |
| c)                           | Speed          |   | 1500 rpm  |
| d)                           | Duties         |   | To supply seal water  |
| ii) Material of construction |                |   |   |
| a)                           | Casing         | - | Cast iron as per IS-210 Gr.25   |
| b)                           | Impeller       | - | Bronze as per IS-318 grade-I  |
| c)                           | Shaft          | - | EN 8  |
| d)                           | Base plate     | - | M.S.  |
| e)                           | Shaft sleeve   | - | Hardened stainless steel  |
| f)                           | Gland/packing  | - | Asbestos free yarn  |

In addition to the above requirements, these pumps shall conform to the requirements of horizontal centrifugal pumps mentioned elsewhere in the specification.

#### 4.3.9 Elevator for Absorber

- i) One (1) number passenger cum goods elevator of capacity 1000 kg shall be provided for each absorber. Minimum cab floor size (inside) shall be 1.3 m x 2.0 m x 2.1 m (W x L x H). Elevator shall be located near the absorber and shall be capable of operating from the ground floor to the top interior platform with intermediate stops at all interior platforms.
- ii) The elevators shall be designed as per latest edition of IS: 14665 (all parts). All mechanical and electrical operating devices and Trailing cable shall be designed for outdoor operation with dusty and high humidity conditions. Additionally, all mechanical and electrical components of the elevator shall be designed to withstand a temperature of 50 °C ambient.

#### iii) Enclosures

A three-sided enclosure with one access door shall be provided. Enclosures shall be fabricated from tubular steel and/or other structural shapes expanded metal or wire mesh of suitable height and primer coated with one coat of the manufacturer's standard primer and finish paint. Enclosure access doors shall be electrically and mechanically interlocked so that they remain closed and locked except when the cab is at a landing. Doors shall be bi-parting and swinging type.



iv) Mast

Mast shall be provided in sections of suitable length, consisting of tubular sections and/or structural shapes welded together to form a framework to which the rack is bolted. Mast shall be securely anchored to the building structure.

v) Cab

Cab frame shall be fabricated from tubular steel and/or other structural shapes enclosed with expanded metal or wire mesh. Cab floor shall be of 6 mm thick Aluminum chequered plate or approved equivalent. Cab door and landing level enclosure doors shall be electrically and mechanically interlocked to prevent the cab from being operated unless the cab door and landing level enclosure doors are fully closed and to prevent the doors from being opened while the cab is in motion.

One cabin fan and two recessed fluorescent lamps along with the fittings to be provided with one no. emergency light with battery & battery charger.

vi) Drive Unit & Safety Device

Drive unit located on the cab shall be complete with AC squirrel cage induction motor, reduction gear, drive pinion and an over-speed governor. Drive unit shall incorporate an electric disc brake and an external manual brake release. In case of the power failure, the brake will be automatically applied & will stop the cab. A hand lever, which can be operated from the cage, is to be provided to enable the occupants to ease the brake and lower the cage to the bottom level.

An over-speed governor shall be incorporated to protect the cab against over speed during the cab downward motion. A remote control shall be provided for testing the safety device.

The drive system shall be designed so that it will be capable to operate smoothly without any tendency to rock or judder with all vertical, horizontal forces as well as the moments through the rack.

Suitable arrangement shall be provided to bring the cage safely to the ground by gravity in the event of power failure.

vii) Buffers

Sufficient no. of buffers of spring loaded/hydraulic type shall be fitted below the cab. The buffer shall be capable of stopping the cab without permanent damage or deformation to themselves or any other part of the equipment.

viii) Power Supply

Two in comers for the power supply to each elevator shall be provided with cable key inter to check.



ix) Power and Control Cabinets

All electrical components furnished with the elevator shall be completely wired, energised and checked.

All electrical control devices shall be in enclosures. Equipment furnished shall also include the following

- (a) Momentary contact push button for raise/lower control.
- (b) Reversing combination motor starter with a three phase thermal overload relay for motor protection. However, the control circuit in the elevator will have miniature circuit breakers.
- (c) Electric and mechanical interlocks on cab access door and landing level enclosure doors.
- (d) An ultimate three phase over travel limit switch which cuts off power and control supply in case of over travel. The switch can also be manually turned to off position.
- (e) The degree of protection of control panel shall be IP- 52 for pressurized dust proof machine room and IP- 21 for air conditioned machine room.
- (f) An alarm push button shall be provided in the cage. Alarm signal will be transferred to the auxiliary panel at elevator base. The auxiliary panel will have battery and battery charger for the alarm horn. Potential free contacts for remote alarm shall also be provided.
- (g) Reverse phase relay connected to prevent operation of the cab with improper phase rotation or failure in any phase in the power supply.
- (h) The cable shall be supported by brackets on the cage and guide rails. A cable trolley will keep it in tension and will be guided on the same rail as the cage. The trailing cable shall run through cable guides.
- (i) One auxiliary panel shall be furnished and mounted on the ground level enclosure. Panel shall be in enclosure equipped with a main "ON-OFF" switch, main Contractor, relays, control transformer and MCB's, terminal blocks, and all other accessories required for normal operation of the elevator.
- (j) One main control panel shall be furnished and mounted on the top of cab. Panel shall be in enclosure equipped with necessary equipment like rectifier, battery, battery charger, contactors, breakers, control transformer and MCB's, thermal overload relays and all other equipment and accessories required for normal operation of the elevator.
- (k) Cab shall be controlled by a semiautomatic control system with push buttons for 'UP' 'Down' and 'Stop next landing'. The cab shall be controlled from inside and shall have painted placard located above the door. Cab shall be furnished with emergency alarm push



button, limit switches, and all other necessary control devices required to ensure safe and continuous cab operation, Cable guides shall be installed every 6 meters to avoid entanglement of this cable.

- (l) Each landing assembly shall include a limit switch and push button control station installed and wired to a landing junction box.
  - (m) All enclosures containing electrical, devices shall be provided with 240 Volts, single phase space heaters with adjustable thermostat control.
  - (n) Cab shall be equipped with a 220 Volts, 20W fluorescent lights, fan, 5A, 220V, 3 pin receptacle, emergency light, battery & battery charger.
  - (o) Control cabinets shall be sheet steel enclosed dust, weather and vermin proof. Sheet steel used shall be cold rolled and at least 2.0 mm thick. Degree of protection of control cabinet shall be as per relevant electrical section. Control cabinet shall be provided with hinged doors (s) with pad locking arrangements. All doors, removable covers and plates shall be gasketed all round with neoprene gaskets.
  - (p) All fuses shall be of the HRC cartridge type mounted on plug in type of fuse base having a prospective current rating of not less than 80 kA.
  - (q) All push buttons shall have 2NO and 2NC self reset contacts.
- x) Electric Motor

Elevator drive motor shall be squirrel-cage induction type designed and manufactured to conform to the requirements of this specification.

Motor shall be designed for operation at the required speed, 415Volts, 3 phase, 50 hertz, and shall be suitable for full voltage starting, frequent starting S3 duty class as per IS:4722 with CDF of 25% and maximum number of starts 120/hour at 50<sup>o</sup> C ambient temperature. Motor shall have class "F" non-hygroscopic insulation with temp. rise limited to Class B (IS:325).

Motor shall be totally enclosed and furnished with cast iron or Al alloy frame, brackets, gaskets conduit box & fan cover. Motor shall be furnished with grease pre lubricated, double-shielded, anti-friction bearing having life rating of not less than 42,500 hours under coupled service requirements. All exposed metal surfaces shall be protected with a polyester paint or coating which is moisture & corrosion resistant.

Motor shall be provided with internal 220 Volt AC single-phase space heaters or an alternate heating system to prevent condensation within the motor during extended periods of idleness.



xi) Cables

Insulated armoured power /control cable shall be FRLS - HR insulated, stranded copper/ aluminum conductors and shall be provided in accordance with IS: 1753 (latest edition) and IS: 1554 (Part-I) (latest edition).

Trailing cables in the elevator shaft should be specially designed for the specific service and shall conform to IS. Trailing cables shall be EPR insulated for 1.1 kV and shall be neoprene jacketed flexible cord.

Conductor accessories including terminal materials like glands, lugs etc. markers, tying materials, and cable supports shall be furnished and installed.

xii) Earthing

Complete earthing system shall be furnished for all equipment and accessories of the elevator as per relevant IS. Clamps and other hardware of iron or steel used with the grounding system shall be hot-dip galvanised. Bolts, washers, and nuts shall be hot-dip galvanised steel.

#### 4.4 Gypsum Dewatering & Handling System

##### 4.4.1 Dewatering Hydro-cyclones

- a) Each dewatering hydro-cyclone shall be sized to dewater the gypsum slurry produced by the power plant operating at Design point with an additional 10% margin. Each set of hydro-cyclone shall be provided with 10% spare hydro-cyclones.
- b) Hydro-cyclones shall be of modular construction. It shall be possible to remove and replace individual hydro-cyclone with the set in service. Individual isolation valve shall be provided for each hydro-cyclone for this purpose.
- c) The primary hydro cyclones shall be fitted directly above the belt filters.
- d) The hydro-cyclone shall be of proven design and shall be provided with replaceable rubber lining of adequate thickness. The liners shall have a minimum wear life of not less than 7000 hrs.
- e) The hydro cyclone system shall be self-supported with structural framework as integral part of design with mounting through structural steel legs. All structures shall be fabricated from carbon steel. To prevent blockage of cyclone by big particles, the cyclone shall be fitted with filters. The filter shall be made of stainless steel.



#### 4.4.2 Vacuum Belt Filters

- a. Each vacuum belt filter shall be sized to handle 110% of gypsum produced by absorbers with an inlet solid concentration of not more than 45%. The gypsum produced shall have moisture content of maximum 10%, chloride content less than 100 ppm and purity of minimum 90% purity (as per purity of available limestone).
- b. Each belt filter shall have independent 2x100% vacuum pumps and 2x100% gypsum cake wash pumps.
- c. Gypsum cake from outlet of each belt filter shall be discharged to gypsum storage area beneath the floor of vacuum belt filters. The elevation of discharge point of vacuum belt filter shall be at least 5.0 m above floor level. GL. **In case, gypsum storage area is located elsewhere in the plant, gypsum cake from outlet of belt filters shall be transported up to that location by 2x100% belt conveyors.**
- d) A 2 m (min.) wide platform shall be provided around each belt filter for easy approach & maintenance. Handling facilities for replacement of heavy components of the belt shall also be provided.
- e) The filter shall be designed with cake washing equipment. This equipment shall be capable of reducing the concentration of dissolved solids in the process liquor (primarily chloride) to levels that meet the commercial gypsum quality specifications.

#### 4.4.3 Vacuum System

- d) Each belt filter shall be provided with independent 2x100% vacuum pumps sized to meet the requirements of the belt filter operating at its maximum capacity. An additional margin of 10% (min.) over the above capacity shall be provided for each vacuum pump.
- e) The vacuum pumps shall be of low speed liquid ring type of proven design. The design of the vacuum pumps shall avoid cavitations under all operating conditions. The seals shall be of proven design.
- f) Silencers shall be provided, if required, to limit the noise level to values stipulated elsewhere in this specification.
- g) The vacuum receiver and pump internals shall be suitably lined to protect against the corrosive environment. The material selected for vacuum pumps & vacuum receivers shall be proven for similar application.



- h) Each vacuum receiver tank(s) shall be provided with slide plate type pneumatic vacuum breaker. The plate shall be stainless steel with a min. thickness of 3 mm.

#### 4.4.4 Filtrate System

Water from vacuum receiver tank(s) and the secondary waste water hydro cyclone underflow shall be taken to a common filtrate tank for recirculation to the wet ball mill/ gypsum recovery system through 2 x 100% pumps. The pump shall be capable of pumping of filtrate water with solid concentration of not less than 10%.

#### 4.4.5 Waste Water Treatment & Disposal System

- i) The overflow from secondary hydrocyclone shall be taken to waste water tanks. Two (2) nos. waste water tanks each sized for 2 hrs storage of waste water with units operating at BMCR load shall be provided. One tank shall always be available to receive the waste water while other is under neutralization & disposal mode. Provision to correct the pH of the waste water by lime dosing shall be provided and the after mixing of the effluent (using re-circulation system of the pumping system), the effluent shall be discharged to ash water sump. A pH monitor shall be provided at the discharge of the pumps for measurement and control. The neutralizing system, including dosing, recirculation and disposal, shall be automatic and controlled from the control desk.
- ii) Two (2) nos. Lime tanks each of minimum 2 m<sup>3</sup> capacity shall be provided for neutralization of waste water. The tanks shall be of carbon steel construction with epoxy painting and shall be provided with SS dissolving baskets, agitators of SS construction, drain, overflow and dosing connections etc.
- iii) The waste water tanks shall be of steel construction with epoxy painting and shall be provided with agitator. 2x100% horizontal centrifugal pumps shall be provided, along with requisite piping for pumping the waste water to ash water sump. The material of Casing and impeller shall be rubber lined Cast Iron (IS:210 Gr FG260). Shaft and Shaft Sleeves shall be Stainless Steel-410.

### 4.5 Limestone Feeding and Crushing System

#### 4.5.1 Limestone Data

The limestone to be used for FGD system shall be received and unloaded in storage area of RCC with covered shed provided in the power plant. The capacity of storage area shall be for 15 days limestone requirement of the power plant. Limestone from storage area to the FGD area shall be transported using trucks/ dumpers (by purchaser).

The size of limestone shall be (-) 250 mm or (-) 25 mm (to be specified by purchaser, depending upon its sourcing). The composition of limestone is indicated elsewhere in this specification.



For design of various components/ equipment of limestone receiving, handling, feeding, conveying, storage etc., the density of limestone shall be considered 1400 kg/m<sup>3</sup> for the purpose of volumetric calculations and 1700 kg/m<sup>3</sup> for the purpose of load calculations.

#### 4.5.2 Hoppers & Chutes

- i) Hoppers & Chutes, flap gates and rack & pinion gates shall be furnished integral with limestone handling system being supplied. All necessary accessories, shall be provided to ensure proper flow/storage/bifurcation of limestone as per system requirements.
- ii) Two (2) no. hoppers of adequate volumetric capacity shall be provided to reclaim limestone with the help of trucks/ bulldozers. The hoppers shall be provided with valley angle of 60° so as to avoid the jamming of limestone.
- iii) A grid of M.S. construction of adequate opening size shall also be provided over this receiving hopper. The larger piece of limestone shall be broken into small sizes over the grid and fed back to the hopper by manual labour. This grid shall be designed to take the load of moving loaded truck/ dumper.
- iv) Transfer chutes shall be adequately sized and sloped to ensure smooth flow of Lime without any accumulation anywhere. The minimum valley angle of chutes shall be 60 degrees from horizontal.
- v) Direct impact of material on conveyor belt shall be avoided by providing an inclined surface at 60 degrees valley angle at the feeding point to guide the material in direction of belt travel. Further, chute construction below flap gate shaft shall such that there will not be any accumulation of limestone dust between chute and gate in that zone.
- vi) Hoppers and Chutes shall be made of minimum 10 mm thick TISCERAL/MS or equivalent with adequate stiffeners. Long chutes guiding flow from considerable height shall be provided with impact plates wherever change in direction of flow takes place. Complete chute work above the drive floor for conveyors provided with 'In-line magnetic separators' shall be of 10 mm thick SS 304 in the zone of magnetic field.
- vii) Hinged inspection doors (generously sized) of leak proof construction shall be provided for access/ maintenance purpose, at approachable heights, of the chutes.
- viii) Bolted flange joints shall be of dust tight construction and necessary sealing material shall be provided in all the flange connections for adequate sealing.

#### 4.5.3 Rack & Pinion Gates

- i) Rotary actuator operated Rack & Pinion isolating gates underneath each hopper shall be provided for controlling the flow of limestone to the respective conveyors. The bidder shall ensure that the arrangement





provided shall control the flow within  $\pm 5\%$ . The isolating gates shall be fabricated from mild steel plate with liner plate of 10 mm thick TISCERAL or equivalent material and shall be encased to the hopper by means of bolts. The gates shall be operated by means of double rack and pinion. The material for rack & pinion wheel shall be cast steel and shaft shall be EN -B.

- ii) The rack and pinion shall be operated by means of hand chain/motor from the floor itself. Manual effort required to operate the rack and pinion gate shall not exceed 35 kg.
- iii) Approach/maintenance platforms complete with chequered plate floor, hand railings, ladder etc. shall be provided for all gates.

#### 4.5.4 Magnetic Separator

- i) Inline Suspended Magnetic Separators shall be provided for continuous and automatic extraction and discharge of tramp magnetic pieces from limestone being discharged from conveyors as specified. The sets shall be complete in all respects with drives, magnets, inline belts, hoppers, chutes, tramp-iron boxes and all electrical ancillaries like control panels etc.
- ii) Magnet core material shall be pure annealed iron or equivalent high permeability magnetic material. The coil shall be of aluminum wire with class 'H' insulation, to limit the absolute temperature of the winding to 140 deg. centigrade. The oil used for cooling the IL-MS and SM shall be silicon based.
- iii) The 'Force Index' i.e. the product of flux density in gauss and rate of change of flux density w.r.t. distance, at the bottom of falling material trajectory shall be 100,000 (gauss x gauss/inch) minimum in hot condition for mounting height of 400mm. However, the strength of the magnet shall not be less than 1000 gauss in hot running condition at distance of 400 mm. The minimum strength of the magnet shall be 1000 gauss at the specified mounting height at the center of Belt width.
- iv) Mounting height of 400 mm shall be taken between top of conveyor belt or bottom of falling material trajectory and the surface of magnetic separator belt. Characteristic curve of magnet with the value of flux density varying between 50 mm to face of conveyor belt shall be provided. The cross section of magnet shall be suitably designed to provide sufficient area for magnetising the coil effectively covering full cross section of the discharge material. The magnetic separator shall be located such that it picks-up tramp iron from Lime trajectory after it has been discharged from head pulley.
- v) The tramp magnetic pieces buried under Lime picked up by the magnetic separator shall be discharged suitably to ensure that it falls into the tramp iron chute, which shall be provided up to ground level. All conveyors with magnetic separator at head end shall have non-magnetic SS pulleys. Head pulleys of all conveyors with in line magnetic separator at head end shall be provided with SS shell and end disc.



- vi) Suitable arrangements shall be provided in the magnet for keeping the coil of the magnet dry from atmospheric condensation when the magnetic separator is not in use.

#### 4.5.5 Vibrating Feeders

The vibratory feeders shall be electromagnetic type. Each hopper shall be served by one vibratory feeder. The feeders would be suspension mounting type supported by a section attached to the bottom of the hopper and a mouth piece.

#### 4.5.6 Skirt Boards

- i) Skirt board shall ensure centralised loading of conveyor belt to avoid limestone spillage. Suitable 'Skirt Plates' of adequate length shall be provided at each feeding point of conveyor. The width of the Skirt Boards shall be two-third the conveyor belt width. The height of the skirt boards shall be sufficient to contain the material volume as it is loaded on the belt.
- ii) The skirt plates shall be fitted with modular segmented and replaceable rubber skirting pads having facility of adjusting the pressure on the belt conveyor and shall have provision of on line removal for the purpose of easy maintenance. All care shall be taken while designing, to combine good sealing with minimum belt wear.

#### 4.5.7 Flap Gates

- i) The motor operated two position flap gates shall be provided in transfer chutes and shall be complete with electrically operated actuators. The gates shall be of robust construction and suitable for trouble free operation. The face of the flap gate shall be made out of 10 mm thick TISCERAL or equivalent material.
- ii) The equipment shall be capable of being operated for at least 15 switchings per hour at rated load and thrust and shall be suitable for 10 Nos. consecutive switchings at rated load and thrust. The equipment shall be shop tested to prove this requirement.
- iv) The motor rating for the actuator shall be so selected as to provide sufficient thrust for operation of the flap gates against the moving weight of limestone and/or flap gate. The flap gate travel shall be in the range of 60 deg. to 70 deg. The motor shall be completely dust tight.
- v) The flap gate shall be provided with 10mm thick TISCERAL liner plate or equivalent material on both faces of main plate. The material of shaft shall be EN-8 or equivalent.
- vi) Suitable thrust dependent limit switches shall be provided in the actuator, which shall trip off the actuator motor in case of excessive thrust due to jamming of the gates during its travel in either direction. Provision for



alternative manual operation shall also be made using declutchable hand wheel. Manual effort required to operation the flap gate shall not exceed 35 kg. Limit switch for safety of person operating the hand wheel shall be provided.

- vii) Suitable self- aligned double row ball bearings in dust tight housing shall carry the gate shaft. Suitable provision for regreasing shall be provided.
- viii) Approach/maintenance platforms complete with the chequered plate floor, hand rails, ladders etc. shall be provided for all flap gates.

#### 4.5.8 Limestone Conveying Equipment

##### i) Belt Conveyor

2x100% capacity belt conveyors shall be provided. 100% capacity of each belt conveyor shall be to meet 6 hour requirement of both the units in one hour (minimum 60 t/h) plus 10% margin.

No belt shall have an inclination of more than 18 degrees to the horizontal on the carrying side. All the conveyor belts shall be of Nylon-Nylon/ Polyester-Polyamide, steel cord etc. with rubber covers of adequate flexibility to give toughing angle of 35 deg. The number of plies and duck weight shall be suitable for the performance required. The plies shall be skim quoted and the belt shall be mildew resistance. Breakers shall be provided on top cover. The cover shall be of natural synthetic rubber. The bottom cover thickness shall at least be 1.5 mm for single drive conveyor belts and 2.5 mm for tandem drive belts.

The belt shall be of grade 'B' as per IS: 1891 latest edition. The tenderer shall include in his tender sufficient length of belt to take care of mechanised joints. The belt shall have enough edge cover anchorage to resist wear. Both ends shall be prepared for full vulcanized plies and all the joints shall be vulcanised type.

##### ii) Idlers

All the idlers shall be heavy duty suitable for continuous operation at high capacity. The diameter of idles roll shall be minimum 152 mm for both carrying and return side. All idlers shall run in taper roller bearings enclosed in dust and moisture tight housing balanced and free to align themselves in carrier brackets. Bearings shall be provided with grease seals to protect them from dust and prevent loss of lubrication. All the roller shall be smoothly finished to prevent wear on conveyor belts. The lubricant arrangement for each set of rollers shall be such that it shall enable lubrication to be done from one side of the idler assembly.

Rollers used for idlers shall be made of ERW steel tube with wall thickness minimum 4mm. The rollers shall be mounted on EN-8 spindles by means of ball bearings. The bearing shall be adequately sealed and lubricated for life.



Special conveyor idlers (non-magnetic) shall be installed under that part of the conveyor belt over which the magnetic separator travels.

iii) Troughing and Return Idlers

The conveyor belts shall be supported by three roll of 35<sup>0</sup> troughing idlers at a suitable spacing along with run of the belt and at closer spacing at vertical bends. The idler spacing at vertical bends shall be about one third of the normal troughing idler spacing. The return idlers shall be placed at maximum suitable spacing. The troughing rollers and return rollers shall be mounted on suitable Brackets. Each roller shall be complete unit removable and inter changeable with other rollers.

iv) Training Idlers

Self aligning trough idlers with side guide rollers shall be provided for training the belt to keep it centered. The idlers shall be located about 3 meters ahead of the head pulley and beyond this at an interval of about 15 meters.

Similarly, on return side of the belt, self aligning idlers with side guide rollers of suitable design and shape to minimise belt contact and edge wear shall be provided. One such idler shall be located about 3 meters head of the tail pulley, to center the belt on the pulley before it enters the conveying run and other self-aligning idlers shall be located at suitable spacing.

v) Impact Idlers

The impact idlers shall have steel diameter of minimum 139mm and rubber thickness of 25mm. The rim and web of each disc shall be made of special resilient rubber to provide with greater shock absorbing capacity. The discs shall be mounted on steel tubes located in place by means of keys and cellars, spaced so that necessary deflection of the rubber may occur without interference. Spacing of impact idlers shall not be more than 500 mm.

vi) Belt Pulleys

All pulleys shall be of mild steel construction with hub and disc conforming to IS:2062 (Tested Quality). The pulley shall be capable of resisting fatigue failure in the members connecting the hub to the rim. The pulley shaft shall be of adequate size to keep the deflection to the minimum and avoid fatigue failure in the pulley. Pulley shaft of 150 mm diameter and less shall be made of machined, hot rolled or turned and ground cold finished carbon steel or EN-8. Pulley shaft larger than 150 mm in diameter shall be made of carbon steel forging. The pulleys shall run in antifriction double row self-aligning roller bearing. The bearing shall be assembled in dust proof plummer block housing of a split type



with labyrinth seal. Shaftings shall have to be keyed. For conveyors with in line magnetic separator the head end of the pulleys shall have shell and end disc made of non-magnetic stainless steel material.

The drive and other belt pulleys shall be of adequate diameter to suit the type of belt, number of plies, weight of duct without causing fatigue in the bond between plies of the belt. Each pulley shall be minimum 50 mm wider than the belt it supports. The diameter of the pulleys shall not be less than those specified in IS: 1891 of 1968. All drive pulleys shall be provided with an approved vulcanized rubber lagging with grooves. Rubber lagging shall be of minimum 6 mm thickness.

For selection of pulley a margin of 20% shall be considered over the maximum tension at designed conveyor capacity.

vii) Driving Gear

The driving gear of each conveyor shall include an electric motor of adequate power and a reduction gear of approved design and manufacture. The drive gear and motor shall be amply rated to take care of possible overloading in practice. All gears shall be totally enclosed oil immersed, silent, smooth and efficient in power transmission. All housing shall be provided with suitable drain plug. All gears shall be machine cut. Suitable coupling guard of approved type shall be provided. Motors and driven gear unit shall be mounted on common base plate of cast iron or fabricated steel. All the gear boxes shall be oil tight and dust proof and shall be provided with glass level gauge. All motors of 50 HP and above shall be provided with fluid coupling for safe operation.

viii) Belt Cleaners

The sloping back of each transfer chute shall be spaced from the return belt to permit use of a belt cleaning unit and arranged in such a way that the dribbles shall be returned to the same chute i.e. handling the main flow of material. The belt cleaner shall be of the rubber edge spring loaded type. Pivots of the scraper arms shall be amply protected from the dust and shall have reliable lubrication to ensure freedom from sticking. The design and construction of the belt cleaner shall be such as to ensure easy installation and maintenance.

ix) Take-Up Tensioning Gear

The take up and tensioning gears shall be sufficient to cope with the anticipated elongation of the belts during service and to maintain the necessary tension. All belt conveyor take-up pulley shall be of the gravity type. The take-up pulley shall be supported on a sliding frame to permit free movement to maintain constant tension of the belt wherever required. The supply shall be complete with all pulleys, cables and counterweights etc. All take up gears shall be provided with suitable guard to the approval of the purchaser. Each belt feeder shall be



equipped at its tail and with a take-up arrangement that shall comprise tail shaft unit mounted in 2 horizontal type screw take-up units. A total adjustment of not less than 300 mm shall be provided in the screw take up units. The provision for the adjustment of take-up bearings by means of hand wheel or ratchet on the outer ends of the adjustment screws shall be made. The take-up travel shall conform to BS:2890.

x) **Hold Back Device and Brakes:**

Automatic hold-back device of approved design shall be provided for elevating belt conveyor. Hold-back shall prevent backward movement of the loaded belt in the event of drive power failure. The hold-back device shall be of the roller type of sufficient torque integral with reduction gear unit. Electro-magnetic brakes of adequate capacity shall also be provided in addition to the hold-back device.

**4.5.9 Lime Stone Crushers, as applicable**

- i) The crushers shall be of hammer mill type for sizing the input limestone feed size of (-) 250mm to (-) 20 mm size. Limestone feeding shall be through vibrating screening feeder arrangement and shall be designed based on following:
  - a. The crusher design should be such that the crushing action is accompanied by the minimum of attrition and Uniform crushing impact shall be assured.
  - b. The crusher shall be capable of delivering the normal rated output even when handling damp limestone having maximum moisture content. No clogging or building up of material on the crushing element shall develop.
  - c. Temperature sensing devices shall be installed on both bearings of each of the crusher to trip the crusher incase temperature goes beyond allowable limit.
  - d. Zero speed limit switch shall be provided for protection against any un-crushable material. It shall sense the speed of rotor and shall trip the rotor when actual speed falls below the design speed.
  - e. Crushers shall be provided with vibration monitoring (VMS) system.
- ii) The rotor shall consist of forged steel shaft with integral discs or key fitted discs on shaft. Hammers shall be held by spring dowel bushes & shall be arranged around the circumference of the rotor. The number of hammers and number of rows shall be selected as per requirements.
- iii) The grinding walls shall be arranged symmetrically around either side of the rotor and carried by spindles supported in bearings attached to the casing. The wall shall consist of grinding wall supports and wear resistant grinding plates/Impact plates bolted on. For product size control, distance between the grinding plates and hammer shall be adjustable.



- iv) The hammer shall be in two parts- head and arm. The hammer head shall be of wear resistant steel material. The hammer arm shall be of forged alloy steel. In the event of wear, only the hammer head shall be replaced. Arms shall be selected so that they have long life and do not require frequent replacement.
- v) The housing shall be split type. Housing shall be fabricated from MS steel plates of weldable quality and shall be stiffened suitably. Maximum accessibility shall be provided for routine inspection and replacement of parts. For these purposes, the doors shall be of hinge connection with effective dust sealing arrangement. Hydraulically operated top cover of crushers shall be provided for quick inspection and replacement of hammers. The entire inside surface of crusher coming in contact with limestone shall be provided with abrasion resistant liners.
- vi) The hammer crusher will be driven through electric motor, scoop type hydraulic coupling and gear box.

#### 4.5.10 Bucket Elevator, as applicable

- i) The Bucket Elevator shall be sized to handle the design capacity with the minimum material bulk density and a maximum bucket filling of 75% & maximum material size, for continuous twenty-four hour service in a heavy duty industrial application, handling abrasive materials in a dusty environment.
- ii) Casing of elevator shall be self supported and capable of supporting head shaft, drive, and service platform. Head section is to be split and equipped with handles or lifting lugs for easy removal. Access and inspection doors are to be provided.
- iii) Intermediate sections are to have a minimum plate thickness of 4 mm. Boot section to be fabricated of minimum 6mm steel plate, with front and rear access panels. A beam is to be provided in casing for servicing internal gravity take-up. The beam may be located either in the boot section or intermediate section as applicable.
- iv) Size, capacity and type of buckets and appropriate reinforcement necessary for the application shall be adequately sized. Pin holes shall be provided in bottom of buckets for air relief.
- v) Bucket elevator drive should be sized for either 100% bucket filling at minimum material bulk density, or 75% bucket filling @ maximum material bulk density, whichever is greater.
- vi) Inspection and Access Doors shall be loose-hinged type with quick-opening jamb bar fasteners and gaskets enclosed and retained in the door.
- vii) A dust collecting vent in the head section and boot section shall be furnished with drilled flanges.

#### 4.5.11 Limestone Silo/ Bunker

Two nos. limestone storage silos/ bunkers each of 24 hours storage capacity of both the units shall be provided and shall be complete with supporting steel



structure, platforms, staircase, air canons power operated gates, gravimetric feeders, level switches, air relief devices, etc. The storage silos and hopper cones shall be fabricated of carbon steel with a SS lining (10 mm minimum) in the complete cones to ensure reliable discharge of material. The design of storage silos shall confirm to IS 9178. The storage silo shall be capable of feeding the limestone by means of gravimetric feeders to the wet ball mills.

#### 4.5.12 Bunker Shut-off Gates

Two bunker outlet chutes shall be provided for feeding limestone from bunker to the feeders. The size of the opening chute shall be sufficient to ensure proper flow of the limestone. There shall be no reduction of section in the bunker outlet chute from bunker to feeder. The inlet chute shall be provided with suitable poke doors/holes in order to remove jamming/blockage. A motorized bunker shut-off gate shall be provided at the inlet to each feeder.

All parts of the gate in contact with limestone shall be of stainless steel construction. The shut-off gates and its actuator shall ensure 100% closing of the gate even with 'bunker full of limestone. Facility shall be provided to open/close the bunker outlet gate, through actuator, from remote as well as local. In addition, a hand wheel with proper access shall also be provided for manual operation of the gate. The force at the rim of the hand wheel shall not exceed 35 kg with bunker full of limestone. The facility shall be provided for unloading the bunker, in case of exigency, through feeder, to a truck at ground level, along with all necessary chutes and diversion chutes.

#### 4.5.13 Gravimetric Feeders

Gravimetric feeders shall be sized to meet 110% of the maximum mill capacity. The limestone feeder belt shall be of seamless rubber construction. It should be possible to adjust the belt tension from outside without opening the feeder body. All parts in contact with limestone except belt shall be of stainless steel construction. The feeder shall have adequate instrumentation to detect 'loss of flow'. The feeder shall have a motor/pneumatic operated gate at the outlet.

### 4.6 Wet Ball Mills

- i) Two horizontal wet ball mills (1 working + 1 standby) shall be provided common for both the units. The ball mills shall be of capable of grinding limestone to fineness of 90% or higher through 325 mesh. The continuous capacity of each mill shall be adequate to meet. 3 hour requirement of the plant in one hour operation (minimum 30 t/h).

The input limestone size shall be considered as 25 mm with bond work index as minimum 14 kWh/ton (to be provided by purchaser). For design of mill system components/ equipment, the density of limestone shall be considered 1400 kg/m<sup>3</sup> for the purpose of volumetric calculations and 1700 kg/m<sup>3</sup> for the purpose of load calculations.





- ii) All integral auxiliaries of the mills like hydro-cyclones, separator tank with agitator(s) & 2x100% mill circuit pumps shall be sized to meet the above conditions
- iii) The mill hydro-cyclone set shall have sufficient redundancy. A minimum 10% spare hydro-cyclone shall be provided in each set of hydro cyclone. Mill hydrocyclone shall meet the requirements indicated elsewhere in the specification.
- iv) All parts of the mill including mill body, trunnion, hydro-cyclones, integral pipes, mill circuit pumps and other parts in contact with limestone slurry shall be provided with replaceable rubber wear liners. The wear liners or wear parts shall have a minimum guaranteed wear life of not less than 8000 hrs without reversal of the liners. The guaranteed capacity and fineness of the mill shall not be affected within the guaranteed life of the mill wear parts.
- v) The material of the balls shall be chosen to ensure that the balls do not lose their original shape and to ensure minimum ball consumption. The contractor shall also guarantee ball consumption per ton of limestone throughput. The contractor shall furnish the minimum ball diameter below which the balls shall be replaced.
- vi) Facility shall be provided for on-load loading of steel balls to the mill.
- vii) The ball mill shall be driven by a motor through a peripheral gear. An auxiliary motor shall also be provided for inching of mills after trip and during maintenance.
- viii) The lube oil system shall have 100% stand-by arrangement for lube oil pumps and oil coolers of each circuit with independent pump / cooler. Wherever required duplex oil filters shall be provided.
- ix) The mill auxiliaries like separator tanks, mill circuit pump, hydro-cyclones and all connecting pipes handling limestone slurry shall have replaceable rubber linings.
- x) Oil used shall be fire resistant. Lubrication oil reservoir shall include heater, vent fill and drain connections, and shall be integrally skid mounted with the oil pumps.
- xi) Complete access platforms and gear guards shall be provided.
- xii) A mill cradle system shall be provided for each ball mill. One (1) portable hydraulic jacking system including jacks, all necessary valves, gauges, controls and flexible hoses shall be provided.



#### 4.7 Limestone Sampling Units

- i) Limestone Sampling Units shall be complete with necessary samplers, crushers, flap valves, chutes, hoppers, belt feeders and sample collectors etc. to give samples from any of the two running streams. Limestone sampling unit shall be automatic type.
- ii) The limestone sampling units shall be suitable to give "Samples" conforming to ASTM-C50/ C50M. The capacity, make and model of all equipment of coal sampling unit shall be subject to approval of Purchaser.
- iii) The normal input feed size shall be considered as (-) 250 mm for limestone sampling unit before coal crushers. For sampling of crushed limestone, lump size shall be considered as (-) 20 mm. However occasionally (-) 50 mm lumps may also be received.
- iv) The primary/ secondary samplers shall be of dust tight construction and self contained type. Primary samplers (separate for each conveyor) shall be rugged, able to withstand severe shock loads and operate trouble free.
- v) Belt feeders shall be provided for entire sampling path up to sample collector. The feeders shall meter the flow accurately, produce a non-plugging condition and resist sticky and wet limestone.
- vi) Suitable sample crushers shall be provided for reducing the main input feed coal to 90% minus 6 mesh size. Single stage crushing shall be provided. There should be no re-circulation of fines in the crushers.
- vii) The sample chutes shall have minimum valley angle of 60 degrees to horizontal and shall be of stainless steel plates. The welding of chutes shall be done externally only. The inside surface of the material near welds shall be smooth.
- viii) The materials rejected from samplers shall be returned to main conveyor stream.

#### 4.8 Dust Control System

- i) The dust control system for control of fugitive dust emissions from dust generation points such as transfer points, feeders, crushers etc. shall be provided. Dust control is to be achieved by dry dust extraction system comprising of dust collection hoods, ducting fans, bag filter and dust collection hopper. Dust control system shall not allow a dust concentration in the ambient air inside the buildings more than acceptable limits as per internationally recognized hygienic standards/ codes.
- ii) Bag filters shall be provided for control of dust nuisance.
  - a) The compressed conveying air shall be passed through these bag filters to retain the Limestone particles in the silo.



- b) The bag filter should be of adequate capacity and shall be fabricated in modular construction. The bag filter shall be arranged in single or double row as per system requirements.
- c) The bag filter shall be of automatic reverse pulse jet cleaning type using jet of air to produce high-pressure wave, which remove the settled limestone particles from fabric and discharge into the silo. Bidder shall supply all accessories like orifice, pipe, solenoid valve, sequential timer etc.
- d) The bag filter must ensure adequate collection efficiency to achieve maximum dust not exceeding 30 mg/m<sup>3</sup> of air flow as per the norm.
- e) The pressure drop across Bag filter should not exceed 100mm of water column.
- f) The ON/OFF indication (feedback) of Bag filter assembly shall be made available in the control room.
- g) The Bag filter cloth shall be of standard quality and bag filter shall be of reverse pulse jet cleaning type.
- h) Material of construction:
  - Casing : M.S. fabricated.
  - Bag : Polyester Needle Felt or any other suitable material for a temperature range of 140-150°C.
  - Cage : G.I. wire
- i) The filtering area of bag filter shall be selected on the basis of 1.5 m<sup>3</sup>/min/m<sup>2</sup>. air flow through filter area. 20% margin should be considered over and above the actual filter area requirement. The bidder shall furnish the calculation for selection of Bag filter.

#### 4.9 Equipment Cooling Water System

DM water shall be used for cooling of FGD system equipment. The DM cooling water shall be tapped from DM cooling water piping of both the existing units. 2x100% DM booster pumps shall be provided by the bidder to meet the pressure requirement for equipment cooling through oil coolers. The return hot water from oil coolers of FGD system shall be terminated by the bidder at suitable terminal points on hot water section of DM cooling water piping of both the existing units. The bidder may propose alternative arrangement to meet close cycle DM cooling water requirement of FGD system and same be acceptable subject to approval of the purchaser.



#### 4.10 Vertical Sump Pumps

The sump pumps shall pump out the drains in various areas of FGD system and shall be provided at all locations where natural drainage is not possible. The piping up to the nearest disposal point shall form part of the tenderer's scope of supply. 2x100% capacity pumps (minimum 50 m<sup>3</sup>/h) of adequate rating shall be provided for each drain sump. The pumps shall be provided with 5% margin in flow and 10% margin in head over duty requirement. Size of the drain pit shall not be less than 2m x 2m x 1.8 (depth) m.

Each drain pump shall be provided with seal water arrangement to prevent ingress of into seals. Necessary inter-locks to ensure that sump start only with adequate seal water flow shall be provided. These pumps shall conform to the following requirements:

- i) Type - Vertical centrifugal, single stage non-clog type impeller suitable for handling abrasive slurry.
- ii) Duty - Intermittent – However, they shall be designed for continuous operation.
- iii) Capacity- Adequate as per requirement
- iv) TDH - Adequate as per requirement
- v) Material of construction:
  - a) Casing/Bowl - Alloy C.I. (350 BHN)  
(min. 2.7 % Ni, 1% Cr)
  - b) Impeller - Alloy C.I. (350 BHN)  
(min. 2.7 % Ni, 1% Cr)
  - c) Shaft - Stainless steel
  - d) Base plate - M.S.
  - e) Gland packing - Clear water sealed bush.
  - f) Shaft sleeve - Stainless steel
  - g) Bearing - Cutless rubber in Bronze

#### 4.11 Horizontal Centrifugal Pumps

- i) General

The design, manufacture, shop testing, erection testing and commissioning of the horizontal centrifugal pumps shall conform to the latest revisions of the following codes and Indian Standards, subject to any modification and requirement, as specified hereinafter.

- a) IS : 1520 - Horizontal Centrifugal pumps for clear, cold, fresh water.
- b) IS: 5120 - Technical requirements for rotodynamic special purpose pumps.



- c) IS: 5639 - Pumps handling chemicals & corrosive liquids.
- d) IS: 5659 - Pumps for process water.
- e) IS: 6536 - Pumps for handling volatile liquids.
- f) API- 610 - Centrifugal pumps for general refinery services.

ii) Materials of Construction

The materials of construction for various components of the pumps shall conform to the applicable standards like – “American Society of Testing of Materials (ASTM) and Indian Standards (I.S.). Where the above standards are in conflict with the stipulation of this specification, this specification shall supersede them.

iii) Design Requirements

The equipment shall be capable of developing the required head at rated capacity for continuous operation.

The pumps shall be provided with 5% margin in flow and 10% margin in head over duty requirement. The bidder shall furnish in the offer detailed calculations justifying capacity and head of the pumps.

Pumps are required to operate for some period with discharge valve closed. The pumps shall be suitable for zero-flow operation for a reasonable period.

iv) Pump Characteristics

Consistent with good operating characteristics and high efficiency, each pump shall have a continuously rising head capacity characteristic curve without any zone of instability. Power flow characteristic shall preferably be non-overloading type beyond rated duty point. The characteristic curves of each set of pumps shall match each other for equal load sharing in case of parallel operation. Margin between shut-off head and operating head shall not be less than 20%.

The name plate kW rating of the pump motor or prime mover (including the service factor) shall be decided after considering all operating conditions specified. At least fifteen (15) per cent margin shall be provided in power under all conditions.

v) Constructional Features

Pumps shall be of horizontal centrifugal type with required number of stages suitable for the service conditions. Each pump shall be provided with a drain, vent and priming connection at suitable locations, wherever applicable.



vi) Casing

The casing shall be structurally sound to provide housing for the pump assembly and shall be designed hydraulically to minimise radial loads at part load operations. The casing shall be capable of withstanding a hydrostatic test pressure equal to twice the pressure at rated capacity or 1.5 times shut-off head whichever is greater.

Pump casing may be axially or radially split or barrel type. The casing shall be of robust construction. All liquid passages in the casing shall be finished to smooth surfaces as far as possible. Casing drain and vent connections with plugs and valves shall be provided where required. Dowels shall be provided. Casing shall withstand without expansion joint the usual moments and thrusts. The casing shall be of cast steel. Pressure casing (or outer casing) shall be generally in accordance with the stipulation of API-610.

vii) Impeller

Impellers shall be made in one piece and securely fixed to the shaft. Means shall be provided to prevent loosening during operation including rotation in reverse direction. Impeller fastening nuts (if provided) shall be of cap type and shall tighten in the direction of normal rotation. The Impeller shall be of stainless steel. Replaceable type wearing rings shall be provided at suitable location for each pump (where applicable). The wearing rings shall be so fitted as to prevent turning while the pump is in operation.

The rotor assembly shall be statically, and dynamically balanced and designed with critical speed substantially above the operating speed.

viii) Shaft

The shaft shall be finished to close tolerance at the impeller, coupling pulley and bearing diameters. The impeller, pulley and shaft sleeves shall be firmly secured to the shaft by key and /or nuts. Slurry pump impellers may be screwed on the shaft (threads to tighten during normal pump rotation).

The shaft shall be adequately sized to withstand all stresses from rotor weight and hydraulic loads etc. ground and polished to final dimensions. The design of the shaft shall also take into consideration the critical speed of the shaft which shall be at least 20 percent above the maximum operating speed.

ix) Shaft Sleeve

Pump shafts shall be protected by renewable type shaft sleeves which shall extend well beyond the pump glands. The sleeves shall be highly



polished and shall be securely fastened to the shaft to prevent any loosening.

x) Bearings

Heavy duty ball, roller (Taper roller wherever required) or sleeve bearings, adequately designed for the type of service specified and for long and trouble free operation, shall be furnished. Sleeve type bearing shall not be supplied for pumps handling slurry.

The design of oil lubricated bearings shall be such that the bearing lubricating oil does not contaminate the liquid being pumped. Grease lubricated ball bearings are acceptable, if the pump is specifically designed for grease lubrication and if shaft speed is less than the speed limit recommended by the bearing manufacturer and the fluid temperature does not exceed 65.5°C (150°F). Each bearing housing shall have drain plug.

xi) Thrust Bearings

Adequately designed thrust bearings to absorb pump end thrust or other unbalanced force, if any, shall be provided wherever required. Suitable arrangement for adjusting clearances shall be provided.

xii) Stuffing Boxes & Sealing

Stuffing boxes of packed ring construction or of mechanical seal type as applicable shall be provided. Packed ring stuffing boxes shall be properly lubricated and sealed as per service requirement and manufacturer's standard. If lantern rings are provided between the packages, these shall be complete with inlet and outlet piping connection. Lantern rings shall be axially split type.

External clear water sealing shall be provided as the pumps will be handling limestone slurry. The design should also provide for flushing of the clearance between pump rotating and stationery parts continuously by clear water flow.

The Bidder shall provide the necessary piping, valves, boosters, fitting etc. for the gland sealing connection. For mechanical seals, the mating surfaces shall be suitably hard faced to ensure long life.

xiii) Coupling

The pump & motor shaft shall be connected with a suitably designed flexible coupling of approved design preferably with a spacer to facilitate dismantling of the pump without disturbing the motor. Necessary expanded metal coupling guards for the coupling shall also be furnished.



xiv) Variable speed drive

For limestone slurry handling pumps and where fast wearing of pumps is likely due to the particular service conditions, variable speed drive shall be employed, thus enabling operation of pumps at 100-200 rpm over-speed compared to the impeller speed corresponding to the rated operating point. Pumps shall be suitable for operation at such higher speeds. When variable speed drive as above is provided, it should also be possible to operate the pumps at 50-100 rpm under-speed.

xv) Base Plates

The base plates shall be of fabricated steel and of rigid construction, properly ribbed as required. The base plate shall be of self draining type. All directly coupled pump-motor sets shall be supplied with common base plates.

For pumps coupled to motor with the variable speed drive transmission system, separate base plates for pumps & motors are acceptable.

xvi) Accessories

The following accessories shall be supplied by Bidder for all pump motor sets:

- a) Foundation bolts and nuts for pump, motor and base plate.
- b) Transmission guard for flexible coupling/V-belt transmission etc. as applicable.
- c) Slide rails for motors if variable-pitch belt drive is provided.
- d) Pump pulley, motor pulley (variable pitch), set of V- belts or flexible coupling, as applicable.
- e) Suitable connections for sealing/cooling/flushing water supply, if applicable.
- f) Lubrication fittings as necessary for proper and easy lubrication of the equipment.
- g) Drain and vent cocks as required.
- h) Priming funnel or overhead tank, as required.
- i) Anchor bolts, sleeves, inserts, lifting lugs, eye bolts etc.
- j) Any other accessories mentioned elsewhere in this specification.

xvii) Drive Motors

Unless otherwise mentioned categorically, all pumps shall be furnished with suitable drive motors, which shall usually be A.C. squirrel cage





induction motors. Selection of proper motors to suit the requirements of the pumps shall always be the pump vendor's responsibility, taking also into cognizance other stipulations in this specifications.

#### 4.12 Painting and Protective Coating

- i) Painting of equipment shall be carried out as per the specifications indicated below and shall conform to the relevant IS for the material and workmanship. The paint to be applied shall be approved by Customer.
- ii) All paints & paint material used shall be procured from approved manufacturers. Paint shall be supplied in manufacturers original containers with the description of content, specification No., colour, ref no, date of manufacture, shelf life expiry date & pot life.
- iii) The paint manufacturers shall provide coating system data sheet for each coating system to be used containing the information on surface preparations, film thickness, recoating intervals, mixing ratio, thinner details and coating repair systems.
- iv) In general Shop fabricated equipment will be delivered to the site coated with a shop applied system or the manufacturer's standard finish in accordance with the requirements of this specification. For equipment that has received shop prime coat, touch-up prime coat and additional coats shall be applied in accordance with the coating schedule.
- v) Preparation of Surfaces
  - a) All surfaces to be painted shall be thoroughly cleaned of all grease, oil, loose mill scale, dust, rust, weld spatters, sharp edges and any other foreign matter. Removal of grease and oil contamination shall be in accordance with SSPC-SPI prior to cleaning process.
  - b) Mechanical cleaning by power tool and scrapping with steel wire brushes shall be adopted to clear the surfaces. However, in certain locations where power tool cleaning cannot be carried out, hand scrapping may be permitted with steel wire brushes and/or abrasive paper.
  - c) The blast cleaned surface shall be checked for signs of salt contamination as per ISO 8502-6 &9. The maximum allowable level of contamination shall be 20 mg/m<sup>2</sup>. Surfaces that do not meet these criteria shall be reprocessed.
- vi) Mechanical /power tool cleaning shall be done as per grade St-2 or St-3, of ISO 8504-3.
- vii) Blast Cleaning:
  - a) Compressed air supply for blast cleaning shall be free of water and oil.



- b) Abrasives used for blast cleaning carbon steel and alloy steel shall be as per ISO 8504-2 and SSPC painting manual. Suggested abrasives may be chilled iron grit or shot steel and malleable iron grit and shots nonmetallic abrasive (aluminum oxide, copper slag, garnet etc.).
- c) Surfaces to be coated shall be free of all grease, oil, loose rust, and loose mill scale. Oil and grease shall be removed by solvent cleaning method as outlined in SSPC - SP - 1 prior to blasting.
- d) Surfaces prepared for coating shall be coated the same day and before any visible rusting occurs (the time elapsed between blast cleaning and commencement of painting shall under no circumstances exceed 4 hours, but in any case must commence before signs of degradation occur).
- e) After blasting cleaning, depending on production flow, a weldable, inorganic ethyl zinc silicate shop primer of minimum dry film thickness 25 mm may be used.

viii) Paint Application Requirements

- a) Paint application shall be by brush, roller or spray gun. Local regulations regarding spray and roller coating shall be observed. A smooth uniform film shall be applied to the surfaces to be coated.
  - b) Painting shall be performed when the temperature of the surface is greater than 3 °C above the dew point of the surrounding air and relative humidity of the air is less than 85% unless local conditions dictate otherwise and the Customer is in agreement.
  - c) Paints shall not be applied within 50 mm of edges which will later have to be welded. Such weld areas shall be taped/one coat of weldable primer for distance of 50 mm either side of the weld line.
  - d) All steel equipment shall be provided with priming or coating system to protect the steel surface during transport, storage, installation and construction.
- ix) The following coating inspection & test shall be carried out:
- a) Dry Film Thickness as per ISO 2808 No.6.
  - b) Holiday Test as per ASTM D 5162/ NACE RP 0188.
  - c) Adhesion Test as per ISO 2409 for cross-cut test, or a pull-off test as per ISO 4624/ ASTM D 4541.
- x) Underground piping shall be given protective coating as per latest edition of relevant codes. The pipelines routed in the corrosive area shall be provided with rubber lining on the external surface. In addition, all steel parts of the plant which are wetted or submerged in water and all structural members shall be given protective coating.

#### 4.13 Ventilation and Air Conditioning System

- i) Pressurized ventilation system shall be provided for MCC & switchgear rooms. The system shall be designed to maintain a positive pressure inside the room with respect to outside air by means of tube axial supply air fans and exhaust fans on the opposite wall. Supply air fans shall be provided with cleanable viscous metallic filters and exhaust fans with gravity louver dampers.
- ii) The pressurized ventilation system shall be designed considering minimum 15 air changes per hour. The mechanical ventilation system shall be designed considering minimum 15 air changes per hour for underground areas and minimum 10 air changes per hour for over ground areas.
- iii) The speed of the fan shall not exceed 960 rpm for fan with impeller diameter above 450 mm and 1440 rpm for fan with impeller diameter 450 mm and less. The first critical speed of rotating assembly shall be at least 25% above operating speed.
- iv) The control room of FGD system shall be air conditioned. The system shall consist of adequate number of package air conditioners (PACs) with 100% standby arrangement. PAC units shall be provided as required. PAC units shall be factory tested and assembled self-contained units complete with refrigerant compressor, coils, fans, insulation and wiring. Various parts of PAC units wherever required shall be insulated with expanded polyethylene conforming to IS:4671. The PAC unit shall comprise of an evaporator (indoor air) blower section and an air cooled condenser (outdoor air) section. Heavy gauge steel cabinet finished with paint of approved color, shall be used to house components of PAC. The evaporator and condenser coils shall be arranged for direct expansion cooling and shall be formed of aluminum fins mechanically bonded to seamless copper tubes and electrically tinned. The inter-connecting refrigerant circuits shall comprise of hermetically sealed scroll compressor and motor with all necessary isolation valves, with adjustable set point, sight glass, copper tubing and pipeline ancillaries. The condenser coils shall be air cooled by propeller type fans complete with safety guards. The condensing coils shall be suitably arranged to avoid radiant heat pickup from solar sources.
- v) All GI sheet metal ductwork required for ventilation and air conditioning system shall be furnished by the supplier. All ducts and plenums shall be constructed out of standard quality galvanised steel sheet. All sheet metal ducts shall be fabricated and installed in conformity to the requirements of IS:655. Steel supports for the ductwork shall be furnished as required. The thickness of ducting steel shall be 1 mm min. For ducting with large size exceeding 1300 mm it shall be 1.25 mm. The flexible connection between fan and ducting shall be on Teflon impregnated canvas. The zinc coating on GI sheet shall be 275 gm/m<sup>2</sup>



- vi) The other areas of the plant, limestone slurry pump house and limestone recirculation pump house adjacent to limestone absorber, toilets etc. shall be provided with mechanical exhaust system, using wall mounted exhaust fans. The exhaust fans shall be horizontal, wall mounted, direct drive type with low noise and minimum vibrations. The impellers shall be of aluminum cast in single piece and dynamically balanced. The fans shall be complete with suitable supporting/mounting brackets, frames nuts, bolts, gravity louver damper, brackets in inlet screen and vibration isolators etc.

#### **4.14 Piping, Valves and Accessories**

- i) Slurry pipes shall be designed to keep the velocity above the settling velocity under all operating conditions. The contractor may provide a recirculation line with motorized isolation valve for the above purpose.
- ii) All the pipes handling slurry shall be provided with replaceable rubber lining of proven quality. The Contractor can provide slurry pipes of size lower than 3" made up of FRP material if it has previous experience of providing the same.
- iii) Motorized actuators shall be provided for valves requiring frequent operation.
- iv) The isolation valves for slurry applications shall be of knife gate/ butterfly type with rubber seats designed to prevent accumulation of solids on the valve seat.
- v) Bidder shall provide all necessary arrangements for purging & flushing of all the process pipelines, equipment etc.
- vi) The pipings to be provided as per the following:
  - a) Steel pipe: Carbon steel piping 150 mm nominal size and smaller shall be ungalvanized IS 1239, Heavy Grade.
  - b) Potable water piping shall be galvanized as per IS 4736.
  - c) DM water piping shall be additionally provided with internal rubber lining with 3 mm thick natural rubber.
  - d) Carbon steel piping 200 mm and larger nominal size shall be ungalvanized IS 3589 Gr. Fe 410.
- vii) All pipes, valves, rubber expansion joints and fittings coming in contact with corrosive fluids shall be made of, or suitably lined with material capable of satisfactorily withstanding the effects of such fluids. All the sampling valves shall be of PVC diaphragm/ rubber lined. The butterfly valves shall conform to ANSI/ AWWA C504-80/ BS 5155 or equivalent. The NRVs shall conform to BS 1868 or equivalent. The rubber expansion joints shall conform to relevant Indian standards or equivalent.



- viii) The pipelines carrying water, air etc. should be sized on the following allowable velocities:

Description	Velocity in m/sec.			
	Pipe Size	Below 50mm	50-150 mm	200 mm & up
a) Water pump suction :		---	1.2 - 1.5	1.2 - 2.0
b) Water pump discharge:		1.2 - 1.8	1.8 - 2.4	2.1 - 2.6
c) Main water header : (for long distance)		---	1.2 - 1.7	1.2 - 1.9
d) Compressed air : below 2.0 kg/cm <sup>2</sup> g		3 - 8	7 - 11	8 - 12
e) Compressed air : 2 kg/cm <sup>2</sup> g and up.		5 - 10	8 - 12	10 - 15

- ix) The over ground pipes shall be suitably laid on proper supports to prevent sagging in any section. Pipe racks shall be provided for over ground crossing of the pipes over the road sections. For underground crossing below the roads, suitable RCC culvert or heavy duty hume pipes shall be provided. All pipe bends shall be provided with suitable anchors.
- x) The valve pits of adequate sizes shall be provided for housing the valves on underground piping. The valve pits shall be properly covered from the top to prevent ingress of rain water into the pits. Suitable rung ladders/stairs shall be provided for entry into the pits.
- xi) Pump suction velocity for water should be restricted to maximum 1.5 m/s. Pump discharge velocity for water should be restricted to maximum 2.5 m/s. Velocity in water drain shall be kept as 1m/s. All piping handling raw water/ clarified water/ DM water shall be designed for a pressure not less than the shut-off head of the pumps of the respective system.
- xii) The fittings shall be constructed of materials equivalent to the pipe with they are used.
- a) Steel Fittings: Steel fittings 65 mm and larger shall be of the butt welding type and steel fittings 50 mm and smaller shall be of the socket welding type.
- b) Butt Welding Fittings: The wall thickness of butt welding fittings shall be equal to the pipe wall thickness with which they are used. The fittings shall be manufactured in accordance with ANSI B16.9. ANSI B 16.28, and IS 1239 Part 2 up to 150 NB and hot bend IS 3589 above 200 NB.



- c) Forged Steel Fittings: Forged steel fittings shall be used for socket-weld and steel threaded connections and shall conform to ANSI B 16.11.
  - d) The minimum class rating of socket shall be 2000 lbs for threaded fittings and 3000 lbs for socket welded fittings.
  - e) Lined pipe Fittings: Fittings used with lined pipe shall be lined with the same material as the pipe with which they are used.
- xiii) Flanges
- a) Flanges shall be constructed of materials equivalent to the pipe with which they are used.
  - b) Steel flanges shall conform to AWWA C207/ ANSI B16.5/ ASME B16.47, 150 #.
  - c) Steel flanges 65 mm and larger shall be of the weld neck or slip-on type; and all steel flanges 50mm and smaller shall be of the socket type. Slip-on flanges shall generally be used only when the use of weld neck flanges is impractical. Steel flanges shall have raised face flange preparation. Flat face flanges shall be used to mate with nonferrous flanges.
  - d) Carbon steel flanges shall be of ASTM A105 material.
- xiv) Expansion joints shall be of spool type with right angle full-faced flanges of reinforced rubber and fabric with metal retaining rings.
- xv) Valves
- a) Valve bodies shall generally be constructed of materials equivalent to the pipe with which they are used. Valve body and trim materials of construction shall be in accordance with applicable ASTM and AISI standards.
  - b) Valve body materials shall generally be as follows:

<u>Material Name</u>	<u>Description</u>
i) Cast iron	ASTM A126 Class B
ii) Bronze	ASTM B61 or ASTM B 62
iii) Carbon Steel	ASTM A216, Grade WCB, (Cast)
  - c) Steel body gate. Globe, angle, and check valves shall be designed and constructed in accordance with ANSI B16.34 as applicable. Valve bodies and bonnets shall be designed to support the valve operators (Hand wheel, gear, or motor) with the valve in any position, without external support.
  - d) Steel body valves 50 mm and smaller shall have forged steel bodies. All valves, except gate valves, shall have seats of the integral type. Gate valves shall have renewable seats. Valve ends shall be socket-weld type unless otherwise required.



- e) Except as otherwise required, check valves shall be of the guided piston or swing disk type. All check valves shall be designed for installation in either horizontal piping or vertical piping with upward flow.
- f) Steel body valves 65 mm and larger shall have cast steel bodies. The face-to-face and end-to-end dimensions shall conform to ANSI B16.10. Bonnet joints shall be of the bolted flanged type having flat face flange facings for Class 150 valves; and male and female facings for Class 300 and 400 valves. Body ends shall be butt weld type unless otherwise required.
- g) Check valves used on pump discharge installations, and on other applications, in which the valves may be subjected to significant reverse flow water hammer or fluid surges, shall be of the non-slam tilting disk type. All other check valves shall be of the guided piston, swing disk, or double disk spring check type. The use of double disk spring check valves shall be limited to 350 mm and larger cold water services. All check valves shall be designed for installation in either horizontal or vertical piping with upward flow. Stop check valves, where specified, shall be Y-pattern globe type.
- h) Iron body gate, globe, and check valves shall have cast iron bodies with bronze trim. The face-to-face dimensions shall be in accordance with ANSI B16.10. These valves shall have flanged bonnet joints. Gate and globe valves shall be of the outside screw and yoke construction. Body seats shall be of the renewable type. Gate valves shall be of the wedge disk type. Lined cast iron body diaphragm and check valves used with lined piping shall be flanged body with liner and diaphragm material suitable for the service.
- i) Rubber-seated butterfly valves shall be generally constructed in accordance with AWWA C504 Standard for Rubber-Seated Butterfly valves. The valves shall also generally conform to the requirements of MSS Standard Practice SP-67, Butterfly Valve. Valves of the wafer or lug wafer type shall be designed for installation between two ANSI flanges. Valves with flanged ends shall be faced and drilled in accordance with ANSI B16.1/ B16.5.
- j) Butterfly valves shall generally be used for size 150 mm and above for cold water services only. Butterfly valves for buried service shall be of cast iron body material and shall be equipped with flanged ends.
- k) Cast iron butterfly valves shall have pressure class selected based on the piping design pressure as follows:

<u>Piping Design Pressure</u>	<u>Valve Class</u>
i) 1.8 bar and below	Class 25
ii) Above 1.8 bar to 5.2 bar	Class 75
iii) Above 5.2 bar to 10.3 bar	Class 150



- l) Butterfly valves for other than buried services shall be of carbon steel or cast iron body material depending on the service application. Valves 600 mm and larger in size shall be equipped with flanged ends. Valves 500 mm and smaller in size shall be of the wafer type, or lug wafer type, if used with steel piping:
- m) Carbon steel butterfly valves shall have pressure class selected in accordance with the pressure temperature ratings specified in ANSI B16.34 for 60 mm and smaller valves.
- n) Bronze gate and globe valves 50 mm and smaller shall have union bonnet joints and screwed ends. Gate valves shall be inside screw, rising stem type with solid wedge disks. Globe valves shall have renewable seats and disks.
- o) Bronze valves 65 mm and larger shall have bolted flange bonnet joints and flanged ends. Gate and globe valves shall be of the outside screws rising stem construction. Gate valves shall have either integral or renewable seats. Globe valves shall have renewable seats.
- p) Bronze valves shall generally be Class 200, and shall be limited to potable water service in size up to 80 mm.

#### 4.15 Thermal insulation

- i) Thermal Insulation along with aluminum cladding shall be provided for all the equipment/ surfaces having skin temperature more than 60 deg C.  

All equipment and ducts starting from tap off on outlet duct of the ID fans to inlet of new chimney, wet flue(s), bypass duct to existing chimney shall be protected for conservation of heat energy from loss to atmosphere, as required.
- ii) The insulating material to be used shall be Lightly Bonded Rock Wool insulation material of density 100 kg/m<sup>3</sup> as per IS:8183 "Specification for Bonded Mineral Wool". The thickness of insulation shall be such as to keep the loss of heat to the minimum/ economical and to limit the surface temperature to 60°C.
- iii) Insulation mattress/section shall be supplied in thickness of 25, 40, 50 and 75 mm. Insulation of higher thickness shall be made up in multiple layers using mattress/slabs of thickness specified above. However, if the required thickness is not achieved, the mattress/slabs in increment of 5mm shall be acceptable. The minimum thickness shall not be less than 25 mm.
- iv) The hot surfaces where the heat loss is inconsequential but are within a distance of less than 2 m from floor or walkways shall be applied with





- insulation for protection and safety of personnel. The minimum thickness of insulation for such purposes shall be 25 mm.
- v) The thermal conductivity of the insulating material to be considered for the design of thickness of insulation shall be the maximum value as per the relevant standard to which the material belongs.
  - vi) Sheathing/cladding material for all insulated surfaces, equipment, piping etc. conforming to ASTM B 209-1060 temper H-14 or IS-737 Gr.19000/H2 shall be provided. The thickness of aluminium sheathing to be used shall be 22 SWG (0.71mm).
  - vii) Binding and lacing wires shall be 20 SWG galvanised Steel wire and screws shall be of galvanized steel, check headed, self- tapping type.
  - viii) Hexagonal wire mesh netting shall be 10-13 mm aperture and at least 0.71mm diameter galvanized steel wire.
  - ix) All Straps and bands shall be Galvanized Steel. Bands shall be 20 mm wide and 0.6 mm thick. For securing Aluminum sheathing material, stainless steel or anodized aluminum bends shall be used.
  - x) The insulation compound shall not contain any substance detrimental to health. The use of asbestos in any form for insulation and elsewhere is not permitted.
  - xi) Suitable lugs and spacer rings shall be provided to support the insulation and cladding. Heat conduction through these lugs and rings shall also be suitably checked.

#### 4.16 Instrument Air Compressors

- i) Two (2) x 100% capacity Indoor, with minimum operating pressure of 8.0 kg/cm<sup>2</sup> (g), AC motor driven multi-stage, oil free, package type rotary screw air compressors shall be provided. Each compressor shall consist of two (2) compressor elements, flanged to a step up gear box with integrated oil sump, oil and water piping, intercoolers, after coolers, pulsation dampers, moisture separators, discharge silencers etc.
- ii) Compressors and all its accessories such as intercooler, after cooler, motor control panel with starter, refrigerated air dryer shall be mounted on a common skid and shall be complete with air, water and drain piping and power and control cabling within the skid limits such that it becomes ready to start commissioning of compressed air package requiring no foundation. This complete skid shall be mounted on a set of anti-vibration mounting pads and shall have a facility for lifting.
- iii) Intake Air Filter-cum-silencer



One cleanable, dry, air intake filter-cum-silencer to prevent dust and other atmospheric impurities from entering compressor and to reduce the noise level to a reasonable limit (85 decibel at a distance of 1.0 m from the compressor) shall be supplied with each compressor. The clear filter area shall be at least twice the inlet area. The filter shall be suitable for removing dust particles down to 10 micron size. The compressor shall be designed for 50°C ambient and 100% RH with 10% margin over the calculated instrument air requirement.

Silencer-cum-filter of dry panel type for oil free compressors shall be provided at each compressor suction side to remove all particles above ten (10) micron size.

Horizontal shell and tube type, water cooled cooler (inter and after) having tubes fixed on tube sheet fixed in a seamless Cast Iron shell shall be provided.

iv) Air Dryer

The air dryer shall be Refrigerant type or dual tower or rotary drum type with heat-of-compression type of regeneration with no purge loss and shall be fully assembled; ready for installation and operation. Each dryer shall have two adsorbing towers, which together provide adequate cycle time and sufficient capacity to continuously dry the volume of air entering under the service conditions specified. The capacity of air dryer shall be 10% more than air delivered from compressor.

v) Air receiver

Each compressor shall be provided with an Air Receiver. The air receiver shall be vertical, cylindrical steel plate fabricated of 10 m<sup>3</sup> capacity with tori spherical/ elliptical dished end construction along with all required accessories such as safety relief valves, pressure gauges, pressure switches, automatic drain trap connections. The design of air receiver shall be as per IS:2825-class II.

#### 4.17 Fire Detection, Protection & Alarm System

- i) Complete firefighting system for all areas viz. absorber, lime handling and preparation, gypsum dewatering/ handling and control room etc. covered under FGD plant shall be provided. Firefighting system for FGD plant shall be provided as per NFPA, USA regulations. All equipment such as flow control valves, nozzles, projectors, fire detectors etc. shall be Underwriters Laboratory/Factory Manual approved. The provisions in the latest revisions of Indian standards shall be applicable to equipment/ services of the system. All equipment such as pipes, valves, fire extinguishers, cables etc. should be ISI marked.
- ii) Firefighting system shall comprise of water hydrant system for FGD plant area. The hydrant system shall be complete with hydrants, hose pipes with instantaneous couplings, branch pipes with nozzles and hose



cabinets etc. The water for hydrant/ spray system for FGD plants shall be suitably tapped from the existing hydrant/ spray headers of the power plant.

- iii) Adequate number of portable fire extinguishers of carbon dioxide, DCP & foam type (as applicable) shall be provided for all buildings and pump houses of plant including MCC & Control rooms. Adequate number of mobile fire extinguishers of carbon dioxide and DCP type shall also be provided. Fire detection & alarm system including call points shall be provided for all buildings & complete area of FGD system.
- iv) The fire detection, protection and alarm system shall be suitably interfaced/ integrated with the existing firefighting system.
- v) Microprocessor based fire detection and alarm system shall be provided to detect fire in the incipient stage, give alarm and protect the life and property in the whole FGD plant area. This shall include automatic fire detectors, manual call points, response indicators, interface units, fire alarm panel etc. and any other equipment required for completion of the system.
- vi) Fire detectors of requisite types such as smoke detectors (ionization and photoelectric type) shall be provided. The coverage area of fire detectors shall be 20-25 m<sup>2</sup>/ detector for air conditioned control rooms and 35-45 m<sup>2</sup>/ detector for other areas. All detectors shall have LED indicators showing 'Normal' and 'Operated' status. The manual call points shall be provided at convenient points such as entrance to rooms, near staircase, passage etc.

#### **4.18 Hangers and Supports**

Hangers and supports shall be capable of carrying the sum of all concurrently acting loads. They shall be designed to provide the required supporting effects and allow pipe line movements as necessary. The bidder shall provide all guides, anchors, braces, dampeners, expansion joints and structural steel to be attached to the civil works and foundations.

All hanger locations/design calculations shall be submitted for purchaser/ consultant's approval.

#### **4.19 Hoisting and Lifting Tackles**

For the normal operation and transfer of equipment to maintenance area with in the building and/ or to transfer the equipment outside the building up to ground floor for further transportation, necessary hoist complete with trolleys and chain-pulley blocks and monorails shall be provided at suitable locations. The tenderer shall indicate the brief description, location and capacity of such hoist in his tender drawings.



#### 4.19.1 Mono Rail and Hoists

- i) The electric hoist shall be designed and constructed in accordance with the latest revision of IS:3938 and shall be suitable for duty class 2. All chain pulley blocks shall be designed to IS:3832, the operating hand chain shall conform to IS:2429 grade 30 pitched and polished and the load chain to IS:6216 grade 80. The chain pulley block shall be suitable for duty class 2. Hooks shall be as per IS: 8610 & with antifriction bearing. Cast iron parts, wherever used, shall be of minimum grade 30, IS:210. All gears and pinions shall be of hardened and tempered steel with machine cut teeth in metric modules.
- ii) The hoist mechanism shall consist of a grooved rope drum driven by electric motor through gears. Each end of the rope shall be anchored to the drum in such a way as the anchorage is readily available for maintenance. Each rope shall have two (2) full turns of the drum when the hook is at its lowest position and one (1) spare groove when the hook is at its highest position. The leading rope taken by the drum should not slope sideways when slack and it should not be caught between the gear wheel. Rope drum, gear box, block etc. should be fabricated out of weldable quality steel.
- iii) All hoists/chain pulley blocks shall be selected to have minimum headroom and shall be selected to lift heaviest piece of equipment. Further, it shall be possible to handle any equipment without disturbing other equipment.
- iv) Electrically operated hoists shall consist of following major components.
  - a) Electrically operated trolley, speed maximum 15 m/min, complete with drive motor.
  - b) Hoist cable, hoisting block and hooks, with maximum hoisting speed 6m/min, complete with drive motor.
  - c) Limit switches to prevent over hoisting, over lowering and over travel.
  - d) Arrangement of feeding power to trolley assembly, Pendant control station suspended from hoist and Control panel mounted on wall.
- v) For the Hoists with more than 2.0 tonne lifting capacity or more than 10.0 m lift, motor operated hoist blocks for both long travel and lift shall be provided. Other hoist blocks shall be of hand operated type for both travel and lift. Minimum 3 meter length of Cantilever from edge of building/cladding shall be provided in monorails coming out of the building to lower the equipment to ground level clearing the building sidewalls/ cladding and any other facilities beneath the floor up to ground level.
- vi) Monorails shall be extended outside the building to handle the equipment to ground level. For monorail/hoist routed inside the buildings, suitable machinery well and removable hand railing and grating shall be provided on various floors of buildings, as necessary, to handle the equipment.



- vii) For electric hoists, trolley movement and hoisting shall be effected by using two separate motors.
- viii) An electromechanical brake shall be provided for hoisting as well as cross travel. Brake lining shall be of asbestos.
- ix) All parts requiring replacement/inspection/lubrication shall be accessible without need for dismantling of other parts/structures.
- x) All components of hoists of identical capacity and duty shall be interchangeable
- xi) For Inspection / maintenance of hoist components a fixed platform (of min 1.5 x 1.5m) with ladder shall be provided for each electrical hoist.

#### **4.20 Wet Chimney**

- i) For retrofitting of wet limestone FGD system in the 2x500 MW TPS, a new RCC chimney of height 150<sup>14</sup> m consisting of two (2) number of wet flues shall be constructed by the bidder. Treated flue gas from the absorber shall be discharged through this new wet chimney. The wet chimney shall be suitably lined. The chimney flue liner cladding shall be made of 2 mm thick Titanium (Grade 2 as per ASME SB265) or C-276 alloy over 8 mm thick (minimum) mild steel base metal of flue liner. Cladding shall be done to achieve the required quality as per ASTM B 898-11. External surface of chimney flue liner projecting over the chimney roof shall be wrapped with 2 mm thick Titanium / C-276 sheet over insulation. The wet stack shall be designed as per the guidelines of EPRI Revised Wet Stack Design Guide.

- ii) Wet Chimney Condensate Collection System

To avoid the carryover of the condensate/acidic dews/water droplets/gypsum coming out of the wet chimney a condensate collection system shall be provided. Design of the condensate system should be such that the liquid condensate film near the exit of the stack is collected in the chimney and preventing falling of the acidic dews/water droplet/gypsum from the chimney in the nearby area.

- iii) Wet stack model study

A wet stack study shall be performed by the Contractor for each unit with a wet stack installation where there does not exist an identical or mirror image installation that has already had a wet stack study performed. A wet stack model study shall consist of the following:

- a) Condensation calculations.
- b) Minimum 1:12 scale physical flow model for liquid collector design.
- c) Computational flow model for plume downwash analysis.

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<sup>14</sup> To be confirmed by the purchaser in line with requirement of MoEF&CC



- d) Physical or computational flow model for CEMS elevation flow performance.
- iv) Liquid collectors shall be designed and developed experimentally using a physical model. The model shall begin at the outlet of the absorber mist eliminator(s), include the absorber outlet and ducting, the stack breaching duct and a minimum of three (3) diameters of the stack liner above the top of the stack breaching duct. Physical model shall include any internal devices that may affect the gas flow, such as structural members, flow controls, and expansion joints. Liquid collectors shall be located where needed in the absorber outlet, the ductwork between the absorber outlet and the chimney liner, in the chimney liner, and in the exit nozzle. These collectors shall collect liquid from surfaces, prevent re-entrainment, and guide the liquid to locations where it can be drained out of the system and prevent the discharge of droplets from the top of the stack that are large enough to rain out to the ground before evaporation.
- v) A common Nickel based alloy material storage/neutralizing tank for the both the units of storage capacity of 12 hrs of condensate from both the chimneys shall be provided complete with neutralizing chemicals dosing, mixing and preparation system. The neutralized condensate shall be pumped to common drain system by 2 x 100% pumps, complete with valves, piping fittings, level control/monitoring etc. All the equipment/piping/ fittings in contact with the condensate shall be of suitable material for the operating duty.
- vi) All chimney condensate collection equipment shall be easily accessible for O&M. The design of the stack condensate collection system shall be provided by the bidders in its bid.

#### **4.21 Structural Steel Works**

All structural and auxiliary steel works covered under the mechanical scope of supply, shall be designed and installed in accordance with the latest applicable code of Indian Standards with regard to earthquake and wind load. While designing the structures, adequate allowance for the maintenance loads shall also be taken into consideration in addition to the equipment loads and live load of 500 kg/sq.m. Structural steel works shall be carried out as specified in the civil and structural works of this specification. Cathodic protection shall be provided for all structural steel works due to very corrosive and saline environment at the plant site.

#### **4.22 Control and Operation Philosophy of FGD Plant**

Complete FGD system for both the units including common auxiliaries shall be controlled from FGD control room. Provision for Operation and control of complete FGD from main plant central control room shall also be provided.



- i) The conveyors, vibrating feeders, crushers, bucket elevators, gravimetric feeders, wet ball mills shall be controlled from the control panel provided in limestone handling and feeding area with interface to FGD PLC.
- ii) PLC with redundant (2x100%) controllers shall be provided and FGD control system shall be capable of ensuring safe and reliable operation during all regimes of operation i.e. start up, normal operation as well as in emergency situations. The PLC shall have a communication interface link from the FGD control system to the existing Main Plant Control system for status/information exchange. However, for control purposes hardwired interconnections shall be provided between existing Main Plant control system and FGD control system. Normal mode of operation in FGD plant control room shall be through CRT/keyboards during all regimes of operation.
- iii) All the required logic and interlocks shall be provided for safe and reliable operation of FGD system. Same shall include but not limited to the following:
  - a) Automatic start up sequence for FGD plant scrubber system.
  - b) All required logics/interlocks for the auxiliaries (startup permissive, interlocks, tripping etc.)
  - c) Wherever redundant pumps/fans have been provided, (e.g. centrifugal pumps, air blowers, fresh slurry pumps, control valves etc.) the standby auxiliary shall cut in automatically in the event of tripping of working auxiliary.
  - d) Required interface with existing unit control system shall be provided through hardwired interconnection which typically shall include the following:
    - Clear path' permissive for starting of ID fans i.e. either FGD bypass damper is open or the FGD system is in operation (all dampers in FGD path open and limestone slurry system, booster fans on).
    - In the event of tripping of any one booster fan, output shall be provided to unit control system for partial unloading of the units.
    - In the event of tripping of both booster fans/GGH, FGD bypass dampers shall be opened and, FGD inlet and outlet dampers shall be closed and FGD units shall be tripped. The bidder shall indicate the ways and means to save the Boiler Turbine unit from tripping under this situation.
    - All other interlocks, as required during detailed engineering
- iv) Necessary closed loop control system shall be provided as required.



#### 4.23 Drawings/Technical Data

4.23.1 The following information/ technical data/ drawings shall be furnished by the bidder along with his bid:

- a) Process Description
- b) System Specification
- c) P & I diagrams.
- d) FGD layout drawing
- e) Equipment layout drawings.
- f) Pump characteristic curves.
- g) Fan/blower/compressor characteristic curves
- h) Technical literature of the equipment.
- i) Design calculations for FGD process, mass balance calculation & sizing of various equipment of FGD plant.
- j) Technical particulars of equipment as per bidding schedules.

Any other data required for proper appraisal of the equipment being offered shall also be furnished if asked for by the purchaser or purchaser's consultants.

4.23.2 The following drawings/technical data shall be furnished after award of contract:

- i) All drawings/technical data mentioned at Cl. 3.5.1 above.
- ii) Flow Schematics of entire plant including complete mass flow balances and operating/design parameters for all media
- iii) Startup & shut down diagrams
- iv) Detailed drawing of connections with existing equipment
- v) Control & Interlock write-ups.
- vi) PG Test procedures.
- vii) Valve schedules
- viii) Motor schedules
- ix) Process Water Balance.
- x) G.A. drawings of all equipment.
- xi) Data Sheet for equipment.
- xii) General assembly plan and elevation drawings including ducts and piping layout drawings.
- xiii) Cross sectional drawings of major equipment of the FGD system
- xiv) Fabrication drawings of equipment.
- xv) Drawings indicating drains, cables channels, various cross overs of above.





- xvi) Complete manufacturer's catalogue of the equipment.
- xvii) Description of mode of operation of major components and auxiliary equipment including interactions with existing units
- xviii) Schedule for maintenance period
- xix) Description of plant performance and plant protection in case of disturbances from any item of equipment and unit failures
- xx) Resistance calculations for FGD System
- xxi) Thermodynamic and design calculations
- xxii) Pipe schedules
- xxiii) List of lifting equipment, cranes.
- xxiv) List of auxiliary devices required for maintenance measures
- xxv) Detail arrangement drawings of stairs, platforms, walkways, rails hoists and lifts
- xxvi) Layout drawings showing configuration of all principal components and auxiliary installations ducts, arrangement of platforms etc. in the buildings as well as outside buildings
- xxvii) Arrangement drawings of piping, piping plans and details of pipe racks and isometrics for main pipe runs
- xxviii) Detail drawings of connection at limits of supply and tie-ins including existing piping and ducting
- xxix) Foundation loads for the major and auxiliary equipment
- xxx) Drawings of cable trays, lay down route, section
- xxxi) Bill of material etc.

#### 4.24 Codes & Standards

All codes and standards referred below shall be understood to be the latest version on the date of offer made by the bidder unless otherwise indicated. Nothing in this specification shall be construed to relieve the vendor of this responsibility.

Sl. No.	Standard	Description
1.	ASME Section II (Part A, B and C)	Materials (ferrous, Non-Ferrous and filler materials respectively).
2.	ASME Section V	Code of practice for Non Destructive Testing
3.	ASME Section VIII	Code of practice for Pressure vessels
4.	ASME – Section – VIII, Division-1	Boiler & Pressure vessel code – Unfired Pressure vessel
5.	ASME Section IX	Code of practice for Welders' Performance qualifications



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6.	ASME B16.1	Cast iron pipe flanges and flanged fittings, class 25, 125, 250, 800
7.	ASME B16.5	Pipe flanges and flanged fittings
8.	ASME B16.9	Factory-made wrought steel butt welding fittings
9.	ASME B16.10	Face-to-face and end-to-end dimensions of valves
10.	ASME B16.11	Forged steel fittings, socket-welding and threaded
11.	ASME B16.25	Butt welding ends
12.	ASME B16.28	Wrought steel butt welding short radius elbows and returns
13.	ASME B16.34	Valves flanged, threaded and welding end
14.	ASME B31.1	Power piping
15.	ASME B36.10M	Welded and seamless wrought steel pipe
16.	ASME B36.10M	Stainless steel pipe
17.	ANSI B 16. 104	Valve leakages acceptance
18.	ASME PTC8.2	Centrifugal pumps
19.	ASME PTC 40	Flue gas desulphurization units
20.	ASME PV Code 8	DIV.1 Pressure vessels – division 1
21.	ASME PV Code 9	Welding & brazing qualifications
22.	MSS-SP-58859	Hangers and Supports
23.	ASTM A105/A105M	Specification for carbon steel forging for piping applications
24.	ASTM A106	Specification for seamless carbon steel pipe for high temperature service
25.	ASTM A182/182M	Specification for forged or rolled alloy steel pipe flanges, forged fittings and valves and parts for high temperature service
26.	ASTM A193/A193M	Specification for alloy steel and stainless steel bolting materials for high temperature service
27.	ASTM A194/A194M	Specification for carbon and alloy steel nuts for bolts for high pressure or high temperature service or both
28.	ASTM A216/A216M	Specification for steel castings, carbon suitable for fusion welding or high temperature service
29.	ASTM A234/A234M	Specification for piping fittings of wrought carbon steel and alloy steel for moderate and high temperature service
30.	ASTM A 240	Specification for stainless steel plate
31.	ASTM A312/A312M	Specification for seamless and welded austenitic stainless steel pipe



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32.	ASTM A333/A333M	Specification for seamless and welded steel pipe for low temperature service
33.	ASTM A403/A403M	Standard specification for wrought austenitic stainless steel piping fittings.
34.	EN287 PT1	Approval testing of welders – fusion welding – steels
35.	EN 288 PT3	Specification and approval of welding procedures for metallic materials – welding procedure tests for the arc welding of steels
36.	NFPA 85 C	Prevention of furnace explosions/implosions in multiple boiler furnaces
37.	API 617	Centrifugal compressors for petroleum, chemical and gas industries
38.	BS 848	Fans for general purpose
39.	BS 1571	Specification for testing positive displacement compressors and exhausters
40.	ISO-8573-1	Quality of Air (Dew Point)
41.	ISA – 7.3	Quality Standard of Instrument Air
42.	BS 487	Fusion welded steel air receivers
43.	IS 5	Colours for ready mixed paints and enamels
44.	IS 101	All parts and Sections for paint testing
45.	IS 104	Ready mixed paint, brushing, Zinc Chrome, priming
46.	IS 158	Ready mixed paint, brushing, bituminous, black, lead-free, acid, alkali, water and heat resisting
47.	IS 210	Cast Iron
48.	IS 276	Manganese steel liners
49.	IS 277	Galvanised Steel sheets
50.	IS 436 (part – 1) – 1976	Methods for sampling of coal
51.	IS 458	Concrete pipes (with and without reinforcement).
52.	IS 554	Pipe thread for pressure tight joints.
53.	IS 655	Air receivers
54.	IS 778	Specification for Copper alloy Gate, Globe & check valve for Water works purposes
55.	IS 803	Code of practice for design, fabrication, erection of vertical mild steel cylindrical welded oil storage tanks.



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56.	IS 804	Rectangular pressed steel tanks
57.	IS 807	Code of practice for design, manufacture, erection, testing (structural portion) of cranes and hoists
58.	IS 816	Code of practice for use of metal arc welding for general construction in mild steel.
59.	IS 817	Code of practice for training and testing of metal arc welders.
60.	IS 822	Code of practice for training and testing of metal arc welders.
61.	IS 1030	Cast steel
62.	IS 1239	Mild steel tubes, Tubulars and other wrought steel Fittings, specification — Part 1
63.	IS 1303	Glossary of terms relating to paints
64.	IS 1363	Black hexagonal bolts, nuts and locknuts (dia 6 to 39 mm) and black hexagon screws (dia to 24 mm).
65.	IS 1367	Pett-13 Hot dip galvanised coatings on threaded fasteners.
66.	IS 1477	Code of practice for painting of ferrous metals in buildings (Parts I & II)
67.	IS 1520	Horizontal centrifugal pump for clean, cold fresh water.
68.	IS 1536	Centrifugally cast (spun) iron pressure pipes for water, gas and Sewage
69.	IS 1537	Vertically cast iron pressure pipes for water, gas and sewage
70.	IS 1538	Cast iron fittings for pressure pipes for water, gas and sewage.
71.	IS 1703	Ball valves (horizontal) plunger type including floats for water supply purposes.
72.	IS 1710	Vertical Turbine Pumps for clear cold fresh water.
73.	IS 1891	Conveyor and elevator textile belting
74.	IS 2524	Code of practice for painting of non-ferrous metals in buildings (Parts I & II)
75.	IS 2594	Horizontal mild steel welded storage tanks
76.	IS 2629	Recommended Practice for Hot Dip Galvanising BS EN



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77.	IS 2685	Code of practice for erection, installation, and maintenance of sluice valves.
78.	IS 2712	Gaskets
79.	IS 2758	Forged alloy Hook
80.	IS 2825	Code for unfired pressure vessels
81.	IS 2825 Class II	Air receivers
82.	IS 2932	Enamel, synthetic, exterior (a) undercoating (b) finishing
83.	IS 3042	Single faced sluice gates (200 to 1200 mm). Single faced sluice gates (200 to 1200 mm).
84.	IS 3114	Code of practice for CI Pipes.
85.	IS 3177	Electric Overhead Travelling Cranes and Gantry Cranes other than Steel Works Cranes
86.	IS 3588	Electric axial fans
87.	IS 3589	Seamless or electrically welded steel pipes for water gas and sewage (168.3 mm to 2032 mm outside diameter)
88.	IS 3938	Electric wire rope hoists
89.	IS 3938	Specification for chain pulley block
90.	IS 3952	Cast Iron butterfly valves for general purposes.
91.	IS 4038	Foot valve for water works purposes.
92.	IS 4049	Specification for formed ends for tanks and pressure vessels
93.	IS 4059	Accuracy requirements for medium quality medium speed gears
94.	IS 4491	Magnetic core material
95.	IS 4671	Expanded polystyrene for thermal insulation purposes
96.	IS 4682	Code of practice for lining of vessels and equipment for chemical processes Rubber Lining.
97.	IS 4682	Code of practice for lining of vessels and equipment for chemical processes-rubber lining
98.	IS 4776	T roughed belt conveyors
99.	IS 4894	Centrifugal fans
100.	IS 4984	High Density polyethylene pipes.
101.	IS 4985	Unplasticised PVC Pipes.
102.	IS 5037	Basic rack and modules of straight bevel gears
103.	IS 5049	Construction of structural steel for stacker reclaimer



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104.	IS 5120	Technical requirements for roto dynamic special purpose pumps
105.	IS 5290	Specification for landing valves
106.	IS 5312	Specification for Swing check type Reflux (Non return) valves for water works purposes — Part —1 • Single door Pattern
107.	IS 5456	Testing of compressors
108.	IS 5639	Pumps Handling Chemicals & corrosion liquids.
109.	IS 5659	Pumps for process water.
110.	IS 5749	Specification for Forged Ramshorn hooks
111.	IS 6206	Compressors
112.	IS 6278	Code of practice for white washing and colour Washing
113.	IS 6393	Steel pipe flanges
114.	IS 7403	Selection of worm or helical gear
115.	IS 7413	Code of practice for application and finishing of thermal industrial application and finishing of thermal insulation
116.	IS 7938	Code for Air receivers
117.	IS 8154	Pre formed calcium silicate insulation (for temperatures upto 650 deg C)
118.	IS 8183	Bonded mineral wool
119.	IS 8531	Pulleys for belt conveyors
120.	IS 8598	Idlers and idler sets for belt conveyors
121.	IS 9137	Code of acceptance test for centrifugal, mixed flow and axial pumps — Class C
122.	IS 9295	Steel tubes for idlers for belt conveyors
123.	IS 10221	Code of practice for coating and wrapping of underground mild steel pipelines.
124.	IS 11592	Selection and design belt conveyors
125.	IS 11592	Selection and design of belt conveyors
126.	IS 11727	Measurement and Evaluation of Vibration severity in Situ of large rotating machines with speed range from 10 to 200 rev/s.
127.	IS 11989	Code for Air driers



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128.	IS 13183	Aluminium Paint, heat Resistant specification
129.	IS 13834	Cranes classification.
130.	IS 14164	Industrial application and finishing of thermal insulation material at temperature above —80 Deg C and upto 700 Deg C — Code of practice
131.	IS 14846	Sluice valve for water works purposes (50 mm to 1200 mm size) Specification
132.	IS 15560	Specification for Point hooks with shank capacity upto 160 Tonnes.
133.	ISO 1217	Performance Guarantee of displacement compressors
134.	ISO-3945	Mechanical Vibration of Large Rotating machines
135.	ISO 8501-1	Preparation of steel substrates before application of paint & related Products. Part-I: Rust grades & preparation grades of uncoated steel substrates & steel substrates after overall removal of previous coatings
136.	ISO 8502-3	Assessment of dust on steel surface prepared for painting (Pressure sensitive tape method)
137.	ISO 12944 (Part 1 to 7)	Corrosion protection of steel structures by Protective paint systems
138.	ISO 20340	Pre-Qualification test
139.	BS EN ISO 14713	Code of practice for protection of iron & steel structure against corrosion
140.	SSPC	US specifications of Steel Structures Painting Council, SSPC Volumes 1 and 11
141.	SSPC-SP-08	Surface preparation by Pickling
142.	NORSOK M-501	Surface preparation & Protective coating
143.	AWWA	American Water works Association
144.	NFPA	National Fire Protection Association
145.	HIS	Hydraulic Institute Standards
146.	HEI	Heat Exchange Institute
147.	TEMA	Tubular Exchange Manufacturer's Association
148.	PTC 8.2	ASME Performance Test Code for Centrifugal Pumps



## SECTION 5.0

### ELECTRICAL WORKS

#### 5.1 11kV, 6.6kV AND 3.3kV SWITCHGEARS

All 11kV, 6.6kV and 3.3kV switchgears shall meet the following requirements:

##### 5.1.1 Codes and standards

The equipment, materials and service shall conform to the latest applicable provision of the following standards :

IS : 722	AC electricity meters
IS : 996	Single phase small AC and universal electrical motors.
IS : 1248	Direct Acting indicating analogue electrical measuring instruments and Accessories
IS : 13947	Degree of protection provided by enclosures for low voltage switchgear and control gear
IS : 2544	Porcelain post insulators for systems with nominal voltages greater than 1000V
IS : 2705	Current transformers.
IS : 3156	Voltage Transformers
IS : 3231	Electrical relays for power system protection
IS : 3427	Metal enclosed switchgear and control gear
IS : 5082	Specification for wrought aluminium and aluminium alloy bars, rods, tubes and selections for electrical purposes.
IS : 6005	Code of practice for phosphating of iron and steel.
IS : 8686	Specification for static protective relays.
IS : 9046	AC contactors for voltages above 1000 volts and upto and including 11000V.
IS : 9224	Low voltage fuses
IS : 9385	HV fuses
IS : 9431	Specification for indoor post insulators of organic material for system with nominal voltages greater than 1000 volts upto and including 300 kV
IS : 9921	AC dis-connectors (isolators) and earthing, switches for voltages above 1000V
IS : 11353	Guide for uniform system of marking and identification of conductors and apparatus terminals.
IS : 13118	Specification for high voltage AC circuit breakers.
IEC-60099 part 4	Metal oxide surge arrester without gap for AC system
IEC-62271	HV Switchgear and Control gear
IEC-60099-1	Non-linear resistor type gapped arrester for AC systems
CIGRE WG 13.02 Chapter-3	Recommendation for substitute test for switching over voltage test





### 5.1.2 Technical Parameters

- i) The switchgears shall be indoor, metal clad, draw out type. The feeders rated 2000kW and above shall be provided with vacuum/ SF<sub>6</sub> circuit breakers. However, the motor feeders below 2000kW rating shall have vacuum/ SF<sub>6</sub> contactors backed up by HRC. The operating mechanism of the circuit breakers shall be of the stored energy type DC motor operated charging springs.
- ii) The circuit breaker, contactor and switchgear assemblies shall have the following technical parameters :

a) System parameters				
1)	Nominal System voltage	11 kV	6.6kV	3.3 kV
2)	Highest System voltage	12 kV	7.2kV	3.6 kV
3)	Rated Frequency	50 Hz	50 Hz	50 Hz
4)	Number of phases	Three	Three	Three
5)	System neutral earthing	Earthed through resistance to limit fault current to 300A or High resistance grounding through artificial earthing transformer and earthing resistor		
6)	One minute power frequency withstand voltage			
	- for Type tests	28	20	10
	- for Routine tests	28	20	10
7)	1.2/50 microsecond Impulse withstand voltage	75 kV (peak)	60 kV (peak)	40 kV(peak)
8)	Maximum system fault level including initial motor contribution	40 kA for 1 second	40 kA for 1 second	40 kA for 1 second
9)	Dynamic withstand rating	100 kA (peak)		
10)	IAC Rating	40kA, 1sec		
11)	Control supply voltage			
	- Trip and closing coils	---- 220V DC ----		
	- Spring charging motor	-----220V DC ----- (240V AC can be accepted for off-site areas)		
	- Space heaters	----- 240V AC ----		
12)	Ambient temperature	50°C		
b) Busbars				
1)	Continuous current rating at 50°C ambient:	as per system requirements		
2)	Temperature rise	- 40°C for plain joints - 55°C for silver plated joints		
c) Constructional requirements				



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1)	Colour finish - exterior and interior	as mentioned elsewhere
2)	Cable entry	
	- Power cables	Bottom
	- Control cables	Bottom
3)	Bus duct entry	----Top---
4)	Earthing conductor	Galvanised steel strip
5)	Service Continuity of swgrs (as per IEC 62271-200)	LSC2B-PM
<b>d) Circuit breakers</b>		
1)	Short circuit breaking current	
	- AC component	40 kA
	- DC component	As per IS 13118 or IEC 62271
2)	Short circuit making current	100 kA (peak)
3)	Operating Duty	B – 3min – MB – 3min – MB
4)	Total break time	Not more than 4 cycles
5)	Total make time	Not more than 5 cycles
6)	Operating Mechanism	Motor wound spring charged stored energy type as per IEC 62271
<b>e) Relays</b>		
1)	One minute power frequency	2.0 kV (rms)
<b>f) Meters</b>		
1)	Accuracy class for energy accounting and audit meters	
	- on incomer of each 11kV, 6.6kV and 3.3kV switchgear	0.2S
	- on all 11kV, 6.6kV and 3.3kV motor other meters	0.2S 1.0
2)	One minute power frequency	2.0 kV (rms)
<b>g) Current Transformer</b>		
1)	Class of Insulation	Class E or better
2)	Rated output of each	Adequate for the relays and devices connected, but not less than fifteen (15) VA.



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3)	Accuracy class			
	Measurement core for energy accounting and audit meters			
	- on incomer of each 11kV, 6.6kV and 3.3kV switchgear		0.2S	
	- on all 11kV, 6.6kV and 3.3kV motor		0.2S	
	Protection core			
	- differential and core balance CTs		PS	
	- other protection CTs		5P20	
4)	Minimum primary earth fault current to be detected by core balance CT		3 A	
<b>h) Voltage Transformers</b>				
1)	Rated voltage factor	1.2 continuous for all VTs, and 1.9 for 30 sec. for star connected VTs.		
2)	Measurement	0.2S		
3)	Protection	3P		
4)	VA burden	Adequate for application		
<b>i) Fuses</b>				
1)	Voltage class	11kV	6.6kV	3.3kV
2)	Rupturing Capacity	Adequate for 100 kA (peak)		
3)	Rated current	As per application		
<b>j) Surge arresters</b>				
		11 kV	6.6kV	3.3kV
1)	Nominal discharge current (8x20 micro-sec.)	500 Amp		
2)	Maximum system voltage	12 kV	7.2kV	3.6kV
3)	Maximum standard impulse spark over voltage (peak)	25 kV (without any positive tolerance)		
4)	Residual voltage at nominal discharge current	25 kV	12kV	8kV
5)	Temporary over voltage capability (rms)			
	a) For 10,000 seconds	12 kV	7.2kV	3.6kV
	b) For 5 seconds	14.3 kV	8.6kV	4.3kV
6)	Installation	Inside the switchgear panel		
<b>k) Contactors</b>				
1)	Nominal system voltage	NA	6.6kV	3.3kV
2)	Highest system voltage	NA	7.2kV	3.6kV



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3)	Rated frequency	NA	50Hz	50Hz
4)	Control supply voltage	NA	220V DC	220 V DC
5.	Utilization category	NA	AC-3	AC-3
<b>l) Transducers</b>				
<b>1) Current transducers</b>				
	a) Input	0-1 A (CT secondary)		
	b) Rated frequency	50 Hz		
	c) Output	4-20 mA (2 Nos. decoupled)		
	d) Accuracy	0.5%		
<b>2) Voltage transducers</b>				
	a) Input	110V, 50 Hz (from VT secondary)		
	b) Output	4-20 mA (2 Nos. de-coupled)		
	c) Accuracy	0.5%		
<b>3) VAR transducers</b>				
	a) Input	3 phase, 3-wire 1 A (CT secondary) 110 V (VT secondary)		
	b) Rated frequency	50 Hz		
	c) Output	4-20 mA (2 nos. de-coupled)		
	d) Accuracy	0.5%		
<b>4) Watt transducers</b>				
	a) Input	3 phase, 3-wire 1A (CT secondary) 110V (VT secondary)		
	b) Rated frequency	50 Hz		
	c) Output	4-20 mA (2 nos. decoupled)		
	d) Accuracy	0.5%		
<b>5) Frequency transducers</b>				
	a) Input	110V (VT secondary)		
	b) Rated frequency	50 Hz		
	c) Range	45 to 55 Hz		
	d) Output	4-20 mA (2 nos. decoupled)		
	e) Accuracy	0.5%		

### 5.1.3 Metering

Ammeters with Ammeter selector switch to be provided on incomers, Bus coupler and out going feeders. Voltmeters with voltage selector switch for each bus section to be provided on bus coupler. On incomer panels of HT switchgear, energy meters (0.5 accuracy class) shall be provided. Transducers shall be provided to transfer the data of current / voltage / power to DCS / PLC.

The energy meters shall be provided as per the Central Electricity Authority (Installation and Operation of Meters) Regulations, 2006 and its amendments. However, the following energy accounting and audit meters shall be provided in general :



- On each incoming feeder of 11kV, 6.6kV and 3.3kV buses.
- On all 11kV, 6.6kV and 3.3kV motor feeders

Energy accounting and audit meters shall be of accuracy class of 0.2S. The accuracy class of CTs and VTs shall not be inferior to that of associated meters. In case, numerical relays having built-in features of energy measurement of requisite accuracy are provided in switchgear, separate energy meter is not necessary.

#### 5.1.4 General Technical Requirements

##### i) Switchgear panel

- a) Each 3.3kV switchboard shall have two sections each of 100% capacity and connected through a 'Normally Open' bus-coupler. These two sections shall be fed from two independent sources to be arranged by the bidder.
- b) Single phase VTs on the incoming breaker panels shall be provided for checking the voltage on both of the sections while paralleling. The Automatic Reserve Closure (ARC) facility shall be provided on bus-coupler breaker such that it will close automatically in case of failure of any one incomer.
- c) The 'Synchronizing Check' relay with necessary ancillary equipment shall be provided for manual bus transfer with and without voltage interruption. The type, make etc. of the relay/scheme shall be subjected to prior approval of the purchaser.
- d) All necessary instruments, such as ammeter, voltmeter with selector switch, etc. in incomer breaker panels shall be provided.
- e) The switchgear shall have a single front, single tier, fully compartmentalized, metal clad construction complying with clause No. 3.102 of IEC-62271-200, comprising of a row of free standing floor mounted panels. Each circuit shall have a separate vertical panel with distinct compartments for circuit breaker/contactors truck, cable termination, main bus bars and auxiliary control devices. The adjacent panels shall be completely separated by steel sheets except in bus bar compartments where insulated barriers shall be provided to segregate adjacent panels.
- f) The circuit breakers/ contactors and bus VTs shall be mounted on withdrawable trucks which shall roll out horizontally from service position to isolated position.
- g) The trucks shall have distinct Service, Test and Isolated positions. It shall be possible to close the breaker/contactors compartment door in Isolated position also, so that the switchgear retains its specified degree of protection. While switchboard designs with doors for breaker/contactors compartments would be preferred, standard designs of reputed switchgear manufacturer's where the truck front serves as the compartment cover may also be considered, provided the breaker/contactors compartment is completely sealed from all other compartments and retains the IP-4X degree of protection in the Isolated position.



- h) The switchgear assembly shall be dust, moisture, rodent and vermin proof with the truck in any position Service, Test and Isolated or removed, and all doors and covers closed. All doors, removable covers and glass windows shall have gaskets all round with synthetic rubber or neoprene gaskets.
  - i) The VT/ relay compartments shall have degree of protection not less than IP:52 in accordance with IS/IEC 60947. However, remaining compartments can have a degree of protection of IP: 4X. No louvers/opening shall be provided on the top of the panel. All other louvers if provided, shall have very fine brass or GI mesh screen. Tight fitting gaskets are to be provided at all openings in relay compartment.
  - j) Enclosure shall be constructed with rolled steel sections and cold rolled steel sheets of at least 2.0 mm thickness, Gland plates shall be 2.5 mm thick made out of hot rolled or cold rolled steel sheets and for nonmagnetic material it shall be 3.0 mm.
  - k) The switchgear shall be cooled by natural air flow and forced cooling shall not be accepted.
  - l) Total height of the switchgear panels shall not exceed 2600 mm. The height of switches, push buttons and other hand operated devices shall not exceed 1800 mm and shall not be less than 700 mm.
  - m) Safety shutters complying with IEC-62271-200 shall be provided to cover up the fixed high voltage contacts on bus bar and cable sides when the truck is moved to TEST and ISOLATED position. The shutters shall move automatically, through a linkage with the movement of the truck.
  - n) The switchgears shall have the facility of extension on both sides.
  - o) The Switchgear shall have an Internal Arc Classification of IAC FLR 40KA, 1 sec. The switchgear construction shall be such that the operating personnel are not endangered by breaker operation and internal explosions, and the front of the panels shall be specially designed to withstand these. Pressure relief device shall be provided in each high voltage compartment of a panel, so that in case of a fault in a compartment, the gases produced are safely vented out, thereby minimizing the possibility of its spreading to other compartments and panels. The pressure relief device shall not however reduce the degree of protection of panels under normal working conditions. To demonstrate that the pressure relief device operates satisfactorily the Contractor shall submit the type test report in line with IEC 62271-200 Annex - A. Wherever louvers are provided, the construction of louvers shall be such that the IAC requirements are satisfied. Further, viewing glass windows shall have the same strength as that of enclosure against internal Arc.
- ii) **Circuit breaker**
- a) The circuit breakers shall be of Vacuum/ Sulphur hexafluoride (SF<sub>6</sub>) type. They shall comprise of three separate, identical single pole interrupting units, operated through a common shaft by a sturdy operating



mechanism. Surge arrestor shall be provided for each motor/ transformer feeder.

- b) Circuit breaker shall be restrike free, stored energy operated and trip free type. Motor wound closing spring charging shall only be acceptable. An anti-pumping relay shall be provided for each breaker, even if it has built-in mechanical anti-pumping features.
- c) Plug and socket isolating Contacts for main power circuit shall be silver plated, of self-aligning type, of robust design and capable of withstanding the specified short circuit currents. They shall preferably be shrouded with an insulating material. Plug and socket contacts for auxiliary circuits shall also be silver plated, sturdy and of self-aligning type having a high degree of reliability. Thickness of silver plating shall not be less than 10 microns.
- d) In case of SF<sub>6</sub> gas type circuit breaker, necessary pressure/ density monitoring switch along with the contact for remote indication shall be provided.

iii) **Protection**

The protective Numerical relays shall be provided for protection of all the three phases of feeders. Adequate electrical protections with auxiliary relays and timers as required shall be provided for all the equipment which shall include but not limited to following.

a. **The 11/6.6/3.3 kV Incoming (Main & Bus Coupler) and Outgoing supply feeders :**

- i) Three Phase Over current (50).
- ii) Bus No-volt
- iii) Lockout (86)
- iv) Earth fault protection (50N)
- v) Synchronizing check (25)

b. **The 11/6.6/3.3kV motor feeders :**

- i) Instantaneous over current relay (50)
- ii) Thermal overload relay (49).
- iii) Locked rotor protection (50LR)
- iv) Protection relay for Unbalance current (46)
- v) Earth fault protection (50N)
- vi) Under voltage (27M) with VT fuse failure
- vii) Motor start monitoring & Restart inhibit feature
- viii) Number of starts limitation (66)
- ix) Differential Protection-High Impedance(87M) for Motors of rating  $\geq$  2MW

c. **11kV/3.3kV, 11kV/433V, 6.6kV/433V auxiliary service transformers feeders :**

- i) Instantaneous Over current for short circuit protection (50)
- ii) Back-up Instantaneous Over current for short circuit protection (51)
- iii) Transformer in-built protection for incipient fault.
- iv) Earth fault protections (50N)



- v) Zero sequence protection/REF on LV side (neutral CT to be provided in case of solid grounding)
- vi) Stand by earth fault protection (51N) for TRF LV neutral resistively grounded
- vii) Transformer Differential protection-Low impedance (87T) for Transformer rating  $\geq 5$  MVA

iv) **Relays**

- a) The protective relays shall be numerical type. All relays, auxiliary relays and devices shall be of reputed make and types proven for the application and shall be subject to purchaser approval. The relays and timers shall have appropriate setting ranges, accuracy, resetting ratio, transient over-reach and other characteristics to provide required sensitivity to the satisfaction of the owner.
- b) Relays shall be suitable for efficient and reliable operation of the protection scheme. Necessary auxiliary relays, timers, trip relays, etc. required for complete scheme, interlocking, alarm, logging, etc. shall be provided. No control relay, which shall trip the circuit breaker when relay is de-energized, shall be employed in the circuits.
- c) Relays shall be flush mounted on the front with connections at the rear. Provision shall be made for easy isolation of trip circuits for testing and maintenance.
- d) Relays shall be provided with self-reset contacts except the trip, lockout relays and interlocking (contact multiplication) relays which shall be manual reset type
- e) Auxiliary relays shall be provided in the trip circuits of protections located outside the board, such as Buchholz relay, temperature indicators, fire protection, etc.
- f) Suitable measures shall be provided to ensure that transients present in CT and VT connections due to extraneous sources in 400kV system do not cause damage to static circuit.
- g) Only DC/ DC converters shall be provided in the solid state devices/ relays wherever necessary to provide a stable auxiliary supply for relay operation
- h) All relays shall have hand-reset flags or other means for ready visual indication of their operation and also of the faulty phase.

v) **Contactors**

- a) Mechanically latched type contactors shall be backed by HRC fuses for outgoing motor feeders. The high voltage contactors shall be of AC-3 utilization category and shall be SF<sub>6</sub> or vacuum type. The fuse and contactor assembly shall be mounted on a withdrawable truck. Circuits shall be provided with suitable single phasing protection.
- b) Surge suppressors shall be provided on all contactor controlled motor feeders.





vi) **Surge arrester**

The surge arrestors shall be provided for all motor/ transformer feeders and shall be metal oxide, gapped or gap less type generally in accordance with IEC 60099-1 and suitable for indoor duty. These shall be mounted within the switchgear cubicle between line and earth, preferably in the cable compartment. Surge arrester selected shall be suitable for non-effectively earthed system and rating shall be in such a way that the value of steep fronted switching over voltage generated at the switchgear terminals shall be limited to the requirements of switchgear.

vii) **Control and Interlocks**

- a) The circuit breaker/ contactor will normally be controlled from remote control panels through closing and shunt trip coils. The control switch located on the switchgear would normally be used only for testing of circuit breaker/ contactor in isolated position, and for tripping it in an emergency.
- b) The circuit-breaker shall have three distinct positions as follows:  
'Service' - Both power and control contacts connected.  
'Test' - Power contacts isolated, control contacts connected.  
'Isolated' - Both power and control contacts isolated.
- c) 'Red', 'Green' and 'white' indication lamps shall be provided on the panel to indicate breaker 'Close', 'Open' and 'Auto-Trip' position. In addition to above, mechanical indicator shall be provided which shall be clearly visible to the operator standing in front of the panel.
- d) Suitable indication to show the circuit-breaker 'service' and 'Test' positions shall be provided.
- e) Facilities shall be provided for mechanical tripping of the breaker/ contactor and for manual charging of the stored energy mechanism for a complete duty cycle, in an emergency. These facilities shall be accessible only after opening the compartment door.
- f) Six (6) normally open (NO) and six (6) normally closed (NC) auxiliary contacts shall be provided in Incomer, Bus coupler and tie feeders for future use. For all other breakers/ contactor modules four (4) NO and four (4) NC contacts shall be provided. The above contacts shall be wired out to the terminal blocks. Contact multiplication, if necessary to meet the above contact requirement, shall be done through electrical reset latch relay.

viii) **Bus bars and Insulators**

- a) All bus bar and jumper connections shall be of high conductivity aluminum alloy. They shall be adequately supported on insulators to withstand electrical and mechanical stresses due to specified short circuit currents.

Bus bar cross-section shall be uniform throughout the length of switchgear. Bus bars and other high voltage connection shall be sufficiently corona free at maximum working voltage. All bus bars shall be



colour coded. All horizontal & vertical bus bars shall have high voltage sleeving.

- b) The temperature rise of the horizontal and vertical bus bars when carrying the rated current shall be in no case exceed 55°C for silver plated joints and 40°C for all other type of joints. The temperature rise at the switchgear terminals intended for external cable termination shall not exceed 40°C. Further the switchgear parts handled by the operator shall not exceed a rise of 5°C. The temperature rise of the accessible parts/ external enclosure expected to be touched in normal operation shall not exceed 20°C.

ix) **Earthing and earthing devices**

- a) A galvanised steel or copper earthing bus shall be provided at the bottom and shall extend throughout the length of each switchgear. It shall be bolted/ welded to the framework of each panel and each breaker/ contactor earthing contact bar.
- b) The earth bus shall have sufficient cross section to carry the momentary short circuit and short time fault currents to earth as indicated under switchgear parameters without exceeding the allowable temperature rise.
- c) All joint splices to the earth bus shall be made through at least two bolts and taps by proper lug and bolt connection.
- d) The truck and breaker / contactor frame shall get earthed while the truck is being inserted in the panel and positive earthing of the truck and breaker / contactor frame shall be maintained in all positions i.e. Service, Test and Isolated as well as throughout the intermediate travel. The truck shall also get and remain earthed when the control plug is connected irrespective of its position.
- e) All metallic cases of relays, instruments and other panel mounted equipment shall be connected to earth by independent stranded copper wires of suitable size.
- f) VT and CT secondary neutral point earthing shall be at one place only on the terminal block. Such earthing shall be made through links so that earthing of one secondary circuit may be removed without disturbing the earthing of other circuits.
- g) Separate earthing trucks shall be provided for maintenance work. These trucks shall be suitable for earthing the switchgear bus bars as well as outgoing / incoming cables or bus ducts. The trucks shall have a voltage transformer and an interlock to prevent earthing of any live connection. The earthing trucks shall in addition have a visual and audible annunciation to warn the operator against earthing of live connections.

As an alternative to separate earthing trucks, built-in earthing facilities for the bus bars and outgoing / incoming connections, in case such facilities are available in their standard proven switchgear design shall also be acceptable. The inbuilt earthing switches shall have provision for short circuiting and earthing a circuit intended to be earthed. These switches shall be quick make type, independent of the action of the operator and shall be operable from the



front of the switchgear panel. These switches shall have facility for padlocking in the earthed condition.

- h) Interlocks shall be provided to prevent :
- Closing of the earthing switch if the associated circuit breaker truck is in Service position.
  - Insertion of the breaker truck to Service position if earthing switch is in closed position.
  - Closing of the earth switch on a live connection. Three (3) nos. voltage capacitive dividers shall be provided on each phase of the section intended for earthing and three (3) nos. "RED" neon lamps/ LEDs connected to these on the panel front for visual indication.
  - Energising an earthed Section : Complete details of arrangement offered shall be included in the bid, describing the safety features and interlocks.
- i) The earthing device (truck/ switch) shall have the short circuit withstand capability equal to that of associated switchgear panel. 4 NO+4 NC of auxiliary contacts of the earthing device shall be provided for interlocking purpose.
- j) All hinged doors shall be earthed through flexible earthing braid.

x) **Painting**

All sheet steel work shall be pretreated, in tanks, in accordance with IS:6005. Degreasing shall be done by alkaline cleaning. Rust and scales shall be removed by pickling with acid. After pickling, the parts shall be washed in running water. Then these shall be rinsed in slightly alkaline hot water and dried. The phosphate coating shall be "Class-C " as specified in IS : 6005. The phosphated surfaces shall be rinsed and passivated prior to application of stoved lead oxide primer coating. After primer application, Electrostatic Powder Painting shall be used. Finishing paint shade for complete panels excluding end covers shall be RAL9002 and RAL5012 for extreme end covers of all switchgears. The paint thickness shall not be less than 50 microns.

xi) **Instrument transformers (CT's and VT's)**

- a) All current and voltage transformers shall be completely encapsulated cast resin insulated type, suitable for continuous operation at the ambient temperature prevailing inside the switchgear enclosure. The class of insulation shall be E or better.
- b) Current transformers may be multi or single core and shall be located in the cable termination compartment. All voltage transformers shall be single phase type. The bus VTs shall be housed in a separate panel on a truck so as to be fully withdrawable. Separate set of current transformer shall be provided for differential protection of the feeder.
- c) Core balance CTs (CBCT) shall be provided on outgoing motor and transformer feeders having CT ratio 50/1A. These CBCTs shall be mounted inside the switchgear panel.



- d) All voltage transformers shall have suitable HRC current limiting fuses on both primary and secondary sides. Primary fuses shall be mounted on the withdrawable portion. Replacement of the primary fuses shall be possible with VT truck in Isolated position.

xii) **Instruments and Meters**

- a) Indicating instruments and integrating meters shall be flush mounted on panel front. The instruments shall be of at least 96 mm<sup>2</sup> size with 90 deg. scales. The covers and cases of instruments and meters shall provide a dust and vermin proof construction.
- b) Ammeters on motor feeders shall have a compressed scale at the upper current region to cover the motor starting current without graduation from one to six times the rated CT secondary current. These shall be suitable to withstand the above current of motors which can last up to 30 seconds (under stalled condition) without any damage or loss of accuracy.
- c) Watt-hour meters shall preferably be 3-phase two (2) element type suitable for measurement of unbalanced loads in three phase three wire system.
- d) Watt-hour meters shall preferably be provided in draw out cases with built-in testing facilities. Alternatively, they may have test blocks to facilitate testing of meters without disturbing CT and VT secondary connections. Watthour meters shall have reverse running stops. They shall have six digit register indicating primary circuit energy in MWH with at least count on 0.1 MWH.
- e) Suitable self powered transducers as per IS:12784 Part-I for feeding signals to panel mounted electrical meters (ammeters, voltmeters, VAR meters and wattmeters etc.) and DCCMIS shall be provided.

Transducers shall be tested as per IEC – 600298 or impulse test etc. and short circuit withstand capability as per ANSI C 37.90a, 1989.

Transducers shall be provided with two decoupled 4-20mA output signals, one for meter and one for DDCMIS. Current limiting features shall be provided for all the transducers.

- f) Necessary hardware shall be provided in the switchgear panel like coupling relays (24VDC with maximum burden of 2.5VA), auxiliary relays in addition to current/ bus-voltage transducers (4-20 mA, dual output) etc. to effect interlocks, exchange information/ status and exercise control from remote.

xiii) **Control and Selector switches**

- a) Control and selector switches shall be of heavy duty, rotary type with escutcheon plates clearly marked to show the positions. The switches shall be of sturdy construction suitable for mounting on panel front. Switches with shrouding of live parts and sealing of contacts against dust ingress shall be preferred.



- b) On-Off control switches shall have three positions and shall be spring return to 'Neutral' from close and trip positions. They shall have two contacts closing in close position and two contacts closing in trip positions, and shall have Pistol Grip handles. Lost motion feature shall be provided wherever required.
- c) Selector switch shall have two stay put positions as per the module requirements indicated elsewhere. They shall have two contacts for each of the positions and shall have black Spade handle.
- d) Ammeter and Voltmeter selector switches shall have four stay-put positions with adequate number of contacts for three phase system. These shall have oval handles. Ammeter selector switches shall have make before break type contacts to prevent open circuiting of CT secondary.

xiv) **Indicating lamps**

- a) Indicating lamps shall be of the panel mounting, LED type and low watt consumption preferably built in the lamp assembly. The lamps shall have escutcheon plates marked with its function, wherever necessary.
- b) Lamps shall have translucent lamp-covers of the following colours, as warranted by the application:

Red	Closed
Green	Open
White	Auto-trip
Blue	For all healthy conditions (e.g. control supply, spring charged, and lock out relay coil healthy)
Amber	For all alarm conditions (e.g. pressure low, over load) also for Service and Test positions indications.

xv) **Control supply and Space heater supply**

- a) Each switchboard shall be provided with two (2) Nos. of 220 V DC feeders for the control supply.
- b) Under voltage relay to monitor each of the control supply shall be provided.
- c) All DC circuits shall be fused on both poles. Single phase AC circuits shall have fuses on line and link on neutral.

xvi) **Space heater**

- a) Each switchgear panel shall be equipped with thermostatically controlled space heater(s), suitably located in breaker/contactors and cable compartments to prevent condensation within the enclosure. The space heater shall be connected to 240 V single phase AC auxiliary supply available in the switchgear, through switches and fuses provided separately for each panel.
- b) For motor space heater supply, one breaker / contactor normally closed (NC) auxiliary contact of each motor feeder shall be wired out in series of switch fuse up to terminals block in the respective panels of switch boards. The



motor space heater supply shall be taken from Panel space heater supply given to switch board.

- c) A 240V single phase 50 Hz AC plug point shall be provided in the interior of each cubicle with ON-OFF switch for connection of hand lamp.

xvii) **Terminal blocks**

- a) Terminal blocks shall be 650 Volts grade, 10 Amps rated, one piece moulded complete with insulating barriers. clip on type terminals, washers, nuts and identification strips.
- b) Terminal blocks for CT and VT secondary leads shall be provided with links to facilitate testing, isolation star/delta formation and earthing. Terminal blocks for CT secondary shall have the short circuiting facility.
- c) At least 10% spare terminals for external connections shall be provided on each panel and these spare terminals shall be uniformly distributed on all terminal blocks. Space for adding another 10% spare terminals shall also be available in each panel.

xviii) **Power cable termination**

- a) Cable termination compartment shall receive stranded Aluminum conductor, XLPE insulated, shielded, armoured/ unarmoured, PVC jacketed, single core/ three core unearthed/ earthed grade power cable(s).
- b) A minimum clearance of about 600 mm shall be kept between the cable lug bottom ends and gland plates for stress cone formation for XLPE cables. Interphase clearance in the cable termination compartment shall be adequate to meet electrical and mechanical requirement besides facilitating easy connections and disconnections of cables.
- c) Cable termination compartment shall be complete with power terminals, power lugs and associated hardware and removable undrilled gland plates. For all single core cables gland plates shall be of nonmagnetic material.

xix) **Name plates and Labels**

- a) Each switchgear shall have a name plate for its identification. All enclosure mounted equipment shall be provided with individual engraved name plates for clear equipment identification. All panels shall be identified on front as well as backside by large engraved name plates giving the distinct feeder description along with panel numbers. Back side name plates shall be fixed in panel frame and not on the rear removable cover.
- b) Name plate shall be of non-rusting metal or 3-ply lacmoid with white engraved letterings, on black background. Letter size shall be of at least 10mm height.

**5.1.5 Spare feeders**

10% spare feeders with at least one of each type of highest rating shall be provided in each switchgear section.



### 5.1.6 Make of Components

The bidder shall indicate the proposed makes of various bought out components such as relays, CT's, VT's, control transformers, load breaker switch, fuse, contactor, push button, Space heater, instruments etc. in the technical bidding schedule. However, this shall not be bindings on the purchaser, final make shall be approved by the purchaser/ consultant during detailed engineering to satisfy the specification requirement.

### 5.1.7 Tests

a) Type Tests:

Reports of all type tests shall be submitted before dispatch for approval. In case type test report on similar equipment (conducted within 10 years as on the date of bid opening) is not available, these tests shall be carried out. The bidder shall clearly indicate in his tender whether he would be furnishing the type tests reports or he shall be conducting the tests along with the additional cost for such tests, if any. The purchaser reserves the right either to waive the type tests or get these type tests conducted.

b) Routine tests:

All routine tests as per relevant standards shall be conducted on the assembly and the various components. The successful bidder shall submit five (5) copies of certified test reports on all routine tests before dispatch for approval.

c) The purchaser reserves the right to witness all the tests. The tenderer shall give at least three weeks clear notice prior to conducting these tests to enable the purchaser and/or his representative to be present to witness the test.

d) Site Tests :

The following site tests shall be conducted as per the approved procedure to be submitted during detailed engineering :

- Visual inspection
- Insulation Test
- Calibration of relays & Instruments
- Function / interlock test
- Ratio and polarity for CTs and VTs
- Breaker closing and tripping time
- Anti-pumping operation
- HV test on completely installed switchboard

### 5.1.8 Drawings and data

The bidders shall furnish the following drawings and data with the bid.

- a) Single line diagram and Bill of Material for every 11kV/6.6kV/3.3kV (as applicable) switchboard including points of control.



- b) Single line diagram and schematic (interconnection) drawing of 11kV/6.6kV/3.3kV (as applicable) switchboards and 415V switchboard / MCCs/ distribution boards.
- c) Layout drawings for the above equipment.

## 5.2 Auxiliary Service Transformer

### a) 11/3.3kV HT OIL/ DRY TYPE TRANSFORMERS

- (i) The transformers shall be provided with delta connected primary and a star connected secondary with the star point brought out and resistance earthed for 3.3kV system.
- (ii) All auxiliary transformers shall be dry type (indoor)/ oil filled (outdoor) as per site requirement and considerations.
- (iii) Rating

1.	Vector Group	--	Dyn11
2.	Tap Changing	--	Off load externally hand operated
3.	Tappings	--	$\pm 2\frac{1}{2}$ % and $\pm 5$ % on HV side
4.	Impulse test Voltage	--	75kV peak on 11kV and 40kV on 3.3kV
5.	Power Freq. Test voltage	--	28kV rms on 11kV, 10kV rms on 3.3kV
6.	Type of transformers	--	Oil/ Cast Resin Dry Type Transformer
7.	Type of cooling	--	ONAN/ AN
8.	Impedance	--	The impedance of the transformers shall be in the range of the values in relevant standards. Impedance shall be chosen to limit the parameters of the 3.3kV system to the following values:
			System fault level - 50kA rms
			Breaking capacity - 50kA rms
			Making capacity - 105 kAp
			Normal system voltage - 3.3 kV
			Highest system voltage - 3.6 kV
			Voltage variation - $\pm 10$ %
			Frequency - 50 Hz
			Frequency variation - $\pm 5$ %





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9.	Terminal connections of 11/3.3 or 6.6kV (as applicable)/ 0.433kV LT Transformers	--	Terminal connections of these transformers on 11/3.3kV side will be through 11/3.3kV (UE) (as applicable) XLPE Aluminium cables. Crimping lugs and compression glands shall be used for cable connections.
10.	CT details and Bushing details		To be given by the utility

**b) 11/0.433kV, 6.6/0.433kV or 3.3/ 0.433 kV LT OIL/ DRY TYPE TRANSFORMERS**

- i) The 415V distribution system shall have solidly earthed neutral. 415V Auxiliary supply for catering to various auxiliaries shall be obtained from 11/6.6/3.3/ 0.433kV Delta/ Star Transformers which in turn shall be fed from 11/6.6/3.3kV switchgear respectively. The 415V distribution system shall be designed with 2x100% rating transformers. The capacity of the transformers shall not exceed 2000kVA. In case the total 415V load for a system works out to be more than 2000kVA, the bidder shall design the 415V supply system with 3x50% rating transformer. These transformers shall have the following technical features and the capacity of each shall be either 500kVA, 630kVA, 1000kVA, 1600kVA or 2000kVA, and they shall be of the same make and type for interchangeability.
- ii) All auxiliary transformers shall be dry type (indoor)/ oil filled (outdoor) as per site requirement and considerations.
- iii) Rating

1.	Vector Group	--	Dyn11
2.	Tap Changing	--	Off load externally hand operated
3.	Tappings	--	± 2½ % and ± 5% on HV side
4.	Impulse test Voltage	--	75/60/40kV peak on HV
5.	Power Freq. Test voltage	--	28/20/10kV rms on 11kV, 2.5kV rms on 3.3kV
6.	Type of transformers	--	Oil/ Cast Resin Dry Type Transformer
7.	Type of cooling	--	ONAN/ AN
8.	Impedance	--	The impedance of the transformers shall be in the range of the values in relevant standards. Impedance shall be chosen to limit the voltage drop on 415V system to the prescribed limits in the relevant standards as well as to limit the parameters of the 415V system to the following values:
			System fault level - 50KA rms
			Breaking capacity - 50KA rms



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			Making capacity - 105 KA p
			Normal system voltage - 415 V
			Highest system voltage - 476 V
			Voltage variation - $\pm 10\%$
			Frequency - 50 Hz
			Frequency variation - $\pm 5\%$
9.	Terminal connections of 11/3.3 or 6.6kV (as applicable)/ 0.433kV LT Transformers	--	Terminal connections of these transformers on 11/6.6/3.3kV side will be through 11/6.6/3.3kV (UE) (as applicable) XLPE Aluminium cables. Terminal connections on LV (0.433kV) side shall be through non-segregated phase bus duct/ Cable. Crimping lugs and compression glands shall be used for cable connections.
10.	CT details and Bushing details		To be given by the utility

c) General Requirements :

- i) For Dry type transformer of encapsulated design HV and LV coils shall be separately encapsulated under vacuum in cast resin compound. In case of design involving coils impregnated in Silicone varnish, the entire winding block shall be vacuum impregnated with polyester material without using any mould such that transformer can be installed in a high humid atmosphere.
- ii) The supplier shall connect tank / body frame and HV neutral terminal to the earth mat. The HV neutral terminal shall be connected at two different points of earth mat.
- iii) Temperature Indicator :  
  
A winding temperature with necessary current transformer, heating coil and RTDs (placed in windings) shall be mounted locally so as to be readable at a standing height from ground level. The WTI shall be provided with necessary contacts for alarm and trip.
- iv) A warning plate indicating "Switch shall be operated only when the Transformer is de-energised" shall be fitted on the off circuit tap changer.
- v) Terminal Arrangement :  
  
The primary and secondary of the transformer shall be suitable for cables/ Bus duct. The cable box shall be self supporting, weather proof to suit out door service. It shall be designed for sufficient phase to phase and ground clearance.



It shall be furnished complete with removable gland plate of non-magnetic material. The terminals for bus duct connections shall be located in this box.

vi) Marshalling Box :

Stainless steel vermin proof, well ventilated and weather proof marshalling box with water-tight hinged and padlocked door of a suitable construction shall be provided for the transformer ancillary apparatus. The box shall have sloping roof. Padlock along with duplicate keys shall be supplied for marshalling box. The degree of protection shall be IP-55.

Cubicle illumination lamp with door switch and space heater with thermostat and ON/OFF switch shall be provided. 1 no. 5 Amp. socket switch shall be provided inside the cubicle.

vii) Standards :

The transformers to be supplied by the bidder shall conform to the latest revision of IS/IEC including the following :

IS 2026	-	Power Transformers
IS 11171	-	Dry type Power Transformers
IS 2029	-	Bushing for Power Transformers

### 5.3 415V SWITCHGEARS AND NON-SEGREGATED PHASE BUS DUCT, DC BOARDS

All 415V switchgears (i.e. Power control centres (PCCs), Motor control centres (MCCs)), 415V non-segregated phase bus duct, and DC Boards for FGD system shall be provided.

#### 5.3.1 Codes and standards

The equipment, materials and service shall conform to the following standards :-

IS : 5	Colours for ready-mixed paints and enamels.
IS: 694	PVC insulated cables for working voltages upto and including 1100V
IS : 722	AC Electricity Meters
IS : 1248	Electrical Indicating instruments
IS : 13947 Pt. 1	Degree of protection provided by enclosures for low voltage Switchgear and Control gear
IS : 13947Part-2 / IEC-60947	AC Circuit Breakers
IS : 2551	Danger Notice Plates
IS : 2629	Hot dip galvanising
IS : 2705	Current Transformers
IS : 13947Pt 4,Sec-1 (IEC-60947)	Contactors and motors starter for voltages not exceeding 1000 V AC or 1200 V DC
IS : 3043	Code of practice for earthing
IS : 3072	Code of practice for installation and maintenance of Switchgear
IS : 3156	Voltage Transformers
IS : 3202	Code of practice for climate proofing of electrical equipment
IS : 3231	Electrical relays for power system protection



Standard Technical Specification for Retrofit of Wet Limestone Based Flue Gas Desulphurisation (FGD) System in a Typical 2x500 MW Thermal Power Plant  
Section- 5 (Electrical Works)

IS : 13947	Air-Break Switches, air break disconnectors, air Break disconnector and fuse combination units for voltages not exceeding 1000V AC or 1200 V DC.
IS : 13947 Pt. - I IEC –60947	General Requirements for Switchgear and Control gear for voltages <1000 V
IS : 5082	Wrought Aluminium and Aluminium alloys for electrical purposes.
IS : 6005	Code of practice of phosphating of iron and steel
IS:13947 Pt.-5 Sec.1, IEC- 60947	LV switchgear and Control gear Control current devices and switching element
IS : 8623 (3 parts) / IEC- 60439	Specification for factory built assemblies of Switchgear and Control gear for voltages up to and including 1000V AC and 1200V DC
IS : 8686	Static Relays
IS : 13703 / IEC-60269	HRC Cartridge fuses
IS : 10118 (4 parts)	Code of practice for selection, installation and maintenance of switchgear and control gear
IS : 11171	Specification for dry type transformers
IS : 11353	Guide for uniform system of marking and identification of conductors and apparatus terminals
IS : 12021	Specification of control transformers for switchgear and Control gear for voltage not exceeding 1000V AC
IS:8084 Updated upto:1992	Interconnecting bus bars for A.C. voltage above 1kV up to and including 36kV.
ANSI C37:20	Switchgear Assemblies including Metal enclosed Bus.

### 5.3.2 Technical parameters

- i) The switchgears shall be indoor, metal clad having following features :

Circuit Breakers	Air break, three pole, spring charged, horizontal draw out type, suitable for electrical operation
Switchgear	Fully draw out type, single front
MCC/ VDDC	Fully draw out type, single front
ACDB/ DCDB	Fixed type, single front
Note : In case of space constraint, double front switchgear can be accepted and shall be decided by the utility as per site conditions.	

- ii) System parameters

1)	Nominal system voltage	415VAC	220V DC
2)	Highest system voltage	456V	240V DC
3)	Voltage variation	± 10%	185 – 240V DC
4)	Rated frequency	50 Hz	--
5)	Frequency variation	(+) 3 to (-) 5%	--
6)	System earthing	solidly grounded	Unearthed
7)	Maximum system fault level	50kA for 1 seconds	20kA for 1 second

### 5.3.3 Metering

The energy meters shall be provided as per the Central Electricity Authority (Installation and Operation of Meters) Regulations,2006 and its amendments.



However, the energy accounting and audit meters shall be provided on LV side of each incoming transformer feeder of 415V buses.

Energy accounting and audit meters shall be of accuracy class of 0.2S. The accuracy class of CTs and VTs shall not be inferior to that of associated meters. In case, numerical relays having built-in features of energy measurement of requisite accuracy are provided in switchgear, separate energy meter is not necessary.

#### 5.3.4 General technical particulars

- a) Temperature rise - The temperature rise of the horizontal and vertical bus bars and main bus link including all power draw out contacts when carrying 90% of the rated current along the full run shall in no case exceed 55°C with silver plated joints and 40°C with all other types of joints over an ambient of 50°C.
- b) **Breakers**
  - i) Breakers shall have anti-pumping feature.
  - ii) The incomer and bus coupler breakers for switchgear shall be electrically operated with over current releases or relays.
  - iii) Breakers shall have inherent fault making and breaking capacities. They shall have shunt trip coils. In case releases are offered, the same shall have contact for energization of lockout relay. All breakers shall have built in interlocks for equipment and personnel safety.
  - iv) Paralleling of two supplies shall be avoided by interlocking except for switchgear where auto-changeover is provided. Breaker contact multiplication, if required, shall be through latch relay.
  - v) Mechanical tripping shall be through red 'Trip' push button outside the panels for breakers, and through control switches for other circuits.
  - vi) Provision of mechanical closing of breaker only in 'Withdrawn' position shall be made. Alternatively, mechanical closing facility should be normally inaccessible, accessibility rendered only after deliberate removal of shrouds. The circuit breaker rack in and rack out from Service to Test, Test to Isolated position or vice-versa shall be possible only in the door closed condition. It shall not be possible to open the ACB panel door in breaker closed condition.
  - vii) Clear status indication for each circuit shall be provided through lamps, switch positions or other mechanical means.
  - viii) Supervision relay shall be provided for trip coil monitoring.
- c) **Switches, Contactors, MCCB and Fuses**
  - i) Incomers for MCCs and DBs rated up to 400A shall be MCCB. Above 400A, breaker shall be provided.
  - ii) Motor starter contactors shall be of air break, electromagnetic type suitable for DOL starting of motor, and shall be of utilisation category AC-3 for ordinary and AC-4 for reversing starters. DC contactor shall be of DC-3 utilisation category.



- iii) Fuses shall be HRC type with operation indicator. Isolating switches shall be of AC 23A category when used in motor circuit, and AC 22A category for other applications. Fuse switch combination shall be provided wherever possible.
- iv) Isolating switches and MCCBs shall have door interlocks and padlocking facility.

d) **Panels**

- i) All switchgears, MCCs, DBs, panels, modules, local starters and push buttons shall have prominent engraved identification plates.
- ii) Local push button stations shall have metal enclosure of die cast aluminium or rolled sheet steel of 1.6mm thickness and shall be of DOP IP55. Push buttons shall be of latch type with mushroom knobs.
- iii) Where breaker/starter module front serves as compartment cover, suitable blanking covers, one for each size of modules per switchboard shall be supplied for use when carriage is withdrawn.
- iv) All non-current carrying metal work of boards/panels shall be effectively bonded to earth bus of galvanised steel, extending throughout the switchboard/ MCC/ DB. Positive earthing shall be maintained for all positions of chassis and breaker frame.
- v) Suitable trolley arrangement shall be provided for breaker/starter modules. One trolley per switchgear room shall be provided so that top most breaker module of all types, sizes and rating can be withdrawn on trolley and lowered for maintenance purpose.
- vi) The incoming connection to transformer of more than 1000KVA and inter-connecting sections between switchboards shall preferably be of bus ducts. The bus duct enclosure shall be made of minimum 3mm thick aluminium alloy. The section of the bus duct should have adequate strength to withstand internal and external forces resulting from the various operating conditions. Aluminium sheet hood shall be provided for outdoor bus duct enclosure joints to provide additional protection against water ingress. The bus duct top shall be sloped to prevent retention of water. The bus duct shall have DOP of IP55.
- vii) It should be possible to carryout maintenance on a feeder with adjacent feeders alive. A full-height vertical cable alley of adequate width shall be provided for power and control cables. Cable alley shall have no exposed live parts and shall have no communication with bus bar compartment. Cable terminations located in cable alley shall be designed to meet the Form 4b as per IEC 61439 for safety purpose. Necessary grommets shall be provided at the cable entry of individual modules.
- viii) All draw-out modules shall be provided with "Closed door operation" feature wherein movement of the module from "Isolated" position to "Service" position & vice-versa and power ON / OFF operation of the module shall be possible only with the module door closed condition.



ix) The switchboards shall comply to the Internal arc fault containment tests of 50 kA for 0.3s.as per IEC/TR 61641.

e) **Relays and Meters**

- i) All breaker feeders shall have Numerical relays. All relays, auxiliary relays and devices shall be of reputed make and types proven for the application and shall be subject to purchaser approval. The relays and timers shall have appropriate setting ranges, accuracy, resetting ratio, transient over-reach and other characteristics to provide required sensitivity to the satisfaction of the owner.
- ii) Relays shall be suitable for efficient and reliable operation of the protection scheme. Necessary auxiliary relays, timers, trip relays, etc. required for complete scheme, interlocking, alarm, logging, etc. shall be provided. No control relay, which shall trip the circuit breaker when relay is de-energized, shall be employed in the circuits.
- iii) Relays shall be flush mounted on the front with connections at the rear. Provision shall be made for easy isolation of trip circuits for testing and maintenance.
- iv) Relays shall be provided with self reset contacts except the trip, lockout relays and interlocking (contact multiplication) relays which shall be manual reset type
- v) Auxiliary relays shall be provided in the trip circuits of protections located outside the board, such as Buchholz relay, temperature indicators, fire protection, etc.
- vi) Suitable measures shall be provided to ensure that transients present in CT and VT connections due to extraneous sources in 400kV system do not cause damage to static circuit.
- vii) Only DC/ DC converters shall be provided in the solid state devices/ relays wherever necessary to provide a stable auxiliary supply for relay operation
- viii) All relays shall have hand-reset flags or other means for ready visual indication of their operation and also of the faulty phase.
- ix) Control circuits shall operate at suitable voltage of 110V AC or 220V DC. Necessary control supply transformers having primary and secondary fuses shall be provided for each MCC, 2 x 100% per section. However, the breakers shall operate on 220V DC The auxiliary bus bars for control supply shall be segregated from main bus bars. The control supplies shall be monitored.
- x) Contractor shall fully co-ordinate overload and short circuit tripping of breaker with upstream and downstream breakers/ fuses/MCCBs motor starters. Various equipments shall meet requirement of Type-II class of coordination as per IEC.
- xi) All relays and timers shall operate on available DC supply and not have any inbuilt batteries. They shall be provided with hand-reset operation indicator (flags) or LEDs with push buttons for resetting.



- xii) All meters/ instrument shall be flush mounted on front panel, at least 96 mm<sup>2</sup> size with 90<sup>0</sup> linear scales and accuracy class of 1.0.
- xiii) All motors of 30kW and above shall have an ammeter. Bus-section shall have bus VT, voltmeter with selector switch, and other relay and timers required for protection. Adequate control and selector switches, push buttons and indicating lamps shall be provided. Thermostatically controlled space heaters with switches shall be provided to prevent condensation.
- xiv) All motors are required to have an emergency stop push button near the motor.
- xv) In case of remote controlled breaker panels, following shall be provided.

Each feeder shall have local/ remote selector switch. Closing from local shall be possible only in test position whereas closing from remote shall be possible in either service or test position. Tripping from local shall be possible only when local/ remote selector switch is in local position. Tripping from remote shall be either breaker in service position or selector switch being in remote position.

- xvi) Suitable self-powered transducers as per IS:12784 Part-I for feeding signals to panel mounted electrical meters (ammeters, voltmeters, VAR meters and watt meters etc.) and DDCMIS shall be provided.

Transducers shall be tested as per IEC-600298 or impulse test etc. and short circuit withstand capability as per ANSI C 37.90a, 1989

Transducers shall be provided with two decoupled 4-20mA output signals, one for electrical meter and one for DDCMIS/ PLC. Current limiting features shall be provided for all the transducers.

xvii) Transducers

- a) Current transducers
  - Input 0-1 A (CT secondary)
  - Rated frequency 50 Hz
  - Output 4-20 mA (2 Nos. decoupled) for meter/ DDCMIS
  - Accuracy 0.5%
- b) Bus voltage transducers
  - Input 110V, 50 Hz (from VT secondary)
  - Output 4-20 mA (2 Nos. de-coupled)
  - Accuracy 0.5%

- xviii) Necessary hardware shall be provided in the switchgear panel like coupling relays (24VDC with maximum burden of 2.5VA), auxiliary relays in addition to current/ bus-voltage transducers (4-20 mA, dual output) etc. to effect interlocks, exchange information/ status and exercise control from remote.





### 5.3.5 Protection

- a) **Incomer to 415V Switch boards :**
- i. Instantaneous over current protection (50)
  - ii. Sync Check (25)
  - iii. Restricted earth fault protection for Transformer LV winding (64R).
  - iv. Lockout (86), preferably built in Numerical Relay
- b) **415 V Bus coupler:**
- i. Instantaneous over current protection (50)
  - ii. Sync Check (25)
  - iii. Lockout (86), preferably built in Numerical Relay
- c) **415V Out going feeders from PCC and Incomer to MCCs:**
- i. Over current protection (50)
  - ii. Lockout (86) ,preferably built in Numerical Relay
- d) **415 Volts motor feeders:**
- 1) Contactor controlled motor feeders (Motors below 110kW)
    - a) Instantaneous short circuit protection on all phases through HRC cartridge type fuses rated for 80kA rms (prospective breaking capacity at 415V).
    - b) Thermal overload protection
    - c) Single phasing protection for motors protected by fuses
  - 2) Breaker controlled motors feeders (motors rated 110kW &above)
    - a) Instantaneous short circuit protection (50)
    - b) Thermal Overload protection (49)
    - c) Over load alarm (49A)
    - d) Earth fault protection (50N)
    - e) Under voltage protection (27M)
    - f) Lockout (86), preferably built in Numerical Relay

### 5.3.6 Design and constructional features

- a) All 415V switchgears, AC and DC distribution boards (DBs) etc. shall have following features :

i)	Shall be of metal enclosed, indoor, floor mounted and free standing type.
ii)	All frames and load bearing members shall be fabricated using mild steel structural sections or pressed and shaped cold rolled sheet steel of thickness not less than 2mm.
iii)	Frame shall be enclosed in cold rolled sheet steel of thickness not less than 2mm (CR). Doors and covers shall also be of cold rolled sheet steel of thickness not less than 1.6 mm. Stiffeners shall be provided wherever necessary. Removable gland plates of thickness 3mm (hot/cold rolled sheet steel) or 4 mm (non-magnetic material) shall be provided for all panels.



iv)	For motors of rating 110kW & above, remote controlled electrical circuit breakers, and for smaller motors, switch-fuse contactor feeders shall be provided. The other Outgoing feeders of rating 100A and above up to 400A shall have MCCBs and below 100A shall be Switch-fuse Units(SFU).												
v)	The switchboards/ MCC/ DBs of 1600A and above rating shall be of DOP IP42 and of IP52 for less than 1600A rating.												
vi)	All 415V switchgears, MCC's, AC and DC distribution boards etc. shall be painted by powder coating process. Paint shade for complete panels excluding end covers shall be RAL9002 and RAL5012 for extreme end covers of all boards.												
vii)	Minimum air clearance in air between phases and phase-earth shall be 25 mm for bus bars and cable terminations. For all other components, the Clearances shall be at least 10mm. Wherever above is not possible except for horizontal and vertical bus bars, insulation shall be provided by anti tracking sleeving or barriers. However, for horizontal and vertical bus bars, clearances specified above shall be maintained even when bus bars are insulated/ sleeved. In case of DCDBs/ fuse boards, the bus bar system shall be insulated or physically segregated with barriers to prevent interpole short circuit.												
viii)	All current and voltage transformers as required for metering and protection specified shall be completely encapsulated, cast resin insulated type. Incomers from transformers shall have CTs for transformer Restricted Earth Fault (REF) protection. All current and voltage transformers as required for metering and protection specified shall be completely encapsulated cast resin insulated type. Incomers from transformers shall have CTs for transformer restricted earth fault protection. The accuracy shall be as follows:												
	<table border="1"> <thead> <tr> <th colspan="2"><u>CTs</u></th> <th><u>PTs</u></th> </tr> </thead> <tbody> <tr> <td>Protection</td> <td>5P20</td> <td>3P</td> </tr> <tr> <td>Metering</td> <td>1.0</td> <td>1.0</td> </tr> <tr> <td>REF</td> <td>PS</td> <td></td> </tr> </tbody> </table>	<u>CTs</u>		<u>PTs</u>	Protection	5P20	3P	Metering	1.0	1.0	REF	PS	
<u>CTs</u>		<u>PTs</u>											
Protection	5P20	3P											
Metering	1.0	1.0											
REF	PS												

b) Indicating lamps shall be cluster LED type.

5.3.7 **Spare feeders** - 20% spare feeders with at least one of each type and rating shall be provided in each switchgear.

5.3.8 **415V Non-segregated phase bus-duct**

- i) The section of three phase and neutral metal enclosed non segregated phase bus duct shall be rectangular. The design of the bus duct enclosures shall be of sturdy construction such that it will withstand the internal or external forces resulting from the various operating conditions.
- ii) The entire bus duct shall be designed for dust, vermin and weather proof construction. A suitable aluminium sheet flange-protection hood shall be provided to cover all outdoor bus duct enclosure joints to facilitate additional protection against rain water ingress. All horizontal runs of bus duct shall have



a suitable sloped enclosure top to prevent retention of water for both indoor and out-door portion of bus ducts. Bus duct enclosure shall have a degree of protection of IP-55.

- iii) The inside of the bus enclosure may be treated with black paint to enable efficient heat dissipation. The matt paint used shall be suitable for temperature experienced during continuous loading of the bus conductor.
- iv) Enclosures shall be provided with flanged ends with drilling dimensions to suit the flanges at the switchgear and transformer terminals.
- v) The synthetic/ neoprene gaskets shall be provided so as to satisfy the operating conditions imposed by temperature, weathering, durability etc. Flange gaskets shall be provided at the equipment terminal connections.
- vi) Necessary earthing arrangement as applicable shall be provided with clamps to receive station earthing bus. This shall be a GI strip of adequate size, continuously running along the bus duct and shall be earthed at both ends. Bus duct enclosures shall be bolted type.
- vii) The material of the conductor shall be aluminium. The bus bars shall be rated in accordance with the service conditions and the rated continuous and short time current ratings.
- viii) All steel structures required for bus duct support shall be hot dip galvanised.

ix) **Technical Data**

a)	Type	Non-Segregated
b)	1 minute power frequency withstand voltage	2.5 kV
c)	Maximum short circuit withstand current	50kA for 1 second
d)	Momentary dynamic current withstand	105kA (Peak)

## 5.4 HT AND LT MOTORS

All the HT and LT motors as required for FGD Plant shall be provided.

- i. All motors upto 200kW rating shall be 3 phase, 415V squirrel cage Induction motors.
- ii. Motors of rating above 200kW and up to 1500kW shall be rated for 6.6/3.3kV voltage and above 1500kW shall be rated for 11/6.6kV.
- iii. All motors of rating 30kW and above shall be provided with single phase 240V space heaters.

### 5.4.1 Codes and Standards

All the motors shall conform to the following standards :

IS/ IEC:60034	Three phase induction motors
IS/ IEC:60034	Single phase AC motors
IS/ IEC:60034	Crane duty motors
IS:4722	DC motors
IS12615, IEC 60034-30	Energy Efficient Motors



#### 5.4.2 General Requirements

- i) All the motors shall be suitable for an ambient temperature of 50°C and relative humidity of 95%. The motors shall be suitable for operation in a highly polluted environment
- ii) Voltage and Frequency variations: All motors shall be suitable for following variations

Frequency variation	(+) 3% and (-)5%
Voltage variation	a. (±) 6% for 11kV,6.6kV & 3.3kV b. (±) 10% for 415 V
Combined variation of voltage and frequency.	10% (absolute sum)

- iii) The voltage level for motors shall be as follows

1)	Upto 200 kW	415V
2)	Above 200 kW and upto 1500 kW	6.6/ 3.3kV
3)	Above 1500 kW	11/ 6.6kV

- iv) Fault level

1)	11kV, 6.6kV and 3.3 kV	40kA for 1 second
2)	415V	50kA for 1 second
3)	220V DC	20kA for 1 second

- v) System grounding

1)	11 kV,6.6kV and 3.3 kV	Earthed through resistance to limit the current to 300A or high resistance grounding through Neutral grounding Resistor (NGR)
2)	415V	Solidly grounded
3)	220V DC	Ungrounded

- vi) Paint shade shall be RAL 5012 (Blue).

- vii) Degree of protection

1)	Indoor motors	IP 55
2)	Outdoor motors	IP 55
3)	Cable box – indoor area	IP 55
4)	Cable box – outdoor area	IP 55

#### 5.4.3 Type

- i) AC Motors:

- Squirrel cage induction motor suitable for direct-on-line starting.  
Further, continuous duty LT motors up to 200 kW Output rating (at 50°C ambient temperature), shall be Premium Efficiency class-IE3, conforming to IS 12615, or IEC:60034-30.
- Crane duty motors shall be slip ring/ squirrel cage with VVVF type induction



motor. Motor operating through variable frequency drives shall be suitable for inverter duty. Also these motors shall comply the requirements stipulated in IEC: 60034-18-41 and IEC: 60034-18-42 as applicable.

- ii) DC Motors: Shunt wound.

#### 5.4.4 Rating

- i) Continuously rated (S1). However, crane motors shall be rated for S4 duty i.e. 40% cyclic duration factor.
- ii) Maximum continuous motor ratings shall be at least 10% above the maximum load demand of the driven equipment unless otherwise specified, under entire operating range including voltage and frequency variations.
- iii) Motors starting shall be as per IEC-60034 (part12)

#### 5.4.5 Temperature Rise

Air cooled motors	70 <sup>0</sup> C by resistance method for both class 130(B) and 155(F) insulation
Water cooled motors	80 <sup>0</sup> C over inlet cooling water temperature, by resistance method for both class 130(B) and 155(F) insulation

#### 5.4.6 Operational Requirements

- i) Starting Time
  - a) For motors with starting time up to 20 secs. at minimum permissible voltage during starting, the locked rotor withstand time under hot condition at highest voltage limit shall be at least 2.5 secs. more than starting time.
  - b) For motors with starting time more than 20secs. and up to 45secs. at minimum permissible voltage during starting, the locked rotor withstand time under hot condition at highest voltage limit shall be at least 5 secs. more than starting time.
  - c) For motors with starting time more than 45secs. at minimum permissible voltage during starting, the locked rotor withstand time under hot condition at highest voltage limit shall be more than starting time by at least 10% of the starting time.
  - d) Speed switches mounted on the motor shaft shall be provided in cases where above requirements are not met.
- ii) Torque Requirements
  - a) Accelerating torque at any speed with the lowest permissible starting voltage shall be at least 10% motor full load torque.
  - b) Pull out torque at rated voltage shall not be less than 205% of full load torque. It shall be 275% for crane duty motors.



- iii) Starting voltage requirement
  - a) All motors (except mill motors):
    - 80% of rated voltage for motors up to 4000 kW
    - 75% of rated voltage for motors above 4000 kW
  - b) For mill motors
    - 85% of rated voltage for motors above 1000 kW
    - 90% of rated voltage for motors below 1000 kW

#### 5.4.7 Design and constructional features

- i) Suitable single phase space heaters shall be provided on motors rated 30kW and above to maintain windings in dry condition when motor is standstill. Separate terminal box for space heaters and RTDs shall be provided.
- ii) All motors shall be either totally enclosed fan cooled (TEFC) or totally enclosed tube ventilated (TETV) or closed air circuit air cooled (CACWA) type. However, motors rated 3000 kW or above can be closed air circuit water cooled (CACW). The method of movement of primary and secondary coolant shall be self-circulated by fan or pump directly mounted on the rotor of the main motor as per IEC 60034-6. However, VFD driven motors can be offered with forced cooling type with machine mounted fan or pump driven by separate electric motor.
- iii) For hazardous location such as fuel oil facilities area, the enclosure of motors shall have flame proof construction conforming to IS:2148 as detailed below:

1)	Fuel oil area	Group – IIB
2)	Hydrogen generation plant area	Group – IIC (or Group-I Div-II as per NEC) or (Class-1, Group-B, Div-II as per NEMA / IEC60034)

- iv. Winding and Insulation

1)	Type	Non-hygroscopic, oil resistant, flame resistant
2)	Starting duty	Two hot starts in succession, with motor initially at normal running temperature
3)	11kV, 6.6kV, 3.3 kV AC motors	Class 155(F) : with winding temperature rise limited to class 130(B). The winding insulation process shall be total Vacuum Pressure Impregnated i.e. resin pour method. They shall withstand 1.2/50microsec. Impulse Voltage wave of 4U+5 kV (U=Line voltage in kV). The coil inter-turn insulation shall be as per IEC-60034-Part 15 followed by 1 min power frequency high voltage test of appropriate voltage on inter turn insulation.
4)	415V AC and 220V DC motors	Class 130 (B) or Better

- v) Motors rated above 1000KW shall have insulated bearings to prevent flow of shaft currents.



- vi) Motors with CACA or CACW enclosure shall have dial type thermometer with adjustable alarm contacts to indicate inlet and outlet primary air temperature.
- vii) Noise level and vibration shall be limited within the limits prescribed in IS: 12065 and IS/IEC 60034-14 respectively.
- viii) In 11kV, 6.6kV and 3.3kV motors, at least four numbers simplex/ two numbers duplex platinum resistance type temperature detectors shall be provided for each phase of stator winding. Each bearing shall preferably be provided with dial type thermometer with adjustable alarm contact and two numbers duplex platinum resistance type temperature detector. Motor body shall have two earthing points on opposite sides.
- ix) 11 kV motors shall be offered with Separable Insulated Connector (SIC) as per IEEE 386. The offered SIC terminations shall be provided with protective cover and trifurcating sleeves. SIC termination kit shall be suitable for fault level of 25 kA for 0.17 seconds.  
  
3.3/6.6 kV motors shall be offered with dust tight phase separated double walled (metallic as well as insulated barrier) Terminal box. Suitable termination kit shall be provided for the offered Terminal box. The offered Terminal Box shall be suitable for fault level of 250 MVA for 0.12 sec. Removable gland plates of thickness 3 mm (hot/cold rolled sheet steel) or 4 mm (non-magnetic material for single core cables) shall be provided.
- x) All motors shall be so designed that maximum inrush currents and locked rotor and pullout torque developed by them at extreme voltage and frequency variations do not endanger the motor and driven equipment.
- xi) The motors shall be suitable for bus transfer schemes provided on the 11kV, 6.6kV, 3.3 kV, 415V systems without any injurious effect on its life.
- xii) Motors rated 2000kW and above shall be provided with neutral current transformers of PS class on each phase in a separate neutral terminal box for differential protection.
- xiii) The ratio of locked rotor KVA at rated voltage to rated KW shall not exceed the following (without any further tolerance) :
  - (a) From 50KW & up to 110KW : 11.0
  - (b) From 110 KW & up to 200 KW : 9.0
  - (c) Above 200 KW & up to 1000KW : 10.0
  - (d) From 1001KW & up to 4000KW : 9.0
  - (e) Above 4000KW : 6 to 6.5

#### 5.4.8 LIST OF TYPE TESTS TO BE CONDUCTED

The following type tests shall be conducted on each type and rating of HT motor:

- a) No load saturation and loss curves up to approximately 115% of rated voltage
- b) Measurement of noise at no load.
- c) Momentary excess torque test (subject to test bed constraint).
- d) Full load test (subject to test bed constraint)



- e) Temperature rise test at rated conditions. During heat run test, bearing temp., winding temp., coolant flow and its temp. shall also be measured. In case the temperature rise test is carried at load other than rated load, specific approval for the test method and procedure is required to be obtained. Wherever ETD's are provided, the temperature shall be measured by ETD's also for the record purpose.

#### 5.4.9 LIST OF TESTS FOR WHICH REPORTS HAVE TO BE SUBMITTED :

The following type test reports shall be submitted for each type and rating of HT motor:

- Degree of protection test for the enclosure followed by IR, HV and no load run test.
- Terminal box-fault level withstand test for each type of terminal box of HT motors only.
- Lightning Impulse withstand test on the sample coil shall be as per clause no. 4.3 IEC-60034, part-15
- Surge-withstand test on interturn insulation shall be as per clause no. 4.2 of IEC 60034, part-15

In case the contractor has conducted such specified type test(s) within last ten years as on the date of bid opening, he may submit during detailed engineering the type test reports to the employer for waiver of conductance of such test(s). These reports should be for the tests conducted on the equipment similar to those proposed to be supplied under this contract and test(s) should have been either conducted at an independent laboratory or should have been witnessed by a client. The employer reserves the right to waive conducting of any or all the specified type test(s) under this contract. In case type tests are waived, the type test charges shall not be payable to the contractor.

### 5.5 HT/LT POWER AND CONTROL CABLES

All 11kV, 6.6kV, 3.3kV and 415V power cables, control cables and DC cables required to connect auxiliaries shall be supplied.

#### 5.5.1 Codes and standards

All cables to be supplied shall conform to the latest revisions of IS or any other international standards acceptable to purchaser. Some of the Indian Standards/ IEC considered relevant to the cables are given below:

IS:1554(Part-I)	PVC insulated (heavy duty) electric cables for working voltage up to and including 1100 V.
IS:1554 (Part-II)	PVC insulated (heavy duty) electric cables for working voltage from 3.3kV up to and including 11kV.
IS:7098 (Part-III)	XLPE insulated PVC sheathed cables for working voltages from 3.3 kV up to and including 33kV.
IS:3961	Recommended current ratings for cables.
IS:8130	Conductors for insulated electric cables and flexible cords.
IS:5831	PVC insulation and sheath of electric cables.
IS:2982	Copper conductor in insulated cables and cords.
IS:3975	Mild steel wires, strips and tapes for armouring cables
IS:5609	Specification for low frequency wires and cables with PVC insulation and PVC Sheath.
IS:6380	Spec. of elastomeric insulation of sheath of electric cables.





IS:434(I and II)	Specification for rubber insulation cables
IEC:540	The methods for insulations and sheaths of electric cables and cords (elastomeric and thermoplastic compounds).
IEC:230	Impulse tests on cables and their accessories.
IEC:60	High voltage test techniques.
IEC:287	Calculations of the continuous current rating of cables(100% load factor).
IEC:288	Nominal cross-sectional area and composition of conductor of insulated cables.
IEC:502	Extruded solid dielectric insulated power cables for rated voltages from 1.00 kV up to 30 kV.
NEMA-WC-5	Thermoplastic insulated wires and cables for transmission and distribution of electrical energy.
IEEE:383	Standard for type test for class IE electric cables, filled splices and connections for nuclear power generation stations
IEC: 332-1	Test on electric cables under fire conditions.
ASTM-D-2843	Standard test method for density of smoke from burning/ decomposition of plastics.
ASTM-D-2863	Test for determination of Oxygen Index.
IEC-754-I	Test method for acid gas generation.
IEC-331	Fire resisting characteristics of electric cables.
SVENSK Standard	SS- 4241475 Class F3
BICC Hand Book	For cables in fire regarding temperature index-chapter-6

### 5.5.2 Design criteria

- i) The cable shall be suitable for installation in a tropical monsoon area having a hot humid climate. The reference ambient temperature to be considered for the purpose of this specification is 50°C.
- ii) The derating factor for the various conditions of installation including the following shall be considered while choosing the conductor size and calculations shall be submitted for purchaser's approval:
  - a) Maximum ambient air temperature.
  - b) Maximum ground temperature
  - c) Depth of laying wherever applicable
  - d) Grouping of cables
- iii) The allowable voltage drop at terminal of the connected equipment shall be maximum 2.5 % at full load while choosing the conductor size and calculations shall be submitted for purchaser's approval. In case of squirrel cage induction motors, the cable size shall be so chosen that the motor terminal voltage does not fall below 85% of the rated voltage, at the time of starting.
- iv) The maximum continuous conductor temperature and the maximum allowable conductor temperature during short circuit are to be taken as 70°C and 160°C respectively in case of PVC insulated cables and 90°C and 250°C respectively in case of XLPE insulated cables.
- v) The minimum size of all 11kV (UE), 3.3kV (UE) grade power cables and 415V power cables connected to circuit breakers shall be chosen taking into account the following factors:
  - a) Fault level due to system contribution.



- b) Fault contribution of running motors.
  - c) Expected time up to which motor contribution persists.
  - d) Maximum time for fault clearance (i.e. operating time of the back-up protection relays plus the time of operation of the circuit breakers).
  - e) Full load current of the circuit.
- vi) The cables shall be capable of continuous satisfactory operation under a power supply system frequency variation of ( $\pm$ ) 5%, voltage variation of ( $\pm$ )10% and combined frequency and voltage variation of 10% (absolute sum).
- vii) The cables shall in general comply with the requirements of the latest revision of IS:7098 (Part-II) for the 11kV (UE), 6.6kV, 3.3kV grade, XLPE insulated cables, IS:7098 (Part-I) for LT XLPE insulated and IS:1554 (Part-I) for the LT PVC power and control cables or the relevant IEC International Standard unless otherwise specified in this specification. The design, manufacture, installation, testing and performance of the cables, shall comply with the latest revisions of IS/ IEC/ NEMA/ ASTM Standard and the most stringent conditions specified in these specification shall be applicable.

### 5.5.3 General technical requirements

- i) Type of cable
- The cable shall be multi-core/ single core (XLPE), PVC and any polymeric/ elastomeric insulation type as specified.
- ii) Conductor
- The cable conductor shall be made from standard copper/ Aluminum to form compact conductor having a resistance within the limits specified.
- All the cables of size 25mm<sup>2</sup> and above shall have sector shaped conductors. The minimum no. of strands in conductor shall be 7 (seven) except as otherwise specified. Power cables shall be of stranded aluminum conductor with a minimum size 6mm<sup>2</sup> and the control cables shall be stranded copper (electrolytic) conductor with a minimum size of 2.5 mm<sup>2</sup>.
- iii) Conductor Shield
- The conductor having a semi-conducting screen shall ensure perfectly smooth profile and avoid stress concentration. The conductor screen shall be extruded in the same operation as the insulation, the semi-conducting polymer shall be cross-linked for XLPE cables.
- iv) Insulation
- The insulation of the cable shall be extruded type and shall be designed and manufactured for the specified system voltage. The manufacturing process shall ensure that insulation shall be free from voids. The insulation shall withstand mechanical and thermal stresses under steady state and transient operating conditions. The extrusion method should give a very smooth interface between semi conducting screen and insulation. The insulation of the cables shall be of high standard quality. The minimum volume resistivity of the PVC insulation of all the PVC insulated cables shall be  $1 \times 10^{14}$  ohm-cm at 27°C and  $1 \times 10^{11}$  ohm-cm at 70°C.



v) Insulation shield

In XLPE cables to confine electrical field to the insulation, a non-magnetic semi-conducting shield shall be put over the insulation. The insulation shield shall be extruded in the same operation as the conductor shield and the insulation by triple extrusion/process. The XLPE cable insulation shield shall be strippable. Metallic screening as given in this specification for the various power and control and special cables shall be provided.

vi) Sheath

The sheath shall be suitable to withstand the site conditions and the desired temperature. It shall be of adequate thickness and applied by a continuous process to produce a sheath of consistent quality free from all defects. PVC sheath shall be extruded.

vii) Armour

Hard drawn aluminum wire armouring/ galvanized steel tape/ wire armouring shall be used for single core and multi-core cable respectively.

The hard drawn aluminium wire for armour shall be of H<sub>4</sub> grade, as per IS-8130 (having tensile strength above 150 N/mm<sup>2</sup>) The diameter of the aluminium wire shall be as per the table for the dimensions of the galvanized steel wire armour given in the relevant standard.

viii) Serving/ outer sheath

Extruded PVC serving as per IS: 5831 or as specified otherwise shall be applied over the armouring with suitable additives to prevent attack by rodent and termites. All serving must be given anti-termite treatment.

#### 5.5.4 Constructional requirements

i) Cable shall have suitable fillers laid up with the conductors to provide a substantially circular cross section before the sheath is applied. Fillers shall be suitable for the operating temperature of the cable and compatible with the insulating material. All materials shall be new, unused and of finest quality. Workmanship shall be neat, clean and of highest grade.

a) 11 kV system power cables - The cable shall be 11kV/11kV (unearthed) grade, heavy duty, stranded aluminium conductor, XLPE insulated, provided with conductor screening and insulation screening, galvanized steel wire/strip armoured, flame retardant low smoke (FRLS) extruded PVC of type ST2 outer sheathed.

b) 6.6kV system power cables - The cable shall be 6.6kV/6.6kV (unearthed) grade, heavy duty, stranded aluminium conductor, XLPE insulated, provided with conductor screening and insulation screening, galvanized steel wire/strip armoured, flame retardant low smoke (FRLS) extruded PVC of type ST2 outer sheathed.

c) 3.3 kV system power cables - The cable shall be 3.3kV/3.3kV (unearthed) grade, heavy duty, stranded aluminium conductor, XLPE insulated, provided with conductor screening and insulation screening, galvanized steel wire/strip armoured, flame retardant low smoke (FRLS) extruded PVC of type

ST2 outer sheathed.

- d) 415V system power cables - The cable shall be 1.1kV, grade, heavy duty, stranded aluminium conductor, PVC Type-A Insulated galvanized steel wire/strip armoured, flame retardant low smoke (FRLS) extruded PVC type ST1 outer sheathed. XLPE insulated cables shall also be acceptable.
  - e) Control cables - The cable shall be 1.1kV grade, heavy duty, stranded copper conductor, PVC Type-A insulated, galvanized steel wire/ strip armoured, flame retardant low smoke (FRLS) extruded PVC of Type-ST1 outer sheathed.
- ii) Special properties - All the above cables shall be conforming to the relevant Indian/ IEC standard in general, with the following special properties:
- a) Oxygen Index of the outer sheath shall not be less than 29, when tested as per ASTM-D-2863.
  - b) Temperature Index of the outer sheath shall not be less than 250°C, when tested as per ASTM-D-2863.
  - c) Halogen acid contents in outer sheath shall not be more than 20%, when tested as per IEC-60754.
  - d) The maximum smoke density in percent light absorption should not exceed 60% in case of PVC compound and 20% in case of fire survival cables, when tested as per ASTM-D-2843.
  - e) Swedish chimney test as per SS-4241475 class F3 and ladder test for flammability as per IEEE-383.
- iii) Fire survival cables - The cable shall be of copper conductor and comply with IEC-60331 in addition to the above requirement. Also the halogen acid contents in outer sheath shall not be more than 2% when tested and per IEC-60754 and the smoke density in percent light absorption shall not exceed 20% when tested as per ASTM-D- 2843.

#### 5.5.5 Identification of cores

The insulated cores of HT and LT power cables shall be identified by coloured code. The control cables shall have identification by means of indelible printing of numbers of its cores at intervals not more than 75 mm. At least 20% cores shall be kept as spares in the multi-core control cables.

#### 5.5.6 Arrangement of cables

As far as feasible, separate cables shall be provided for circuits of different plant and auxiliaries, for circuits of different voltages, and for circuit used separately. Power, control and instrumentation circuit shall invariably be taken through different routes, which shall not be laid together on the same cable trays.

#### 5.5.7 Drums lengths

Drum lengths of the cables shall be so chosen that straight through joints are eliminated. However, the drum lengths shall not be less than the following lengths:



- i) 11/ 6.6/ 3.3 kV grade power cables: 500 M
- ii) 1.1 kV grade power / Fire survival cables etc.
  - a) Including and above 400 mm<sup>2</sup> size: 400 M
  - b) Below 400mm<sup>2</sup> size: 500 M
- iii) 1.1 kV grade control and instrumentation cables: 1000M

## 5.6 INSTALLATION OF CABLES, EARTHING SYSTEM AND LIGHTNING PROTECTION SYSTEM

1. The cable trays, and accessories, supports, conduits, cable glands, lugs, ferrules, tags, clamps and other accessories for installation of cables in cable galleries, trenches etc. for auxiliaries; earthing system network/ earth mat including interconnections; and lightning protection of service buildings and other tall structures shall be provided.
2. The supply, laying and termination of bidder's cables shall include installation of cable facilities viz. cable trays and conduits, supports, trays, lugs, terminals, tags, clamps etc. as required.
3. All cables shall be run in GI cable trays / rigid GI conduits as far as possible. The bidder has the option to make use of existing cable facilities to the extent feasible without causing any damage/disruption.
4. The bidder shall carefully examine the possibility of making use of the existing cable facilities before preparing his offer with a view to correctly estimate the quantity of cable trays/conduits that would have to be supplied and installed by him.

### 5.6.1 Codes and standards

All work shall be carried out as per the following standards/ codes as applicable.

IS:513	Cold rolled low carbon steel sheets and strips.
IS:802	Code of practice for the use of Structural Steel in Overhead transmission Line Towers.
IS:1079	Hot Rolled carbon steel sheet and strips
IS:1239	Mild steel tubes, tubulars and other wrought steel fittings
IS:1255	Code of practice for installation and maintenance of power cables up to and including 33 KV rating
IS:1367 Part-13	Technical supply conditions for threaded Steel fasteners. (Hot dip galvanized coatings on threaded fasteners).
IS:2147	Degree of protection provided by enclosures for low voltage switchgear and control gear
IS:2309	Code of Practice for the protection of building and allied structures against lightning.
IS:2629	Recommended practice for hot dip galvanising of iron and steel
IS:2633	Method for testing uniformity of coating on zinc coated articles.
IS:3043	Code of practice for earthing
IS:3063	Fasteners single coil rectangular section spring washers.
IS:6745	Methods for determination of mass of zinc coating on zinc coated iron and steel articles.



IS:8308	Compression type tubular in- line connectors for aluminium conductors of insulated cables
IS:8309	Compression type tubular terminal ends for aluminium conductors of insulated cables.
IS:9537	Conduits for electrical installation.
IS:9595	Metal arc welding of carbon and carbon manganese steels- recommendations.
IS:13573	Joints and terminations for polymeric cables for working voltages from 6.6kV up to and including 33kV performance requirements and type tests.
BS:476	Fire tests on building materials and structures
IEEE:80	IEEE guide for safety in AC substation grounding
IEEE:142	Grounding of Industrial and commercial power systems
DIN 46267 (Part-II)	Non tension proof compression joints for Aluminium conductors.
DIN 46329	Cable lugs for compression connections, ring type ,for Aluminium conductors
VDE 0278	Tests on cable terminations and straight through joints
BS:6121	Specification for mechanical Cable glands for elastomers and plastic insulated cables.

### 5.6.2 Design and Constructional Features

#### i) Inter Plant Cabling

Interplant cabling for main routes shall be laid along overhead trestles/duct banks/buried cables. However, from tap-offs, same can be through shallow trenches/ support taken from nearest building/ structure. In case of Duct banks, pull-pits shall be filled with sand and provided with a PCC covering. Directly buried cables, if essential, shall not have concentration of more than 4 cables in one route.

- ii) Cable entry - Cable entry from outdoor underground/ cable routes to the buildings, if any, shall be above the finished floor level of the building.
- iii) Trenches - PCC flooring of built up trenches shall be sloped for effective drainage with sump pits and sump pumps.
- iv) No sub-zero level cable vault/ trenches shall be provided below control building/ switchgear rooms.

### 5.6.3 Equipment Description

#### i) Cable trays, fittings and accessories

a) Cable trays shall be ladder/perforated type as specified complete with matching fittings (like brackets, elbows, bends, reducers, tees, crosses, etc.) accessories (like side coupler plates, etc. and hardware (like bolts, nuts, washers, GI strap, hook etc.) as required. Cable tray shall be ladder type for power and control cables and perforated for instrumentation cables.

b) Cable trays, fittings and accessories shall be fabricated out of rolled mild steel sheets free from flaws such as laminations, rolling marks, pitting etc. These (including hardware) shall be hot dip galvanized as per relevant IS.



c) Cable trays shall have standard width of 150 mm, 300 mm and 600 mm and standard lengths of 2.5 metre. Minimum thickness of mild steel sheets used for fabrication of cable trays and fittings shall be 2 mm. The thickness of side coupler plates shall be minimum 3 mm .

ii) **Support system for cable trays**

a) Cable tray support system shall be pre-fabricated.

b) Support system for cable trays shall essentially comprise of the two components i.e. main support channel and cantilever arms. The main support channel shall be of two types : i) C1: having provision of supporting cable trays on one side and ii) C2: having provision of supporting cable trays on both sides. The support system shall be as follows :

- Cable supporting steel work for cable racks/cables shall comprise of various channel sections, cantilever arms, various brackets, clamps, floor plates, all hardwares such as lock washers, hexagon nuts, hexagon head bolt, support hooks, stud nuts, hexagon head screw, channel nut, channel nut with springs, fixing studs, etc.
- The system shall be designed such that it allows easy assembly at site by using bolting. All cable supporting steel work, hardwares fittings and accessories shall be prefabricated factory galvanized.
- The main support and cantilever arms shall be fixed at site using necessary brackets, clamps, fittings, bolts, nuts and other hardware etc. to form various arrangements required to support the cable trays. Welding of the components shall not be allowed. However, welding of the bracket (to which the main support channel is bolted) to the overhead beams, structural steel, insert plates or reinforcement bars will be permitted. Any cutting or welding of the galvanized surface shall be brushed and red lead primer, oil primer and aluminium paint shall be applied.
- All steel components, accessories, fittings and hardware shall be hot dip galvanized after completing welding, cutting, drilling and other machining operation.
- The main support channel and cantilever arms shall be fabricated out of minimum 2.5 thick rolled steel sheet conforming to IS.
- Cantilever arms of 300 mm, 450mm, 600 mm and 750 mm in length are required. The arm portion shall be suitable for assembling the complete arm assembly on to component constructed of standard channel section. The back plate shall allow sufficient clearance for fixing bolt to be tightened with tray in position.

iii) **Pipes, Fittings and accessories**

a) Pipes offered shall be complete with fittings and accessories (like tees, elbows, bends, check nuts, bushings, reducers, enlargers, coupling caps, nipples etc.) The size of the pipe shall be selected on the basis of maximum 40% fill criteria



- b) GI Pipes shall be of medium duty as per IS:1239.
- c) Duct banks shall be high density PE pipes encased in PCC (10% spare of each size, subject to minimum one) with suitable water-proof manholes.

iv) **Junction boxes**

- a) Junction Boxes with IP:55 degree of protection, shall comprise of a case with hinged door constructed from cold rolled sheet steel of minimum thickness 2mm. Top of the boxes shall be arranged to slope towards rear of the box. Gland plate shall be 3mm thick sheet steel with neoprene/ synthetic rubber gaskets. All junction boxes shall be of adequate strength and rigidity, hot dip galvanized as per relevant IS, and suitable for mounting on wall, columns, structures etc. The boxes shall include brackets, bolts, nuts, screws M8 earthing stud etc. required for installation
- b) Terminal blocks shall be 650 volts grade, rated for 10 Amps and in one piece moulding. It shall be complete with insulating barriers, Klip-on-type terminals and identification strips. Marking on terminal strip shall correspond to the terminal numbering on wiring diagrams. It shall be Elmex type CSLT-1 with insulating material of Melamine conforming to ESI Standard 12.1 or equivalent. Terminal block shall be suitable for terminating 2 wires of 2.5mm<sup>2</sup> on both sides arranged to facilitate easy termination

v) **Terminations and straight through joints**

- a) Termination and jointing kits for 11/6.6/ 3.3 kV grade XLPE insulated cables shall be of proven design and make which have already been extensively used and type tested. Termination kits and jointing kits shall be pre-moulded type, tapex type or heat shrinkable type. 11/6.6/ 3.3kV grade joints and terminations shall be type tested as per IS:13573. Critical components used in cable accessories shall be of tested and proven quality as per relevant product specification/ ESI specification. The kit shall be complete with the aluminium solderless crimping type cable lugs and ferrule as per DIN standard.
- b) Straight through joint and termination shall be capable of withstanding the fault level for 11/6.6 and 3.3kV kV system.
- c) 1.1KV grade straight through joints shall be of proven design.

vi) **Cable glands**

Cable shall be terminated using double compression type cable glands. Cable glands shall conform to BS:6121 and be of robust construction capable of clamping cable and cable armour (for armoured cables) firmly without injury to insulation. Cable glands shall be made of heavy duty brass machine finished and nickel chrome plated. Thickness of plating shall not be less than 10 micron. All washers and hardware shall also be made of brass with nickel chrome plating Rubber components shall be of neoprene and of tested quality. Necessary cable dimensions shall be furnished to the successful bidder.

vii) **Cable lugs/ ferrules**

Cable lugs for power cables shall be Aluminium solderless crimping type





conforming to IS:8309 suitable for aluminium compacted conductor cables. Cable lugs and ferrules for control cables shall be tinned copper conforming to IS:8309. The cable lugs for control cables shall be provided with insulating sleeve and shall suit the type of terminals provided on the equipments.

viii) **Trefoil clamps**

Trefoil clamps for single core cables shall be pressure die cast aluminum or fibre glass or nylon and shall include necessary fixing accessories like G.I. nuts, bolts, washers, etc. Trefoil clamps shall have adequate mechanical strength to withstand the forces generated by the system short circuit current of 105 KA peak.

ix) **Cable clamps and straps**

The cable clamps required to clamp multicore cables on vertical run shall be made up of Aluminium strip of 25x3 mm size. For clamping the multicore cables, self-locking, de-interlocking type nylon clamps/ straps shall be used. The clamps/ straps shall have sufficient strength and shall not get affected by direct exposure to sun rays and outdoor environment.

x) **Receptacles**

Receptacles boxes shall be fabricated out of MS sheet of 2mm thickness and hot dipped galvanized or of die-cast aluminium alloy of thickness not less than 2.5 mm. The boxes shall be provided with two nos. earthing terminals, gasket to achieve IP55 degree of protection, terminal blocks for loop-in loop-out for cable of specified sizes, mounting brackets suitable for surface mounting on wall/ column/ structure, glandplate etc. The ON-OFF switch shall be rotary type heavy duty, double break, AC23 category, suitable for AC supply. Plug and Socket shall be shrouded Die-cast aluminium. Socket shall be provided with lid safety cover. Robust mechanical interlock shall be provided such that the switch can be put ON only when the plug is fully engaged and plug can be withdrawn only when the switch is in OFF position. Also cover can be opened only when the switch is in OFF position. Wiring shall be carried out with 1100 V grade PVC insulated stranded aluminium/ copper wire of adequate size. The Terminal blocks shall be of 1100V grade.

xi) **Galvanizing**

a) Galvanizing of steel components and accessories shall conform to IS:2629 and IS:2633. Additionally galvanizing shall be uniform, clean smooth, continuous and free from acid spots.

b) The amount of zinc deposit over threaded portion of bolts, nuts, screws and washers shall be as per IS:1367. The removal of extra zinc on threaded portion of components shall be carefully done to ensure that the threads shall have the required zinc coating on them as specified.

xii) **Welding**

The welding shall be carried out in accordance with IS:9595. All welding procedures and welders qualification shall also be followed strictly in line with IS:9595.



#### 5.6.4 Installation

##### i) Cable tray and support system installation

- a) Cables shall run in cable trays mounted horizontally or vertically on cable tray support system which in turn shall be supported from floor, ceiling, overhead structures, trestles, pipe racks, trenches or other building structures.
- b) Horizontally running cable trays shall be clamped by bolting to cantilever arms and vertically running cable trays shall be bolted to main support channel by suitable bracket/ clamps on both top and bottom side rails at an interval of 2000 mm. For vertical cable risers/shafts cable trays shall be supported at an interval of 1000mm. Fixing of cable trays to cantilever arms or main support channel by welding shall not be accepted.
- c) The cantilever arms shall be positioned on the main support channel with a minimum vertical spacing of 300 mm unless otherwise indicated in the relevant tray layout drawings
- d) All cable way sections shall have identification, designations as per cable way layout drawings and painted/stenciled at each end of cable way and where there is a branch connection to another cable way. Minimum height of letter shall be not less than 75 mm. For long lengths of trays, the identification shall be painted at every 10 meter. Risers shall additionally be painted/ stenciled with identification numbers at every floor.
- e) In certain cases it may be necessary to site fabricate portions of trays, supports and other nonstandard bends where the normal prefabricated trays, supports and accessories may not be suitable. In such cases the Contractor shall fabricate at site suitable sections of trays, supports and accessories to make the installation complete for the specific purpose after obtaining Project Manager's prior approval, which shall be neat in appearance and shall match with the prefabricated sections in the dimensions. They shall be applied with one coat of red lead primer, one coat of oil primer followed by two finishing coats of aluminium paint.

##### ii) Conduits/ Pipes/ Ducts installation

- a) All openings in the floor/ roof/ wall / cable tunnel/ cable trenches made for conduit installation shall be sealed and made water proof.
- b) GI pull wire of adequate size shall be laid in all conduits before installation. Metallic conduit runs at termination shall have two lock nuts wherever required for junction boxes etc.
- c) Conduit runs/sleeves shall be provided with PVC bushings having round edge at each end. All conduits/ pipes shall have their ends closed by caps until cables are pulled. After cables are pulled, the ends of conduits/ pipes shall be sealed with Glass-wool/ Cement Mortar/ Putty to prevent entrance of moisture and foreign material
- d) Exposed conduit/ pipe shall be adequately supported by racks, clamps, straps or by other approved means. Conduits / pipe support shall be installed



square and true to line and grade with an average spacing between the supports as given below, unless specified otherwise:

Conduit / pipe size (dia).	Spacing
Upto 40 mm	1 m
50 mm	2.0 m
65-85 mm	2.5 m
100 mm	3.0 m

iii) **Junction boxes installation**

Junction boxes shall be mounted at a height of 1200mm above floor level or as specified in the drawings or as decided by Project Manager and shall be adequately supported/mounted on masonry wall by means of anchor fasteners/expandable bolts or shall be mounted on an angle, plate or other structural supports fixed to floor, wall, ceiling or equipment foundations.

iv) **Cable installation**

- a) Cable installation shall be carried out as per IS:1255 and other applicable standards. Cable drums shall be unloaded, handled and stored in an approved manner on hard and well drained surface so that they may not sink. In no case shall be drum be stored flat i.e. with flange horizontal. Rolling of drums shall be avoided as far as possible. For short distances, the drums may be rolled provided they are rolled slowly and in proper direction as marked on the drum. In absence of any indication, the drums may be rolled in the same direction as it was rolled during taking up the cables. For unreeling the cable, the drum shall be mounted on suitable jacks or on cable wheels and shall be rolled slowly so that cable comes out over the drum and not from below. All possible care shall be taken during unreeling and laying to avoid damage due to twist, kink or sharp bends. Cable ends shall be provided with sealed plastic caps to prevent damage and ingress of moisture.
- b) While laying cable, ground rollers shall be used at every 2 metre interval to avoid cable touching ground. The cables shall be pushed over the rollers by a gang of people positioned in between the rollers. Cables shall not be pulled from the end without having intermediate pushing arrangements. Pulling tension shall not exceed the values recommended by cable manufacturer. Selection of cable drums for each run shall be so planned so as to avoid using straight through joints. Care should be taken while laying the cables so as to avoid damage to cables.
- c) Cables shall be laid on cable trays strictly in line with cable schedule furnished.
- d) Power and control cables shall be laid on separate tiers. The laying of different voltage grade cables shall be on different tiers according to the voltage grade of the cables. In horizontal tray stacks, HT cables (11kV) shall be laid on topmost tier and cables of subsequent lower voltage grades on lower tiers of trays. Single core cable in trefoil formation shall be laid with a distance of four times the diameter of cable between trefoil center lines and clamped at every two metre. All multi-core cables shall be laid in touching



formation. Power and control cables shall be secured fixed to trays/ support with self locking type nylon cable straps with de-interlocking facilities. For horizontal trays arrangements, multi-core power cables and control cables shall be secured at every five meter interval. For vertical tray arrangement, individual multi-core power cables and control cables shall be secured at every one meter by nylon cable strap. After completion of cable laying work in the particular vertical tray, all the control cables shall be binded to trays/ supports by aluminium strips at every five meter interval and at every bend.

- e) Bending radii for cables shall be as per manufacturer's recommendations and IS:1255.
- f) Where cables cross roads/rail tracks, the cables shall be laid in hume pipe/ PVC pipe.
- g) Joints for less than 250 Meters run of cable shall not be permitted.
- h) In each cable run some extra length shall be kept at suitable point to enable one LT (415V system) / two HT (11/6.6kV, 3.3kV) straight through joints to made, should the cable develop fault at a later stage. Control cable termination inside equipment enclosure shall have sufficient lengths so that shifting of termination in terminal blocks can be done without requiring any splicing.
- i) Wherever few cables are branching out from main trunk route troughs shall be used.
- j) The installation work shall be carried out in a neat workman like manner and areas of work shall be cleaned of all scraps, water, etc. after the completion of work in each area every day. RCC/ Steel trench covers shall be replaced after the installation work in a particular area is completed or when further work is not likely to be taken up for some time.
- k) Separation- At least 300mm clearance in horizontal configuration and 100mm in vertical configuration shall be provided between:
  - HT power and LT power cables,
  - LT power and LT control/ instrumentation cables,
- l) Segregation
  - Segregation means physical isolation to prevent fire jumping.
  - All cables associated with the unit shall be segregated from cables of other units.
  - Interplant cables of unit critical drives shall be segregated in such a way that not more than half of the drives are lost in case of single incident of fire. Power and control cables for AC drives and corresponding emergency AC or DC drives shall be laid in segregated routes. Cable routes for one set of auxiliaries of same unit shall be segregated from the other set.
- m) Minimum number of spare cores required to be left for interconnection in



control cables shall be as follows :

No. of cores in cable	No. of spare cores
2C, 3C	NIL
5C	1
7C-10C	2
14C and above	3

**n) Cable fire sealing**

Wherever the cables pass through walls/ floors, fire proof cable penetration seals rated for two hours shall be provided. This shall be by suitable block system using individual blocks with suitable framework or by silicon RTV foaming system. In case foaming system is offered, damming board, if used, shall not be considered for fire rating criteria. Any of the system offered shall be of proven type as per BS:476 (Part-20) or equivalent standard.

**o) Directly buried cables**

- Cable trenches shall be constructed for directly buried cables. Construction of cable trench for cables shall include excavation, preparation of sieved sand bedding, riddled soil cover, supply and installation of brick or concrete protective covers, back filling and compacting, supply and installation of route markers and joint markers. Laying of cables and providing protective covering shall be as per IS:1255.
- RCC cable route and RCC joint markers shall be provided wherever required. The voltage grade of the higher voltage cables in route shall be engraved on the marker. Location of underground cable joints shall be indicated with cable marker with an additional inscription "Cable Joint". The marker shall project 150 mm above ground and shall be spaced at an interval of 30 meters and at every change in direction. They shall be located on both sides of road crossings and drain crossings. Top of cable marker/joint marker shall be sloped to avoid accumulation of water/dust on marker.

p) Cable tags shall be provided on all cables at each end (just before entering the equipment enclosure), on both sides of a wall or floor crossing, on each duct/conduit entry, and at every 20 meters in cable tray/trench runs. Cable tags shall also be provided inside the switchgear, motor control centers, control and relay panels etc. where a number of cables enter together through a gland plate. Cable tag shall be of rectangular shape for power cables and control cables. Cable tag shall be of 2 mm thick aluminum with number punched on it and securely attached to the cable by not less than two turns of 20 SWG GI wire conforming to IS:280. Alternatively, cable tags made of nylon, cable marking ties of 'TY-CAB' or equivalent type with cable number heat stamped on the cable tags may also be provided.

q) While crossing the floors, un-armoured cables shall be protected in conduits up to a height of 500 mm from floor level if not laid in tray.



v) **Cable terminations and connections**

- a) The termination and connection of cables shall be done strictly in accordance with cable termination kit manufacturer instructions, drawings etc. Cable jointer shall be qualified to carryout satisfactory cable jointing/termination.
- b) Work shall include all clamps, fittings etc. and clamping, fitting, fixing, plumbing, soldering, drilling, cutting, taping, preparation of cable end, crimping of lug, insulated sleeving over control cable lugs, heat shrinking (where applicable), connecting to cable terminal, shorting and grounding as required to complete the job.
- c) The equipment will be generally provided with undrilled gland plates for cables/ conduit entry. The Contractor shall be responsible for punching of gland plates, painting and touching up. Holes shall not be made by gas cutting. The holes shall be true in shape. All cable entry points shall be sealed and made vermin and dust proof. Unused openings shall be effectively sealed by 2mm thick aluminium sheets.
- d) Control cable cores entering control panel/ switchgear/ MCCs etc. shall be neatly bunched, clamped and tied with self locking type nylon cable ties with de interlocking facility to keep them in position.
- e) The panels where a larger number of cables are to be terminated and cable identification may be difficult, each core ferrule shall include the complete cable number as per the drawings. The ferrules shall be indelible interlocking type and shall fit tightly on cores. Spare cores shall have similarly ferrules with a suffix letter 'S' along with cable numbers and coiled up after end sealing.
- f) All cable terminations shall be appropriately tightened to ensure secure and reliable connections.

**5.6.5 Earthing system**

- i) Earthing system shall be in strict accordance with IS:3043/ IEEE-80/ IEC and Indian Electricity Rules/ Acts.

Wherever existing main earthing system is not available, the main earthing system will be designed considering suitable corrosion allowance based on earthing conductor material and type of soil, for a service life of at least forty (40) years for maximum fault current or system fault current of 40kA whichever is higher for 1 second. The minimum rate of corrosion of earthing conductor shall be considered as 0.12mm per year while determining the conductor size.

- ii) The earth conductors shall be free from pitting, laminations, rust, scale and other electrical, mechanical defects.
- iii) The material of the earthing conductors shall be as follows :
  - a) Conductors above ground level and trenches - Galvanized steel in built up
  - b) Conductors buried in earth - Mild steel
  - c) Earth electrodes - Mild steel rod



- iv) The sizes of earthing conductors for various electrical equipments shall be as below:

	<b>Equipment</b>	<b>Earth conductor buried in earth</b>	<b>Earth conductor and in built-up trenches</b>
a)	Main earth grid	40 mm dia. MS rod	65x12mm GS flat
b)	11kV/6.6kV switchgear/ equipment		65X12MM GS flat
c)	3.3 kV switchgear/ 415V switchgear/ Transformers		50X6MM GS flat
d)	415V Motors		
	- above 125 kW		50 x 6mm GS flat
	- 25 kW to 125 kW		25 x 6mm GS flat
	- 1kW to 25 kW		25 x 3mm GS flat
e)	Control panel/ desk		25 x 3 mm GS flat
f)	Push button station/ Junction Box		8 SWG GI wire
g)	Columns, structures, cable trays and bus ducts enclosures		50x6mm GS flat
h)	Crane, rails, rail tracks and other non-current carrying metal parts		25x6mm GS flat

- iv) Metallic frame of all electrical equipment shall be earthed by two separate and
- v) distinct connections to earthing system, each of 100% capacity, Crane rails, tracks, metal pipes and conduits shall also be effectively earthed at two points. Steel RCC columns, metallic stairs, and rails etc. of the building housing electrical equipment shall be connected to the nearby earthing grid conductor by one earthing ensured by bonding the different sections of hand rails and metallic stairs. Metallic sheaths/screens, and armour of multi-core cables shall be earthed at both ends. Metallic Sheaths and armour of single core cables shall be earthed at switchgear end only. Every alternate post of the switchyard fence shall be connected to earthing grid by one GS flat and gates by flexible lead to the earthed post.
- vi) Each continuous laid lengths of cable tray shall be earthed at minimum two places by GS flats to earthing system, the distance between earthing points shall not exceed 30 metre. Wherever earth mat is not available Contractor shall do the necessary connections by driving an earth electrode in the ground.
- vii) Neutral connections and metallic conduits/pipes shall not be used for the equipment earthing. Lightning protection system down conductors shall not be connected to other earthing conductors above the ground level.
- viii) Connections between earth leads and equipment shall normally be of bolted type. Contact surfaces shall be thoroughly cleaned before connections. Equipment bolted connections after being tested and checked shall be painted with anti corrosive paint/compound.
- ix) Suitable earth risers shall be provided above finished floor/ground level, if the



equipment is not available at the time of laying of main earth conductor.

- x) Connections between equipment earthing leads and between main earthing conductors shall be of welded type. For rust protection the welds should be treated with red lead compound and afterwards thickly coated with bitumen compound. All welded connections shall be made by electric arc welding.
- xi) Resistance of the joint shall not be more than the resistance of the equivalent length of conductors.
- xii) Earthing conductors along their run on columns, walls, etc. shall be supported by suitable welding/ cleating at interval of 1000mm and 750mm respectively.
- xiii) Earth pit shall be constructed as per IS:3043. Electrodes shall be embedded below permanent moisture level. Minimum spacing between electrodes shall be 600mm. Earth pits shall be treated with salt and charcoal if average resistance of soil is more than 20 ohm metre.
- xiv) Earthing conductor shall be buried at least 2000mm outside the fence of electrical installations. Every alternate post of the fences and all gates shall be connected to earthing grid by one lead.

#### 5.6.6 Lightning Protection System

- i) All lightning protection installation work shall be in accordance with the Indian Electricity Rules and IS Code of Practice for the Protection of Buildings and allied Structures against Lightning (IS:2309).
- ii) Lightning protection system shall comprise vertical air terminations, horizontal air terminations, down conductors, test links and earth electrodes.
- iii) Air terminations, down conductors and test links shall be of galvanized steel conductors and earth connection below ground level shall be of mild steel rod.
- iv) For tall buildings and structures, early streamer emission (ESE) type air terminal systems such as marketed by Heary Brothers (USA) are preferred.
- v) Lightning protection conductors/ air termination rods and circumferential bands provided at the top portion of chimney stack shall be lead coated in order to avoid melting by exposure to hot flue gases.
- vi) Horizontal air termination flats provided on top of control building, pump houses and other buildings shall be laid such that no part of the roof shall be more than 9 meters
- vii) Conductors of lightning protection system shall not be connected with conductors of earthing system above ground level.
- viii) Down conductors shall be cleated on outer side of building wall at 1000 mm interval or tack welded to outside of building columns at 1000 mm interval.
- ix) Down conductors shall be connected to separate earth electrodes through test points located at height of above 1000 mm above ground level. These earth electrodes shall in turn be connected to earth mat at two points.





- x) Lightning protection conductors shall not pass through or run inside GI conduits.
- xi) All metallic equipments on roof and exposed steel works within the vicinity of 2000 mm from lightning protection conductors in air shall be bonded to conductors of lightning protection system.
- xii) Lightning protection system shall have as few joints as possible and avoid sharp bends. Down conductors shall have, as far as possible, no joint except at test point and end termination.
- xiii) Termination at the metallic equipments on roof should be made by suitable nuts, bolts, pressure washers and bitumen washers with good electrical conductivity.
- xiv) All lightning protection conductors shall be exposed to atmosphere unless specifically mentioned.

## **5.7 LIGHTING**

### **5.7.1 Make of Equipment / Components**

All components such as lighting fixtures, lighting/ welding branch boards/ Distribution boards, switches, sockets, MCBs, MCCBs etc. must be of standard reputed make. The bidder shall propose makes of the various components in his offer for proper assessment. The makes proposed by the bidder in his bid shall however not be binding on the purchaser and the same shall be finally decided during detailed engineering with a view to meet the specification requirements.

### **5.7.2 Normal Service Conditions**

The equipment supplied by the contractor shall be suitable for installation in an area having hot and humid climate and dusty atmosphere.

### **5.7.3 Lighting System**

#### **i. A.C. Normal Lighting :**

In this system, the lighting circuits would be fed on the normal A.C. supply available from the Main lighting boards. All the lighting fixtures connected to this system shall be 'ON' as long as the 415/240V normal supply is healthy.

#### **ii. AC/DC Emergency lighting :**

At strategic locations in the main building, control building, pump house viz. near entrance, stair-case landing, important control points etc. permanent type incandescent AC/DC lighting fixtures shall be provided to enable safe movement of operating personnel and access to important control points during station emergency involving total AC system failure.

### **5.7.4 Main Lighting Board (MLB)**

The complete lighting of the FGD plant shall be met through 2 or 3 nos. Main Lighting Boards. Each main Lighting Board shall be having Dry type 415 V/ 415 V lighting transformer of adequate rating. The main lighting boards shall feed various lighting

distribution boards to be located suitably near individual load centres. The incoming supply to Main Lighting Board shall be arranged from 415V Switchboard to be supplied by the bidder, through 1.1 kV grade armoured cable. MLBs shall be having MCCBs of adequate rating for incoming supply and outgoing feeder.

#### 5.7.5 Lighting Distribution Board (LDB)

The outgoing feeders power from MLB shall be taken through stranded Aluminium conductor, PVC insulated, 1.1kV grade, armoured cable of appropriate size and shall be terminated on lighting distribution boards (LDB). The required number of LDB shall be wall mounting type having sheet metal enclosure, 3X63A copper bus bars and 63A Neutral terminal block.

The incoming cables shall be terminated on 63A TPN switch and 4 nos. MCBs each of 16A rating shall be provided on each of the three phases (i.e. total of 12 O/G MCBs) for outgoing circuits. The minimum interrupting capacity of the miniature circuit breaker (MCB) shall be 9kA rms. The LDB enclosure shall be duly earthed as specified.

The LDBs shall be located near entry doors. The LDB door shall have a cut out for operating the MCBs. The cut out portion shall have a transparent plastic/acrylic cover for its protection against dust. The LDB shall be of dust proof design.

#### 5.7.6 AC/DC Emergency Lighting Distribution Board (ELDB)

In order to provide emergency lighting during normal AC failure, an AC/DC emergency lighting distribution cabinet (ELDB) shall be provided which shall incorporate AC/DC change over scheme and have outgoing feeders meant to provide functional lighting in control rooms, stair cases, exit points and vital locations during black out.

#### 5.7.7 Guidelines for Design of Lighting Distribution System

##### Indoor Areas

- i. Working plane shall be assumed about 800 mm above the finished ground level.
- ii. Fluorescent luminaries with pendant suspensions shall be installed 3.5 metre above the finished floor level.
- iii. Maintenance factor shall be taken as 0.7.
- iv. Average illumination level shall be taken in the horizontal plane as specified.

##### Outdoor Areas:

- i. Initial calculations shall be done by average illumination method with suitable coefficient of utilization which shall be then cross-checked/ verified for correctness and uniformity with sample calculations by 'point by point' calculation method.
- ii. Maintenance factor shall be taken as 0.6.

#### 5.7.8 Illumination Level Design Factors and Type of Luminaires

The following table gives the desired average illumination level, recommended luminaire type, reflection factors and maintenance factors applicable to various rooms/ areas :



Standard Technical Specification for Retrofit of Wet Limestone Based Flue Gas Desulphurisation  
(FGD) System in a Typical 2x500 MW Thermal Power Plant  
Section- 5 (Electrical Works)

SN	Area	Average illumination level (Lux)	Reflection factors floor/wall/ceiling	Maintenance Factor (%)	Type of Luminaire as given below or equivalent
1.	Switchgear room	200	10/50/50	0.7	IRF 2X40 W
2.	Office rooms w/o false ceiling	200	10/50/50	0.7	IRF 2 x 40 W
	with false ceiling	200	10/50/50	0.7	RLF 2X40 W
3.	Conference Room Library	300	10/50/50	0.7	IRF 2 x 40 W
4.	Control room / DAS room	450	10/50/70	0.7	RLF 2 x 40 W
5.	Control Equipment Room	300	10/50/50	0.7	RLF 2 x 40 W
6	Pump House	150	10/50/50	0.7	RLF 2 x 40 W or FPM – 125 W
7	Battery room	200	10/50/50	0.7	CPF (2 x 40 W)
8	Stair case, corridor, toilets, etc.	70		0.7	IF (1 x 40 W)
9	Outdoor areas / Street lighting and adjacent GTG areas	20		0.6 0.6	FLS – 400 W STS – 150 W
10	AC/DC Emergency lighting:- Control room, stair cases Exit points		Functional	--	BHI – 100 W

#### 5.7.9 Description for each type of luminaire

All luminaire to be supplied complete with lamps, starting gear and all necessary accessories for mounting on ceiling/ poles/ false ceiling as required. Pendants/ brackets of suitable sizes shall be provided as required.

i. Type IRF (2 x 40 W)

Industrial type fluorescent tube fixtures with vitreous enameled reflector, channel housing containing vacuum filled polyester ballast and power factor improvement capacitors, 19 mm conduit entry, spring loaded rotor lamp holder, starters, complete with 2 x 40 W fluorescent tubes.

ii. Type IF (1 x 40 W)

Similar to type IRF but without reflector and with 1 x 40 W fluorescent tube.



- iii. Type BHI (100 W)  
Bulk head luminaire of cast aluminium body, finished in stove enamel, white inside, 19 m conduit entry, prismatic front glass, gasket, porcelain lamp holder complete with 100 W incandescent lamp.
- iv. Type RLF (2 x 40 W)  
Recessed type decorative luminaire without acrylic cover (as per TAC norms) with housing made of heavy gauge steel, stove enameled white inside with lid all around to enable flush mounting with false ceiling with opal acrylic diffuser complete with ballasts, capacitors, starters, rotor lamp holder and 2 x 40 W fluorescent tubes.
- v. Type CPF (2 x 40 W)  
Corrosion proof luminaire, cast aluminium control gear housing containing ballasts, starters, capacitors & terminal block. Structured on seamless heavy gauge aluminum pipes and cast aluminium end boxes incorporating specially designed vapour proof lamp holder complete with 2 x 40 W fluorescent tubes.
- vi. Type FLS (400 W)  
Flood lighting sodium vapour lamp luminaire (IP:55) heavy duty die cast aluminium housing finished in stove enamel with clear neat resistant flat toughened front glass with tropicalised gasket, anodized aluminum reflector, GI cradle, three plane focusing device, complete with starting/ control gear in a weather proof enclosure and a 400 W HPSV lamp. The beam angle shall be  $\pm 30^\circ$ .
- vii. Type STS (150 W)  
Dust and weather proof (IP:55) sodium vapour lamp street lighting fixture comprising of cast aluminium housing accommodating all pre-wired control gear accessories, white stove enameled from inside deep drawn aluminum reflector, accommodating lamp holder with clear acrylic cover fixed by means of four toggles clamps complete with 150 W HPSV lamp.
- viii. Type FPM (125 XW)  
Flame proof mercury vapour lamp fixture for hazardous areas such as fuel oil pump house. Thermal shock proof well glass fixed in a canopy. Weatherproof construction suitable for indoor as well as outdoor. GI wire guard, porcelain lamp holder, control gear also housed in a heavy gauge gasket, flame proof enclosure complete with 125 W HPMV lamp.

#### 5.7.10 Lighting Distribution System Design

- i. While designing the protection of the circuit supplying the mercury and sodium vapor lamps, it shall be ensured that the circuit is not interrupted due to starting current.
- ii. Distribution system shall be designed for 45°C ambient for voltage drop at the end point limited to 5%.
- iii. Distribution Boards / Cabinet shall be located as near as possible to the centre of the load which they are intended to supply.



- iv. Each out going feeder of the lighting / power socket distribution board shall be loaded up to 70 to 80% the MCB rating.
- v. The current rating of wires connected to the outgoing side of any MCB shall not be less than the MCB thermal rating. Similarly cables connected to MCCBs shall have current rating not less than the thermal current rating of its MCCB.
- vi. As far as possible load shall be balanced on three phases of each lighting Dist. cabinet.
- vii. Separate MCB and sub-circuits from the LDB shall be utilized for luminaries and 15A power socket outlets.
- viii. Lighting load on individual sub circuit emanating from LDB shall be restricted to 2 kW.

#### 5.7.11 Emergency lighting Distribution system

The AC/ DC Emergency Lighting Distribution system :

- i. The AC/DC emergency lighting distribution board shall be wall mounted type sheet metal enclosure similar to the normal LDB in general constructional features.
- ii. It shall have the provision to receive two incoming supplies viz. 240V, 2 wire AC and 220V, 2 wire DC which shall terminate on a 2 wire, 240V Bus through MCCBs and changeover AC & DC contactors. Suitable number of outgoing feeders shall be tapped from the bus through 2 pole MCB of adequate thermal and short circuit rating.
- iii. The automatic changeover scheme between AC and DC sources shall incorporate positive interlock to avoid paralleling of two power supplies. The auto changeover scheme shall be achieved using AC and DC voltage sensing relays. Lockable type auto/manual selector switch shall also be provided. Normally the AC contactor shall be ON. In case of AC failure it shall open and DC contactor shall close. When the AC is restored, the DC contactor shall open and AC contactor shall reclose automatically.

#### 5.7.12 Spare Feeders

Provision of at least 20% subjected to minimum of one spare outgoing feeder shall be kept on each Main Lighting Board and Lighting Distribution Board/ Cabinet.

#### 5.7.13 Power Socket Outlets

All buildings/ rooms are to be equipped with 5A and 15 A utility power socket with individual control supply as required. 15A sockets shall be fed through independent circuits from the lighting distribution cabinets and that shall installed 250mm above floor level.



#### 5.7.14 Welding outlet

A few welding outlets are to be provided in the power plant area as per the system requirement and these shall be directly feed from 415V switchboard. The welding outlets shall be of 63 A, 3 phase & neutral controlled by a switch suitable for indoor / outdoor duty as required. The plug tops shall be supplied loose and handed over separately.

All three phase welding power outlets shall incorporate a fourth pin for earthing purpose and shall be fitted with a mechanical interlock which will prevent the plug being inserted or withdrawn while the switch is in "ON" position.

#### 5.7.15 Drawings and Data

The bidder shall submit the following drawings/ data after award of contract for approval :

- Lux level calculation for each area
- Lighting fixtures layout drawing for each area
- Single line diagram and GA drawing for MLB, LDB and ELDB
- Key distribution diagram for lighting, power socket and welding system.
- Typical voltage drop calculation for various application
- Scheme drawings for AC / DC changeover
- Leaflets .and instruction manual for all types of lighting fixtures etc.

#### 5.7.16 Standards

The complete lighting equipment (lighting fixtures, Distribution boards, etc.) to be supplied by the tenderer shall conform to latest revision of I.S/ IEC. Bidder shall submit the type and routine test certificate as per relevant I.S. for approval.

### 5.8 DC SYSTEM

1. Each DC system shall be ungrounded (unless asked otherwise) and each system shall be provided with its own separate battery, 2x100% rating Float-cum-Boost charger, DC distribution boards and sub-distribution boards for meeting the 220V DC power supply for continuous and emergency DC power and control requirements, emergency lighting and AC power requirement (through inverter), if any.
2. **Battery:**
  - i. The battery shall be Lead acid (Plante) type or Ni-Cd pocket plate high discharge (KPH) type.
  - ii. The ampere-hour capacity of battery of each DC system shall be designed to meet the duty cycle and loads associated with respect to that DC system for duration of one hour.
  - iii. Battery shall be designed for proper operation and to meet specified load and their duty cycle under all ambient and site conditions specified elsewhere.
  - iv. Number of cells: 220V batteries shall have a minimum of 110 cells each.



- v. Nominal voltage : 220V DC for each DC system .
- vi. End voltage : End voltage of batteries at the end of duty cycle : not less than 1.85V per cell for Lead-acid and 1.14V per cell for Ni-Cd type.
- vii. The bidder shall indicate in their bid the ampere-hour capacity of various batteries at 10 hour rate of discharge for lead-acid and 5 hour rate of discharge for Ni-Cd battery at 27°C envisaged by them.
- viii. The battery shall preferably be arranged in single tier arrangement. However, batteries having a complete cell weight less than 50kg could be located in the double tier arrangement. The battery racks shall be wood coated with acid resistant and flame resistant coating or mild steel racks, free standing type mounting on porcelain/ hard rubber/ PVC pads insulators/ high impact plastic insulators.
- ix. Each battery should be provided with suitable moulded case circuit breaker which shall be located adjoining the battery itself in a separate panel viz. battery panel. All the MCCBs will have adjustable Short circuit & Overload settings. The bidder will ensure proper coordinated settings from the charger board and beyond. All the DC motor feeders will also be provided with over load alarm. Suitable arrangement shall be provided to annunciate the tripping of breaker in battery panel as well as at remote control board.

### 3. **Float-cum-Boost Chargers**

- i. The Float (trickle) charger shall have a rating to need float charging load of the associated battery at the rate of 2 to 2.2V/ Cell for lead-acid and 1.4 to 1.42V/ cell for Ni-Cd and for meeting the constant DC loads to be fed from the DC system with an overall margin of 10%.
- ii. The Boost (quick) charger shall have a rating to meet boost charging load, equalising charging load of the associated battery at the rate of 1.5 to 2.75V / cell for lead-acid and 1.53 to 1.7V/ cell for Ni-Cd and current as recommended by the battery manufacturer and for simultaneously meeting the constant DC loads to be fed from the DC system with an overall margin of 10%. The quick chargers of the battery system shall also be suitable for routine testing of DC motors connected to the DC system.
- iii. The trickle charger and quick charger shall also be capable of meeting short time impulse loads of the associated DC systems.
- iv. DC output voltage variation for trickle chargers and quick chargers shall be in accordance with requirements of the equipments offered but shall normally be 210 to 250V and 200 to 320V respectively.
- v. The trickle chargers and quick chargers shall be of static type using silicon-controlled rectifiers with three-phase bridge circuit and ripple factors suiting the equipment offered but not exceeding 1% pk-pk without battery. This value of ripple factor shall not affect the performance of electronic and static equipment supplied by the bidder.



- vi. Each trickle charger shall have an arrangement for automatic and normal DC voltage regulation with selector switch for mode of operation.
- vii Each quick charger shall have normal voltage regulating system.
- viii Voltage regulating system for trickle charger and quick charger shall be of 'static' type.
- ix The automatic voltage regulator of trickle charger shall hold the DC voltage constant from zero to full load but with a definite drop at load greater than full load so that such loads are transferred to the battery. The automatic voltage regulating system shall maintain DC voltage constant to the requirement of equipment offered but to a voltage not more than +1 % of the set value for a fluctuation of +10% in voltage and +5% in frequency in the AC input voltage for purpose of bid.
- x. Each trickle charger and each quick charger panel shall be complete with all necessary equipment and shall be subjected to purchaser's approval.
- xi The rectifier assemblies shall be provided with all necessary protection devices, which shall be subject to approval.
- xii Facia windows with indicating lamps and inscriptions shall be provided in each charger panel for annunciations provided in each charger panel shall at least include the following:
  - AC supply failure
  - Battery protection operated
  - Surge circuit fuse failure
  - Charger trip
  - Rectifier fuse failure
  - Charger load limiter operated
  - Battery on boost

Necessary potential free contacts for annunciating the above shall be provided.

- xiii The transformers associated with trickle chargers and quick chargers shall be air cooled type.

#### 4. **DC Distribution Boards**

- i. Each DC system shall be provided with suitable independent DC Distribution Board to make available the DC power requirements.
- ii Each DC Distribution board shall have incoming supply arrangement from the associated battery, trickle charger and quick charger and adequate number of outgoing feeders with 20% spare feeders suitably rated for various loads to be set by the DC system. No. of feeders / equipment including 20% spare feeders as required during engineering shall be deemed to be included in the quoted price.

DC Distribution arrangement shall be designed to provide duplicate DC supply feeders for each load and system from separate sections.





The DC motor load shall be fed from separate bus with isolation facility from the main bus to facilitate testing of motors.

- iii Each DC Distribution board shall be provided with (i) earth fault detecting relays which shall give alarm for earth fault in positive or negative of the system. (ii) voltage level indicating devices for annunciating 'DC voltage low' and 'DC voltage high' with additional initiating contacts for annunciating the same at control board (iii) voltmeter with selector switch to read voltages positive to earth, negative to earth and between positive and negative.
- iv Various annunciations in DC Distribution Boards shall be by means of facia windows with indicating lamps and inscriptions.
- v. Each incoming and outgoing feeder shall be provided with magnetic short circuit protection having adjustable range of pick up current and time delay. In addition to the above, the feeder breakers for motors shall be provided with overload protection with suitable range.
- vi Protection coordination: short circuit protection in various feeders of DC system shall be coordinated so as to achieve selective tripping on fault on any feeder.

**5. Battery Panels, Charger Panels and DC Distribution Boards constructional features:**

- i. The boards shall be fully compartmentalized type i.e. each feeder equipment shall be accommodated in a separate module.
- ii The DC boards shall have degree of protection as IP-52. The degree of protection of charger board shall be IP-42. Panel of all the faces of the DC board shall be 2.0mm thick. The sheet steel thickness for charger panel shall be minimum 2.0mm. Removable gland plates of thickness 3mm (hot/cold rolled sheet steel) or 4 mm (non-magnetic material) shall be provided.
- iii. The bus bars shall be of high conductivity aluminium / electrolytic copper of ample cross section, shall have adequate current rating and shall be without maximum short circuit stresses. The bus bars shall be insulated and supported from the structure by means of durable non-hygroscopic, non-combustible and nontracking material. The entire bus bar system shall be insulated with PVC sleeves.
- iv. DC Distribution arrangement, type, make, ratings and voltage ratings of batteries, charges, DC Boards, circuit breakers, contactors, switches, relays, instruments etc. shall be subject to prior approval of the purchaser.

**6. Tests**

The bidder shall carry out all the tests on batteries, battery charger and DC board as per relevant standards and shall also carry out one hour rate of discharge test on the batteries. Test reports will be furnished for approval.



Capacity test on each complete battery at 10hr rate of discharge for Lead acid battery and 5 hr rate of discharge for Ni-Cd battery shall be carried out at site after installation.

7. **Drawings and Data:** The following drawings shall be supplied by the tenderer with his tender for each battery system.
- i. General arrangement drawing of the cell.
  - ii. General arrangement drawing of battery stand.
  - ii. Layout drawing of the battery in the battery room with details of cell insulators/ stand insulators and end take off terminals of batteries.
  - iv. Charge and discharge performance curves of cells.
  - v. Schematic diagrams of charger panels.
  - vi. Control schemes and characteristic curves for voltage regulators of charges.
  - vii. Schematic drawings for earth fault detection device and voltage level indicating devices.
  - viii. Typical General arrangement drawings for each battery panel charger panel and DC distribution Boards.
  - ix. Duty cycle for each battery system (load Vs time)



## SECTION 6

### CONTROL & INSTRUMENTATION WORKS

#### 6.0 TECHNICAL SPECIFICATION - C&I WORKS

#### 6.1 GENERAL

##### 6.1.1 General Requirements

- i) The bidder shall provide all material, equipment and services so as to make a totally integrated Instrumentation and Control System together with all accessories, auxiliaries and associated equipment ensuring operability, maintainability and reliability. The Instrumentation and Control System shall be consistent with modern power plant practices and shall be in compliance with all applicable codes, standards, guides, statutory regulations and safety requirements in force.
- ii) The bidder shall also include in his proposal and shall furnish all equipment, devices and services which may not be specifically stated in the specification but are needed for completeness of the equipment/systems furnished by the bidder and for meeting the intent and requirements of the specification.
- iii) It may be noted that where equipment or system for the unit are described, same refer to only one set per unit to be furnished by the contractor unless specifically indicated otherwise. Where equipment or systems for plant common facilities are described, it will be understood that the quantities described are the total quantities required.

##### 6.1.2 Reliability and Availability

- i) Each component and system offered by the bidder shall be of established reliability. The minimum target reliability of each piece of equipment like each electronic module/card, power supply, peripheral etc. shall be established by the bidder, considering its failure rate/mean time between failures (MTBF), meantime to repair (MTTR), such that the availability of the complete C&I system is assured for 99.7%.
- ii) When more than one device uses the same measurement or control signal, the transmitter and other components/ module shall be fully equipped to provide all signal requirements. The system shall be arranged so that the failure of any monitoring device or control components or spurious intermediate grounding in the signal path shall not open the signal loop nor cause the loss or malfunction of signal to other devices using the same signal.



- iv) To ensure availability, adequate redundancy in system design shall be provided at hardware, software and sensor level to satisfy the availability criteria as mentioned above. For the protection system, independent sensing device shall be provided to ensure adequate safety of plant equipment.

### 6.1.3 Standardisation and Uniformity of Hardware

To ensure smooth and optimal maintenance, easy interchangeability and efficient spare parts management of various C&I instruments/equipment, the Bidder shall ensure that all instruments/devices are of the same make, series and family of hardware to the extent possible.

### 6.1.4 Operability & Maintainability

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

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

- a) Failure of sensor or transmitter,
  - b) Failure of main and/or redundant controller/other modules,
  - c) Loss of motive power to final control element,
  - d) Loss of control power.
  - e) Loss of instrument air
- ii) The choice of hardware shall also take into account sound maintainability principles and techniques. The same shall include but shall not be limited to the following:
    - a) Standardization of parts.
    - b) Minimum use of special tools.
    - c) Grouping of functions.
    - d) Interchangeability.
    - e) Malfunction identification facility/self surveillance facility.
    - f) Easy modular replacement.
    - g) Fool proof design providing proper identification and other features to preclude improper mounting and installation.
    - h) Appropriate derating of electronic components and parts.
  - iii) The equipment shall employ latest state of the art technology to guard against obsolescence. In any case, bidder shall be required to ensure supply of spare parts for 15 years of the plant. In case, it is felt by the Bidder that certain equipment/component is likely to become obsolete, the Bidder shall clearly bring out the same in his bid and indicate steps proposed to deal with such obsolescence.



### 6.1.5 Control & Monitoring

PLC system based control, monitoring & operation shall be provided for the flue gas desulphurization (FGD) system. Further, the FGD PLC shall be provided with soft link for collection of data in the DDCMIS (In Purchaser's scope) for the information of unit-incharge / shift-incharge etc. through Station Wide LAN. All required interfacing hardware and software shall be provided by bidder.

### 6.1.6 Environmental Conditions

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

Ambient temperature (outside cabinets)	Pressure	Relative humidity	Atmosphere	Required protection Class of panels/ cabinets/ desks
<b>Outdoor Location</b>				
55 degree C max.	Atmosphere	100 % Max.	Air (dirty)	IP 55***
4 degree C min.	Atmosphere	5 % min.	Air (dirty)	IP 55***
<b>Indoor Location</b>				
55 degree C max.	Atmosphere	95 % Max.	Air	IP 54**
4 degree C min.	Atmosphere	5 % min.	Air	IP 54**
<b>Air Conditioned Areas</b>				
24 +/- 5 degree C normal	Atmosphere	95 % Max.	Air	IP 32
50 deg C max. *	Atmosphere	5 %min.	Air	IP 32
* During air conditioning failure.				
** For non-ventilated enclosures. For ventilated enclosures, protection class shall be IP 42.				
***With a suitable canopy at the top to prevent ingress of dripping water.				
For PCs, OWS, EWS, Servers, Printers and other peripherals, maximum temperature limit shall be 35 <sup>0</sup> C.				



## 6.2 PLC BASED CONTROL SYSTEM

### 6.2.1 General Requirements

- i) Contractor shall provide complete and independent PLC based Control and Instrumentation system with all accessories, auxiliaries and associated equipments and cables for the safe, efficient and reliable operation of the FGD system.
- ii) Bidder shall include in his proposal all instruments and devices, which are needed for the completeness of the system. Same shall be subject to approval of the purchaser during detailed engineering.
- iii) All instruments and control equipments like primary and secondary instruments etc. shall meet the requirements specified in sub-section on Measuring Instruments. In addition, all electrical instrument devices like switches/transmitters/ controllers/ analysers/ solenoid valves which are located in the field/hazardous locations shall be provided with explosion proof enclosure suitable for hazardous areas described in National Electric Code (USA), Article 500, Class-I, Division-I. All field wiring should be through conduits. All fittings, double compression type cable glands etc. shall be strictly as per NEC recommendation article, 500 to 503.
- iv) Contractor shall provide independent control systems for safe, efficient and reliable operation of each of the plant auxiliary systems. The control system shall provide safe operation under all plant disturbances and on component failure so that under no condition the safety of plant, personnel or equipment is jeopardized. Control system shall be designed to prevent abnormal swings due to loss of Control System power supply, failure of any Control System component, open circuit/short circuit, instrument air supply failure etc. On any of these failures the controlled equipment/parameter shall either remain in last position before failure or shall come to fully open/close or on/off state as required for the safety of plant/personnel/equipment and as finalised during detailed engineering. System shall be designed such that there will be no upset when Power is restored.
- v) ON/OFF control, indication, annunciation of incomers and bus-coupler are also to be performed from contractor's control system for each of the above system as applicable.
- vi) The control system shall be located in air conditioned area. However, the control system shall be designed to operate in non-air conditioned area also during air-conditioning failure.

### 6.2.2 Programmable Logic Based Control System

- i) PLC Processor  
The processor unit shall be capable of executing the following functions:-



- a) Receiving binary and analog signals from the field and operator initiated commands from OWS/ control panel.
  - b) Implementing all logic functions for control, protection and annunciation of the equipment and systems.
  - c) Implementing modulating control function for certain application as specified elsewhere in the specification.
  - d) Issuing control commands.
  - e) Providing supervisory information for alarm, various types of displays, status information, trending, historical storage of data etc.
  - f) Performing self-monitoring and diagnostic functions.
- ii) The controller shall provide all basic functions for binary gating operations, modulating controls, storage, counting, timing, logging, transfer operations and comparison functions.
  - iii) Each PLC unit shall be provided with two processors (Main processing unit and memories) one for normal operation and one as hot standby. In case of failure of working processor, there shall be an appropriate alarm and simultaneously the hot standby processor shall take over the complete plant operation automatically. The transfer from main processor to standby processor shall be totally bumpless and shall not cause any plant disturbance whatsoever. In the event of both processors failing, the system shall revert to fail safe mode. It shall be possible to keep any of the processors as master and other as standby. The standby processor shall be updated in line with the changes made in working processor. Power supply unit shall be hot redundant for each CPU & I/O rack.
  - iv) The memory shall be field expandable. The memory capacity shall be sufficient for the complete system operation and have a capability for at least 20% expansion in future. Programmed operating sequences and criteria shall be stored in non volatile semiconductor memories like EPROM. All dynamic memories shall be provided with buffer battery backup which shall be for at least 360 hours. The batteries shall be lithium or Ni-Cd type.
  - v) The OWS shall perform control, monitoring and operation of all auxiliaries/ drives interacting with PLC based control system. It shall basically perform the following functions:
    - a) Operator interface for PLC based control system. Operator functions shall as minimum include local/ remote selection, A/M selection, open/ close operation, sequence auto, start/ stop selection, ON/OFF, bypassing criteria etc.
    - b) Supervisory functions like:-



Mimic displays, which shall depict the process in graphical form and shall cover all the process areas being monitored.

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

- c) Suitable Interface with stations wide LAN (in Purchaser's Scope) for two-way transfer of data.
- vi) Programming station shall have access to the processor of the control system for programming. Programming shall not require special computer skills. On the programming console, it shall be possible to do the programming, self-diagnostics, testing of sequence, simulation and any sequence modification. A forcing facility shall be provided for changing the states of inputs and outputs, timers and flags to facilitate fault finding and other testing requirements. It shall be possible to display the signal flow during operation of the program. Programming shall be possible OFF line.
- vii) Manual intervention shall be possible at any stage of operation. Protection commands shall have priority over manual commands and manual commands shall prevail over auto commands.
- viii) All necessary software required for implementation of control logic, operator station displays / logs, storage & retrieval and other functional requirement shall be provided. The programs shall include high level languages as far as possible. The contractor shall provide sufficient documentation and program listing so that it is possible for the Purchaser to carry out modification at a later date.
- ix) The Contractor shall provide all software required by the system for meeting the intent and functional/parametric requirements of the specification.
  - a) Industry standard operating system like UNIX/ WINDOWS (Latest) etc. to ensure openness and connectivity with other system in industry standard protocols (TCP-IP/ OPC etc.) shall be provided. The system shall have user oriented programming language & graphic user interface.
  - b) All system related software including Operating System, File management software, screen editor, database management software. On line diagnostics/debug software, peripheral drivers software and latest versions of standard PC-based software and latest WINDOWS based packages etc. and any other standard language offered shall be furnished as a minimum.
  - c) All application software for PLC system functioning like input scanning, acquisition, conditioning processing, control and communication and software for operator interface of monitors, displays, trends, curves, bar charts etc. Historical storage and retrieval utility, and alarm functions shall be provided.





- d) The Contractor shall provide software locks and passwords to Purchaser's engineers at site for all operating & application software so that Purchaser's engineers can take backup of these software and are able to do modifications at site.

### 6.2.3 Human Machine Interface System (HMIS)

#### 6.2.3.1 General

- i) Operator work station (OWS) shall perform control, monitoring and operation of all auxiliaries/ drives interacting with PLC based control system. It shall be possible to use the same as programming station of the PLC and the Human Machine Interface System. It shall basically perform the following functions. In case the PC based OWS cannot be used as programming station of the PLC and the Human Machine Interface System, then separate PC based programming station shall be provided.
- ii) Operator shall be able to access all control/information related data under all operating conditions including a single processor/computer failure in the HMIS.
- iii) All frequently called important functions including major displays shall be assigned to dedicated function keys on a soft keyboard for the convenience of the operator for quick access to displays & other operator functions.
- iv) The operator functions for each OWS shall as a minimum include Control System operation (A/M selection, raise/lower, set point/bias change, on/off, open/close operation, mode/device selection, bypassing criteria, sequence auto, start/stop selection, drive auto selection, local-remote/other multi-position selection etc.); alarm acknowledge; call all kind of displays, logs, summaries, calculation results, etc.; printing of logs & reports; retrieval of historical data; and any other functions required for smooth operation, control & management of information as finalized during detailed engineering.
- v) The display selection process shall be optimized so that the desired display can be selected with the minimum no. of operations. Navigation from one display to any other should be possible efficiently through paging soft keys as well as through targets defined on the displays. There should be no limitation on number of such targets.
- vi) The system shall have built-in safety features that will allow/disallow certain functions and entry fields within a function to be under password



control to protect against inadvertent and unauthorized use of these functions. Assignment of allowable functions and entry fields shall be on the basis of user profile. The system security shall contain various user levels with specific rights as finalised by the Employer during detailed engineering. However, no. of user levels, no. of users in a level and rights for each level shall be changeable by the programmer (Administrator).

- vii) When any drive or sequence is being controlled from one OWS, the system shall inhibit control access of the same drive or sequence from other OWS or Local Control Panel.

### 6.2.3.2 Servers/ Programming station/operating work station/PC

The hardware of Servers/ Programming station/operating work station/PC shall conform to the following minimum requirements:

Sl. No	Features	Servers/ programming station/ workstations for information functions	Operator workstations/ PC
1	Processor	Intel Xeon Six (6) 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.	64 bit/32 bit - On board Intel – Xeon quad core, 3.46 GHz processor with 1066 MHz bus with Hyper threading or higher.
2	Memory	64GB ECC DDR – 3, 800 SDRAM.	8 GB DDR3 RAM
3	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 2048 MB Graphic Accelerator	1 x 1000 GB IDE Hard Disc Drive of 7200 RPM or higher. 2048 MB Graphic Accelerator.
4	Monitor (colour)	LED based 24” sized Monitors. with non-interfaced refresh rate min. 75 Hz. Full HD resolution 1920 X 1080,	LED based 24” sized Monitors. with non-interfaced refresh rate min. 75 Hz. Full HD resolution 1920 X



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		256 colours with MRPII compliant, viewing angle 178° vertical & Horizontal and fastest response time.	1080, 256 colours with MRPII compliant, viewing angle 178° vertical & horizontal and fastest response time.
5	RAID	SAS-channels, hardware RAID level 5 implemented	
6	Redundant hot swappable power-supply	2 nos.	
7	Removable bulk storage drive (DVD)	6 GB (minimum)	
8	Removable bulk storage media for above (with each server/ work-station)	10 nos.	
9	DVD R/W	16x or higher	16x or higher
10	Power Supply	230 V AC UPS with 30 mins. battery backup on machine load and 10% design margin at full load.	230 V AC UPS with 30 mins. battery backup on machine load and 10% design margin at full load..
11	Keyboard	ASCII	ASCII
12	Pointing Device	Optical Mouse	Optical Mouse
13	Accessories	Industrial grade furniture as approved during detailed engineering	Industrial grade furniture as approved during detailed engineering
14	Software	<p>Latest &amp; proven version of Windows Operating system.</p> <p>General MS Windows latest, MS- Office Professional, Adobe Acrobat, anti-virus software with IPS, etc. Application engineering &amp; HMI software - to suit project Specific requirement.</p>	<p>Latest &amp; proven version of Windows OS with Multimedia. Third party operating system, graphical users interface and software, if required. General MS Windows latest, MS-Office Professional, Adobe-Acrobat, anti-virus software with IPS, AutoCAD etc. Application engineering &amp; HMI</p>



			software - to suit project specific requirement.
15	Additional general purpose software (for using over network by servers/ workstations PCs)	Comprehensive disk maintenance utility for disk clean sweep/ crash guard/ antivirus, etc. (like "Norton System Works")	Comprehensive disk maintenance utility for disk clean sweep/ crash guard/ antivirus, etc. (like "Norton System Works")

The supervisory functions like log, calculations, shall be implemented in redundant Server/Information workstation, so that no functions are lost due to a signal failure.

Individual Monitors shall be supplied for all stations.

### 6.2.3.3 Laptop

The laptop shall meet following minimum requirements:

- Intel Centrino TM Mobile Technology.
- Intel Core – i7 Processor with 3.46 GHz, 4 MB L2 cache, 1066MHz.
- FSB.
- 15" WXGA LED Screen with wide angle viewing.
- 1000 GB 7200 rpm HDD with shock absorber.
- 4 GB 800 MHz DDR3 SDRAM (slot for 1no. additional RAM slot should be provided)
- 1024 MB Graphic Accelerator
- Latest & proven version of Windows OS with Multimedia
- Slim type DVD-RW/DVD ROM combo drive.
- Internal 10/100/1000Mbps Ethernet card
- IEEE 802.11B connectivity port & IR port
- 2Nos. USB 3.0/2.0 ports & Wireless INTERNET & blue tooth interface
- External mouse connectivity and optical mouse
- Minimum 8 hrs battery backup.
- Recovery software tools.
- Sound cards & internal speakers
- General MS Windows latest, MS-Office Professional, Microsoft
- Adobe Acrobat, anti-virus McAfee or equivalent, etc.

The Laptop will also be used as pluggable temporary programmer's station and operator station functionalities of the programming stations mentioned in the specifications shall be provided (including requisite license).

### 6.2.3.4 Graphical Interface Unit

Minimum specifications of Graphical Interface unit shall be as follows:-

Sl. No.	Features	Description
1.	Power supply (Redundant)	230 V AC from UPS/24 V DC as per requirements.
2.	Display Size	10.4-15" minimum. Actual size as per owner's approval.
3	Display Type	Coloured, TFT high resolution screens
4.	Protection class	IP-55.
5	Keys	Function keys and numeric keys
6	Functional requirements	Ability to do programming. Graphics display including alarms and operator guidance messages.

### 6.2.4 Input/ Output Modules

- i) The PLC system should be designed according to the location of the input/output cabinets as specified.
- ii) Input Output modules, as required in the Control System for all types of field input signals ( 4-20 mA, RTD, Thermocouple, non change over/change over type of contact inputs etc.) and outputs from the control system (non change over/change over type of contact, 24/48 VDC output signals for energising interface relays,4-20 mA output etc.) are to be provided by the Contractor.
- iii)
  - a) Electrical isolation of 1.5 kV with optical couplers between the plant Input/output and controller shall be provided on the I/O cards. The isolation shall ensure that any inadvertent voltage or voltage spikes (as may be encountered in a plant of this nature) shall not damage or mal-operate the internal processing equipment.
  - b) The Input/output system shall facilitate modular expansion in fixed stages. The individual input/output cards shall incorporate indications on the module front panels for displaying individual signal status.
  - c) Individually fused output circuits with the blower fuse indicator shall be provided. All input/output points shall be provided with status indicator. Input circuits shall be provided with fuses preferably for each input, alternatively suitable combination of inputs shall be done and provided with fuses such that for any fault, fuse failure shall affect the particular drive system only without affecting other systems.



- d) All input/output cards shall have quick disconnect terminations allowing for card replacement without disconnection of external wiring and without switching of power supply.
- e) The Contractor shall provide the following monitoring features:
  - 1. Power supply monitoring.
  - 2. Contact bounce filtering.
  - 3. Optical isolation between input and output signals with the internal circuits.
  - 4. In case of power supply failure or hardware fault, the critical outputs shall be automatically switched to the fail-safe mode. The fail-safe mode shall be intimated to the successful Contractor during detailed engineering.
- f) Further, keying-in of individual wire connectors shall be provided to ensure that only the correct card is plugged on the I/O module. It shall be possible to remove I/O module without disconnecting wiring from field inputs or outputs. There shall be at least 20% spare capacity available on input, output and memory modules, over and above the system requirement.
- g) Binary Output modules shall be rated to switch ON/OFF coupling relays of approx. 3 VA at 24 VDC. Analog output modules shall be able to drive a load impedance of 500 Ohms minimum.
- h) Output module shall be capable of switching ON/OFF inductive loads like solenoid valves, auxiliary relays etc. through Inter-posing relay.
- i) Only one changeover contact shall be provided in MCC for control and interlock requirement. Further multiplication, if required, shall be done by the contractor in PLC system.
- j) All input field interrogation voltage shall be 24V DC or 48 V DC.
- k) In case of loss of I/O communication link with the main processing unit, the I/O shall be able to go to predetermined fail safe mode (to be decided during detailed engineering) with proper annunciation.
- l) Contractor shall provide for 20% spare I/O modules in each system cabinet to take care of any further addition.
- m) Wiring Scheme for inputs to control system shall be as follows:
  - 1. Input sensors used for interlock/protection shall be dual redundant. Each of the redundant binary & analog inputs shall be wired to separate input modules. These input modules shall be placed in different racks, which will have separately fused power supply distribution. Implementation of multiple measurement scheme of

these inputs will be performed in the redundant hardware. Loss of one input module shall not affect the signal to other modules. Other channels of these modules can be used by other inputs of the same functional group.

2. The single (i.e. non-redundant) binary & analog signal required for control purposes shall be wired as follows:
  - a) All single analog & binary inputs including the limit switches of valves/dampers MCC/SWGR check-backs of all drives & information related signals shall be wired to single (i.e. non-redundant) input modules.
  - b) The on-off status of HT drives etc., however, shall be wired to two separate input modules.
3. Inputs and Outputs related to each of the redundant drives / equipments (e.g. each of the 3x50 % drives, each of the storage vessel/sump/tank storing same fluid, each of the streams and its related drives etc.) shall be wired to separate input and output modules.

#### 6.2.5 Data Communication System (DCS)

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

The DCS shall have the following minimum features :

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



- f) Data transmitting speed shall be sufficient to meet the responses of the system in terms of displays, control etc. plus 25% spare capacity shall be available for future expansion.
- g) Passive coaxial cables or fibre optic cables shall be employed.

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

## 6.2.6 Control System Requirements

### 6.2.6.1 General requirements

- i) The control system shall function reliably under the environmental conditions as specified in this specification. It shall be immune from the interferences resulting from disturbances in power supply feeders, signal lines, inputs, outputs, etc. as experienced in a coal fired power station.
- ii) The control system shall have on-line simulation and testing facility. Further, it shall be possible to on-line configure and tune controllers through configuration and tuning station for control system.
- iii) 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.
- iv) The executive programs for the controller modules shall be firmware based, which shall be non-volatile and shall not be alterable except by replacement of parts. The application programs for the functional controllers shall be software based and shall be alterable through the configuration and tuning station for all configuration and strategy changes, etc., and through the operator's console for set point/bias changes, device selection, etc.
- v) All the 100% hot/redundant backup controllers shall be identical in hardware and software implementation to their corresponding main controllers and shall be able to perform all its tasks. The backup controller shall track its corresponding main controller. There shall be an automatic and bumpless switchover from the main controller to its corresponding backup controller in case of main controller failure and vice versa without resulting in any change in control status. In case of switchover from main controller to the 100% hot backup controller, the back-up controller shall work as the main controller.
- vi) Facility shall also be provided for manual switchover from main to 100% hot back-up controller and vice versa from the programmer's console.





- vii) The control system hardware design shall be such that it is able to withstand power line disturbances as per relevant standard.
- viii) Functional grouping of various controllers shall be decided during detailed engineering which shall be subject to purchaser's approval. For each of the functional groups, separate sets of controllers, I/O modules, communication controllers, power packs/ modules etc. shall be provided. Mixing of hardware of two or more functional groups (FG) shall not be acceptable.

#### 6.2.6.2 Binary controls/open loop control system (OLCS)

- i) The OLCS shall include sequence control, interlock & protection for various plant auxiliaries, valves, dampers, drives etc. The sequence control shall provide safe and automatic startup and shutdown of plant and of plant items associated with a plant group. The interlock and protection system shall ensure safe operation of plant/plant items at all times and shall automatically shut down plant/plant items when unsafe conditions arise.
- ii) The OLCS shall be arranged in the hierarchical control structure consisting of unit level, group level, subgroup level & drive level (as applicable).
- iii) It shall be possible to perform automatic unit startup & shutdown by issuing minimum number of command from the OWS. Thus, the unit level shall control all the control system blocks and issue appropriate startup and shutdown commands to various blocks of control system.
- iv) The group level shall control a set of functional sub-groups of drives. Appropriate start-up and shut down commands shall be issued to the sub-group control and various check backs shall be received from sub-groups or drives. Each sub-group shall execute the sequential start-up and shut down programmes of a set of inter-related drives along with system interlocks and protections associated with that sub-group as well as basic interlocks and protections related to individual drive falling under that sub-group. The drive level shall accept commands from the sub-groups, push buttons (wherever provided), etc., and transmit them to the respective drive, after taking into account various interlocks and protections and the safety of that particular drive.
- v) A sequence shall be used to move a set of groups and sub-groups from an initial steady state (for instance 'OFF') to a final steady state (for instance 'ON'). The sequence initiating command for the unit and group level shall be issued from OWS.
- vi) A sequence shall be made of steps. The steps shall be executed in predetermined order according to logic criteria and monitoring time consisting of the interlock & protection requirements and check back of previous step which shall act as pre-conditions before the sequence



control can execute the command for that step.

- vii) Each step shall have a "waiting time" implying that the subsequent step would not be executed unless the specified time elapses. A monitoring time shall also be defined as the maximum time required in executing the commands of any step and the time required for appearance of check back signals. In case, this is not completed within the specified time, a message shall be displayed and programme will not proceed further.
- viii) Manual intervention shall be possible at any stage of operation and the sequence control shall be able to continue at the correct point in the programme on return to automatic control. Protection commands shall have priority over manual commands, and manual commands shall prevail over auto commands.
- ix) Open or close priority shall be selectable for each drive.
- x) The sequence startup mode shall be of the following types.
  - a) **Automatic Mode**

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

In this mode of operation, once the sequence is initiated, the step progressing shall be displayed on the operator station. But the step execution command shall be prevented and shall be sent by the operator via the keyboards. It shall be possible to bypass and/ or simulate one or more criteria to enable the program to proceed. This facility shall allow the program to be executed even if some criteria are not fulfilled because of defective switching device, etc., while the plant condition is satisfactory. All the criteria bypassed shall be logged and displayed. It shall be possible to put the system on the auto-mode after operating it on semi-automatic mode for some steps or vice-versa, without disturbance to the sequence operation.
  - c) **Operator Test Mode**

It shall be possible to use the sequential control in operator guide mode/ test mode i.e. the complete system runs and receives input from the plant and the individual push button stations (where provided)/ keyboards but its command output is blocked. The whole programme, in this case shall run in manual mode. This mode shall allow the operator to practice manual operation using step and criteria indications. The actual protection should remain valid during this mode of operation also.
- xi) The sequence shall be started by putting the sequence on 'auto' and on receipt of 'start' command from the OWS or from a higher level group/ protection action as defined. The sequence shall then progress as per

the defined logics. It should be possible to select alternative operation in the same sequence depending on certain process/ equipment condition. Some step can be automatically bypassed also based on certain process/ equipment condition. When the expected results of the sequence are reached the sequence is considered as "End".

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

- xii) For the critical HT drives, the command shall be provided through redundant output module and inputs (status, switchgear & process) shall be acquired through input modules. The drive logic shall be implemented in the redundant controller.
- xiii) The output modules shall have the feature that ensures that in case of failure, all the outputs are driven to zero. The 24V DC command outputs to drives for on/open, off/close shall be separate and independent and inverted outputs shall not be employed. For inching type of drives, position transmitter power supply and monitoring of position transmitter signal shall be provided.
- xiv) The termination for open/ close command for the drive actuator shall be performed in the actuators with integral starter specified elsewhere in the specification. However, open/ close and disturbance status as a minimum shall be monitored in OLCS.
- xv) The OLCS shall also include the control of electrical systems such as open/close or on/off etc. of breakers of 11kV/ 6.6 kV/ 3.3 kV/ 415 V switchgears.

#### 6.2.6.3 Analog controls/closed loop control system (CLCS)

- i) The CLCS shall continuously act on valves, dampers or other mechanical devices such as hydraulic couplings etc., which alter the plant operation conditions. The controller capability shall, as a minimum, include (i) P, PI, PD and PID control functions and their variations (ii) cascade control (iii) feed forward control (iv) On-Off control, (v) Ratio and bias control, (vi) Logical operation .
- ii) The loop reaction time (from change of output of the transmitter/temperature element to the corresponding control command output) shall be within 500 milli seconds. For binary control the response time shall be within 100 milli seconds only.
- iii) The control loop shall have enough flexibility and various features to perform feed forwards, balancing of controller, increasing the response to achieve the desired process parameter within prescribed time frame.
- iv) The control system shall be bumplessly transferred to manual on the conditions of control power supply failure, failure of redundant



controllers, field input signal not available, analog input exceeding preset value, etc.

- v) Any switch over from auto to manual, manual to auto and switchover from OWS operation to auto manual station operation and vice versa shall be bumpless and without resulting in any change in the plant regulations and the same shall be reported to the operator.
- vi) Buffered analog output (positioning signal) of 4-20mA DC shall be provided from CLCS to the respective E/P converters. For electrical actuators, pulse type output (bound less control) shall be preferred. CLCS shall also provide all the necessary outputs for indicators & recorders with output loop resistance of 500 ohms for each channel of the output module.
- vii) The system being supplied shall be such that when permissible limits are exceeded, an automatic switchover from an operation governed by maximum efficiency, to an operation governed by safety and availability is affected.
- viii) For safety reasons, switchover logics associated with the modulating control loops, shall be performed within the closed loop control equipment. Modulating control loops shall be provided with standard features to interface overriding commands from OLCS/Protection System like open, protection open etc.
- ix) Time supervision facility shall be provided to monitor the final control element.
- x) It shall be possible to block the controller output on a pre-programmed basis.
- xi) All controllers shall be freely configurable with respect to requisite control algorithms.

#### 6.2.6.4 Wiring scheme for inputs to control system shall be as follows:

- i) Input used for protection shall be dual redundant. Each of the redundant binary & analog inputs shall be wired to separate input modules. These redundant modules shall be placed in different racks, which will have separately fused power supply distribution. Implementation of multiple measurement scheme of these inputs will be performed in the redundant hardware. Loss of one input module shall not affect the signal to other modules. Other channels of these modules can be used by other inputs of the same functional group.
- ii) The single binary and analog signals required for control purposes shall be wired as follows:



- a) The limit & torque switches and the MCC/ Swgr check backs shall be wired to drive control modules wherever provided. For the drives where drive control modules are not provided, these signals shall be connected to input module only.
- b) Other single analog & binary inputs shall be wired to single input modules. The on-off status of HT drives etc., however, be wired to two input modules in parallel.
- iii) Inputs and outputs related to each of the redundant drives / equipment (e.g. each of the 3x50 % drives, each of the storage vessel/sump/tank storing same fluid, each of the streams and its related drives etc.) shall be wired to separate input and output modules.

6.2.6.5 The signal conditioning functions like multiple measurement schemes, square root extraction for flow signals, pressure and temperature compensation, limit value computation can be performed either in the controllers or in signal conditioning and processing hardware outside controllers.

6.2.6.6 The maximum number of inputs/outputs to be connected to each type of module shall be as follows:

i) Analog input module	-	16
ii) Analog output module	-	16
iii) Binary input module	-	32
iv) Binary output module	-	32
v) Analog input & output (combined)	-	16
vi) Binary input and output (combined)	-	32

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

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

6.2.6.7 The following requirements shall be met for analog/binary input/output module:

- a) Input filters to attenuate noise shall be provided.
- b) All analog outputs shall be short circuit proof.

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



### 6.2.6.9 Programming functionalities

Programming of the PLC Processor / controller as well as programming of HMIS shall be user friendly with graphical user interface and shall not require knowledge of any specialized language. For example, the programming of PLC shall use either of the following:-

- Flow-chart or block logic representing the instructions graphically.
- Ladder diagram

The programming of HMIS (like development and modification of data base, mimics, logs / reports, HSR functionalities etc.) shall also be possible through user-friendly menus etc.

All programming functionalities shall be password protected to avoid unauthorised modification.

### 6.2.6.10 Parametric requirements

The control system shall be designed such that under worst case loading conditions the response time shall not be worst than the following:-

- |                              |  |
|------------------------------|--|
| On/off Command               | - The response time for screen update after the execution of the control command from the time the command is issued (for example command to start a motor to the time the screen is updated) shall be two seconds (excluding the drive actuation time). |
| Adjustment Command           | - 0.5 to 1 second.   |
| On screen Updating           | - 1 second.  |
| All Control related displays | - 1 second.  |
| Bar Chart displays           | - 2 to 3 seconds.  |
| Plant Mimic displays         | - 2 to 3 seconds.  |
| Group review displays        | - 2 to 3 seconds.  |
| X-T Plot Displays            | - 1 to 2 seconds.  |
| Plant Summary Displays       | - 1 to 2 seconds.  |

Even under worst case loading condition of HMIS and system Bus, each HMIS processor shall have 50 % spare time when measured over any one minute period and the system bus shall have at least 50 % spare duty cycle.

#### 6.2.6.11 Control cabinets/ panels/ desks

- i) The cabinets shall be IP-32 protection class. The Contractor shall ensure that the packaging density of equipment in these cabinets is not excessive and abnormal temperature rise, above the cabinet temperature during normal operation or air-conditioning failure, is prevented by careful design. This shall be demonstrated to the Purchaser during the factory testing of the system. The Contractor shall ensure that the temperature rise is limited to 10 deg. C above ambient and is well within the safe limits for system components even under the worst condition as specified in Sub-section-basic Design criteria and specification requirements for remote I/O cabinets.

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

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

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



Interior:- Same as above.

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

- vi) Cabinets shall be designed for a grounded installation on the building structure. Any isolation from the building ground which is required by equipment design shall be provided internal to the cabinet.
- vii) The mimic shall be configured on the OWS/ TFTs and it shall be possible to control, monitor and operate the plant from the same.
- viii) Ammeters will be provided on switchgear panel for all motors rated 30kW and above and shall be suitable for 4-20 mA DC signals wired to Analog input cards of PLC.
- ix) OWS (operator Work Station) of PLC shall be mounted on table type control desk to house PC/ keyboards/ mouse etc. The profile and dimension shall be decided during detailed engineering and shall be subject to Owner's approval.
- x) The technical specification covering panel fabrication details, wiring and termination details etc. shall be as described under Instrumentation Cables of this volume.

#### 6.2.7 Annunciation System

- i) Contractor shall provide OWS based annunciation system as integral part of PLC system with audio alarm facility. Field contacts shall be acquired through PLC only. The annunciation sequence logics shall be implemented as a part of PLC controllers.
- ii) The annunciator sequence shall conform to ISA sequence ISA-2A. Alarm boxes shall be provided in each display to alert the operator about an alarm when he is viewing some other picture. The number of alarm boxes and the provision for original input will be on as required basis. However, the minimum number of alarm boxes shall be 25 nos.

#### 6.2.8 Historical Storage and Retrieval System (HSRS)

- i) The HSRS shall collect, store and process system data from MMIPIS data base. The data shall be saved online on hard disk and automatically transferred to erasable long term storage media once in every 24 hours periodically for long term storage. Provision shall be made to notify the operator when hard disk is certain percentage full. The disk capacity shall be sufficient to store at least seven days data.
- ii) The data to be stored in the above system shall include alarm and event list, periodic plant data, selected logs/reports. The data/information to be stored & frequency of storage and retrieval shall be as finalised during detailed engineering. The system shall provide user-friendly operator functions to retrieve the data from historical storage. It shall





be possible to retrieve the selected data on OWS or printer in form of trend/report by specifying date, time & period. Further, suitable index files/directories shall also be provided to facilitate the same. The logs/reports for at least last seven (7) days shall be available on the disk.

- iii) In addition to above, the system shall also have facility to store & retrieve important plant data for a very long duration (plant life) on portable long term storage media). These data will include any data from the database as well as processed/computed data based various calculations/ transformation. The retrieved data from long term storage media should be possible to be presented in form of alarms, logs, reports etc.

#### 6.2.9 Printer

One number A4 size color laser printer and one number A3 sized dot matrix printer shall be provided as a part of the supervisory system. It shall print out all alarm/trip conditions and event changes in plant status along with date and time of occurrence. 5 set of print cartridges shall be provided with each type of printer.

#### 6.2.10 Furniture

Bidder shall provide following industrial grade furniture items as a minimum from reputed manufacturers/suppliers meeting International Standards. The furniture shall be modular and latest with ease of operational features. The furniture shall be modern, aesthetically designed, modular, flexible, space saving and future safe. Each module shall have transparent cover and adjustable partition. It shall have locking provision for security. The components shall be suitable for integration/fabrication without any welding technology.

- i) **Work Station furniture**

Modular work station furniture, suitable for mounting servers & historians, programmer stations, PC based systems, printers (A4 laser) etc. is to be provided.

- ii) **Server Rack**

Server rack, if applicable, shall be provided to mount programmer stations, PC based systems (of rack type and tower type), Mini UPS (if applicable) etc. Suitable arrangement for ventilation and cooling shall be built in.

- iii) **OWS/PC rack**

OWS/PC rack shall be provided to mount CPUs of work stations/PCs of OWS etc. in Control Room.



- iv) **Chairs**  
Industry standard revolving chairs with wheels and with provision for adjustment of height (hydraulically/gas lift) shall be provided for the operators, unit-in-charge, shift in charge & other personnel in control room area & other rooms etc. These shall be designed for sitting for long duration such that these are comfortable for the back. Chair pedestal shall be made of 5mm thick MS plate covered with poly-propylene cladding. Arm-rests in one piece shall be of poly-urethane and twin wheel castor of glass filled nylon. The exact details shall be finalised & approved by Purchaser during detailed engineering.
- v) **Tables**  
Industry standard computer tables shall be provided & shall be as approved by Owner during detailed Engineering.
- vi) **Almirahs**  
Minimum 4 nos. vertical Steel Almirahs shall be provided for keeping documents etc. Final quantity shall be decided by owner during detailed engineering.
- Thickness of steel almirah sheet shall be 18 gauges with neat finish. Tentative size of Almirah shall be 78”(H) x 36”(W) x 19”(D). 4-5 mm thick Glass doors for each rack shall be provided such that the documents are visible from outside. Minimum 5 no. horizontal partition/rack shall be provided in the almirah. 3 point locking system shall be provided. Size of the rack shall be sufficient to easily fit technical manuals. The exact details shall be approved by owner during detailed engg. One uniform colour shall be finalized during detailed engineering by owner.
- vii) **Keypad**  
Keypads shall be provided for the storing of keys of relevant areas in the respective control rooms
- viii) **Lockers**  
Suitable lockers shall be provided in the room adjacent to the control room for storing of personal articles of control room personnel & also for documents.

#### 6.2.11 Software Documentation and Software Listings

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



iii) Software Licenses

The Contractor shall provide software license for all software being used in Contractor's 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 Purchaser to seek a new license/renew license due to upgradation/change of hardware/machine in PLC at site. All licenses shall be valid for the continuous service life of the plant.

iv) Software Upgrades

As a customer support, the Contractor shall periodically inform the designated officer of the Purchaser about the software upgrades/new releases that would be taking place after the system is commissioned so that if required, same can be procured & implemented at site. The updated/upgraded version of any software shall be supplied & installed by bidder free of cost **for a period of three (3) years after warranty period.**

### 6.3 MEASURING INSTRUMENTS (PRIMARY AND SECONDARY)

#### 6.3.1 General

- i) Measuring instruments/equipment and subsystems offered by the bidder shall be from reputed experienced manufacturers of specified type and range of equipment, whose guaranteed and trouble free operation has been proven. Further, all instruments shall be of proven reliability, accuracy, repeatability requiring a minimum of maintenance. They shall comply with the acceptable international standards and shall be subject to purchaser's approval. All instrumentation equipment and accessories under this specification shall be furnished as per technical specifications, ranges, make/ numbers as approved by the purchaser during detailed engineering.
- ii) Every panel mounted instrument requiring power supply shall be provided with a pair of easily replaceable glass cartridge fuses of suitable rating. Every instrument shall be provided with a grounding terminal and shall be suitably connected to the panel grounding bus.
- iii) All local gauges as well as transmitters, sensors, and switches for parameters like pressure, temperature, level, flow etc. and vibration transmitters as required for the safe and efficient operation and maintenance as well as for operator and management information (including all computation) of equipment under the scope of specification shall be provided. In general, transmitters shall be provided for all the cases, instead of switches. Use of processor actuated switches shall be avoided and shall be acceptable only where the same is as per manufacturer's standard & proven factors.



- iv) Vibration transmitters with 4-20 mA signals hard wired to FGD PLC shall be provided for all critical HT drives.
- v) The necessary root valves, impulse piping, drain cocks, gauge-zeroing cocks, valve manifolds and all the other accessories required for mounting/erection of these local instruments shall be furnished, even if not specifically asked for, on as required basis. The contacts of equipment mounted instruments, sensors, switches etc. for external connection including spare contacts shall be wired out in flexible/rigid conduits, to suitably located common junction boxes. The proposal shall include the necessary cables, flexible conduits, junction boxes and accessories for the above purpose.
- vi) All field instruments shall be weatherproof, drip tight, dust tight and splash proof suitable for use under outdoor ambient conditions prevalent in the subject plant. All field-mounted instruments shall be mounted in suitable locations where maximum accessibility for maintenance is achieved. The enclosures of all electronic instruments shall conform to IP-65 unless otherwise specified.
- vii) For all instruments envisaged for corrosive liquid applications, they shall be provided with wetted parts made of Monel / Hastelloy C or any other material (if provenness experience of the proposed material for such applications is established by Contractor).
- viii) All instruments shall be provided with durable epoxy coating for housings and all exposed surfaces of the instruments.
- ix) All field instruments shall be weatherproof, drip tight, dust tight and splash proof suitable for use under outdoor ambient conditions prevalent in the subject plant and shall be mounted in suitable locations where maximum accessibility for maintenance is achieved. The enclosures of all electronic instruments shall conform to IP-65 unless otherwise specified (Explosion proof for NEC article 500, class 1/2, Division 1 area & Flame proof area) and an anti corrosive paint shall be applied to the field mounted enclosures/ instruments.

#### 6.3.2 **Specification for Electronic Transmitter for Pressure, Differential Pressure (DP), Flow and Level**

<b>Sl. No.</b>	<b>Features Essential/ minimum requirements for electronic transmitter</b>
1.	Type of transmitter Microprocessor based 2 wire type, HART protocol compatible.
2.	Sensor type Capacitance/Piezo-electric



3.	Accuracy	Minimum $\pm 0.1\%$ of span
4.	Output signal range	4-20 mA DC (analog) along with superimposed digital signal (based on HART protocol)
5.	Turn down ratio	10:1
6.	Stability	$\pm 0.15\%$ of calibrated span for ten years
7.	Zero and span drift	$\pm 0.015\%$ per deg. C at max span and $0.11\%$ per deg. C at min. span.
8.	Load impedance	500 ohm (min.)
9.	Housing	Weather proof as per IP- 67 with durable corrosion resistant coating
10.	Over Pressure	150% of max. operating pressure
11.	Connection (Electrical)	Plug and socket type
12.	Process connection	1/2 inch NPT (F)
13.	Span & zero adjustability	Continuous, tamper proof, remote as well as manual from instrument with zero suppression and elevation facility.
14.	Accessories	(a) Diaphragm seal, pulsation dampeners, siphon etc. as required by service and operating condition  (b) 2 valve manifold for absolute & gauge pressure transmitters, 3 valve manifold and 5 valve manifold for DP/ level/ flow transmitters.  (c) For hazardous area, explosion proof enclosure as described in NEC article 500.
15.	Diagnostics	Self indicating feature
16.	Power supply	24V DC $\pm 10\%$



17. Adjustment/ calibration/ Through Universal HART hand held calibrators.
18. Response time Suitable to meet closed loop control reaction time specified elsewhere

**Notes**

- (i) In case it becomes necessary to use a DP transmitter for pressure measurement then a 3 valve manifold should be used in place of 2 valve manifold.
- (ii) Where the process fluids are corrosive, viscous, solid bearing or slurry type, diaphragm seals shall be provided. Parts below the diaphragm shall be removable for cleaning. The entire volume above the diaphragm shall be completely filled with an inert liquid suitable for the application.

**6.3.3 Specification for Pressure Gauge, Differential Pressure Gauge, Temperature Gauge and Level Gauge**

Sl. No.	Features	Essential minimum requirements		
		Pr. Gauge/DP Gauge/Draught gauges	Temperature gauge	Level Gauge
1	Sensing Element and Material	Bourdon for high pressure, Diaphragm/ Bellow for Low pr. of SS 316	Bimetallic type for below 450°C and inert gas actuated for above 450°C of SS bulb and capillary	Tempered toughened Borosilicate gauge glass steel armoured reflex or transparent type.
2	Body Material	Die Cast Aluminum with stoved enamel black finish /SS316	Die Cast Aluminum with stoved enamel black finish /SS316	Forged carbon steel/SS 304
3	Dial Size	150 mm with toughened shatter proof glass	150 mm with toughened shatter proof glass	Tubular covering entire range
4	End Connection	½ inch NPT (M)	½" NPT (M)	Process connection as per ASME PTC and drain/vent 15 NB
5	Accuracy	+/- 1% span	+/- 1% span	+/- 2%
6	Scale	Linear, 270° arc graduated in metric units	Linear, 270° arc graduated in °C	Linear vertical



7	Range Selection	Cover 125% of max. of scale	Cover 125% of max. of scale	Cover 125% of max. of scale
8	Over range test	Test pressure for the assembly shall be 1.5 to the maximum design pressure at 38°C.		
9	Housing	Weather and dust proof as per IP-65	Weather and dust proof as per IP-65	CS/304 SS leak proof.
10	Zero/span Adjustment	Provided	Provided	-
11	Identification	Engraved with service legend or laminated phenolic name plate		
12	Accessories	Blow out Disc, siphon, snubber, pulsation dampener, chemical seal (if required by process) gauge isolation valve	SS316 Thermowell	Gasket for all KEL-F shield for transparent type vent and drain valves of steel/SS as per CS/ alloy process requirement.
13	Material of Bourdon/ movement	SS 316	SS 316	

Notes:

- (i) Length of gauge glass shall not be more than 1400 mm. If the vessel is higher, multiple gauge glasses with 50 mm overlapping shall be provided.
- (ii) Where the process fluids are corrosive, viscous, solid bearing or slurry type, diaphragm seals shall be provided. Parts below the diaphragm shall be removable for cleaning. The entire volume above the diaphragm shall be completely filled with an inert liquid suitable for the application.
- (iii) Float & Board type level gauges may also be acceptable as per process requirement subject to approval of purchaser.

**6.3.4 Specification for Guided Wave Radar type Level Transmitter**

Guided wave radar type level transmitters shall be provided for level measurements of the vessel under vacuum or low pressure applications.	
Type	Guided wave Radar
Principle	TDR (Time domain reflectometry)
Probe Type & Material	Coaxial, SS316/316L. If required, probe shall be suitable for overflow prevention.
Connection type and material	Flanged and SS316/316L.



Signal o/p	4-20mA with HART signal suitable for overflow prevention.
Display	Integral
Power supply	24 VDC
Accuracy	5mm
Electromagnetic compatibility	Shall meet EN 61326-1 (1997) and AmdtA1, class A equipment/EN 50081-2 & EN 5008 1-2 & EN 50082-2
Housing material	Die cast Aluminum/SS316.
Vent & Drain Plug material	SS 316
Local Display	LCD digital type, configured in engg. Units.
Accessories	Integral cable between sensor and transmitter unit with connectors on both side, gasket and cable gland, digital panel meter, name plate and metal tag. All material of accessories will be SS 316.
Mounting	External cage mounting
<p>The transmitters shall be provided with IP-65 protection class with durable corrosion resistant coating. The transmitters shall be able to provide digital signals super imposed on 4-20 mA signal as per HART protocol.</p>	

### 6.3.5 Ultrasonic Type level Transmitter

Sl.No.	Features	Essential/Minimum requirement
1.	Type of Transmitter	Non contact Microprocessor based 2 wire type, HART protocol compatible Ultrasonic transmitter. Also refer note-3.
2.	Output signal	4-20mA DC (Analog) along with superimposed digital signal (based on HART protocol)
3.	Sensor Accuracy	+/- 0.5% of calibrated span.
4.	Sensor Repeatability	3mm or better
5.	Power supply	24 V DC +/-10%
6.	Temperature compensation	To be provided within transducer
7.	Housing	Weather proof as per IP-65 with durable
8.	Adjustment/Calibration/maintenance	From hand held calibrators/ centralized OWS HART based system (as
9.	Zero and Span adjustment	Continuous, tamper proof, remote as well as manual adjustability from instrument. It shall be possible to calibrate the instrument without any level in the tank/sump etc.





10.	Sensor Material	Corrosion resistant material to suit individual application requirement.
11.	False signal tolerance	Transmitter shall be capable of ignoring false echoes from internal tank/sumps obstructions such as pipes, agitator blades. Also transmitter shall have adjustable damping circuitry
12.	Range	Range of transmitter shall be capable of covering the complete level span of tank taking care of blocking distance, frequency attenuation due to surface, obstructions, vapors etc.
13.	Display	LCD display with integral keypad to be provided.
14.	Diagnostics	Loss of echo alarm etc.
15.	Load Impedance	500 ohms minimum
16.	Electrical Connection	Plug and socket
17.	Accessories	<ul style="list-style-type: none"> <li>• All weather canopy for protection from direct sunlight and direct rain.</li> <li>• All mounting hardware and accessories required for erection and commissioning mounting fittings materials shall be SS 316.</li> <li>• For hazardous area, explosion proof enclosure as described in NEC article 500.</li> </ul>
Note:-	1) Bidder can also provide Radar type transmitter in place of ultrasonic transmitters subject to approval by Owner during detailed Engineering.	
	2) The frequency used for ultrasonic/ sonic measurements shall be suitable for envisaged applications and this shall be supported by the standard product catalogue of the instrument manufacture.	
	3) Four wire type transmitters can also be provided subject to Owner's approval during detailed engineering stage. However, in such cases isolated 4-20mA DC (analog) output shall be provided. Power supply required for such transmitters shall be 24V DC.	
	4) For applications where transmitter location is not accessible, separate sensor unit & electronics unit with LCD display at an accessible location shall be provided which will be decided during detailed engineering by owner.	

### 6.3.6 HART Hand Held Calibrator

Hand held calibrator shall be provided for adjustment/calibration/maintenance of the HART compatible transmitters. The hand held calibrator shall be suitable for all types of transmitters supplied in the package. If one type of hand held



type calibrator is not suitable for communicating with all types of transmitters then separate hand held calibrator will be provided.

HART hand held calibrator shall be provided with following minimum accessories per set:-

- i) Soft carrying case with adjustable shoulder straps & lead compartments.
- ii) HART lead set.
- iii) Rechargeable batteries.
- iv) Battery charger.
- v) Power adaptor.
- vi) Universal plug kit for power adaptor.
- vii) Load resistor.
- viii) Interfacing cables of each type as per requirements.
- ix) Protective boot.
- x) Standard banana jack.
- xi) Operation manual & software CD.

### 6.3.7 Temperature Elements and Accessories

#### i) Thermocouples

S. No.	Features	Essential/Minimum Requirements
1.	Type of Thermocouple	16 AWG wire of Chromel-Alumel (Type K) or 24 AWG wire Pt-Rhodium Pt (Type S/R) depending on operating temperature Range (ungrounded type).
2.	No. of element	Duplex
3.	Housing/Head	IP-65/Die cast Aluminum.
4.	Sheathing of Thermocouple	Swaged type magnesium oxide insulation
5.	Calibration and accuracy	As per IEC-751/ANSI-C-96.1 (special class) for T/C
6.	Characteristic	Linear with respect to temp, within $\pm 1/2$ percent of top range value
7.	Response Time	6-10 Sec bare & 30 Sec. With protective sheath/thermowell
8.	Accessories	Thermo well (as specified below) and shall be spring loaded for positive contacts with the well.
9.	Standard	ANSI C 96.1 for Thermocouple and ASME PTC-19.3 (latest edition) for Thermo-well.
10.	Enclosure Class	IP-65 or better.



ii) **Resistance temperature detector (RTD)**

S.No.	Features	Essential/Minimum Requirements
1.	Type of RTD	Three/ Four wire, Pt-100 (100 Ohms resistance at zero degree Centigrade).
2.	No. of element	Duplex
3.	Housing/Head	IP-65/Diecast Aluminum.
4.	Sheathing of RTD	Metal sheathed, ceramic packed
5.	Calibration and accuracy	As per DIN-43760/IEC 60751 Class-A for RTD
6.	Characteristic	Linear with respect to temp, within $\pm 1/2$ percent of top range value.
7.	Response Time	6-10 Sec bare & 30 Sec. With protective sheath/thermowell
8.	Accessories	Thermowell (as specified below) and shall be spring loaded for positive contacts with the well
9.	Standard	DIN-43760/IEC 60751 for RTD and ASME PTC-19.3 (latest edition) for Thermowell.
10.	Enclosure Class	IP-65 or better.

iii) **Thermowell**

- (a) Shall be one piece solid bored type of 316 SS material or better (as per process requirement), of step-less tapered design. (As per ASME PTC 19.3 (Latest).
- (b) For Air & Flue gas, 316 SS protecting tube with welded cap shall be provided.

6.3.8 **Temperature transmitter**

Following types of 2-wire temperature transmitter (directly powered from 4-20mA input cards of PLC) shall be provided as per requirement of application. The temperature transmitter shall be fully compatible with thermocouples and RTDs being provided by the contractor. Temperature compensation of the thermocouples shall be performed in the temperature transmitter itself.

- a. Single Input Head mounted Temperature Transmitter



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

b. Single Input DIN-rail mounted Temperature Transmitter

These shall be especially designed for DIN-rail mounting in JB's. The specifications of the JB's shall be same as indicated in Subsection-IV:17 (INST CABLE) with additional DIN-rails and IP 65 Protection class. This temperature transmitter shall be the ones which are specially designed for DIN-rail mounting with IP 20 protection class. These shall have terminals for input/output provided on front side when mounted on DIN-rail. Head mounted temperature transmitter with clamps to make it suitable for DIN-rail mounting shall not be acceptable under this category.

c. Dual-input Temperature Transmitter with Indicator:

The dual-input TTs shall be suitable for mounting in enclosures/racks and shall be provided with clamps. Indicator shall be provided with these transmitters. These transmitters shall have bump less change over facility to second sensor in case first sensor fails. This change-over is to be alarmed. Protection class shall be IP65 minimum.

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

Output : 2-wire (power supply from input card of Control System) with 4-20mA output with superimposed HART protocol signal.

Input : Same transmitter shall be capable to handle Pt-100 RTD, Thermocouples -K&R types (input type to be selectable at site through HART terminal)

Isolation : min. 500 V AC

EMC compatibility : as per EN

61326

Operating ambient: 0 to 85 deg C (without  
indicator) temperature 0 to 70 deg C (with indicator)



Power supply System compatible with input module of Control

Accessories Mounting arrangements including clamps etc.

Composite accuracy types: (a) For head mounted and DIN-rail mounted

RTD =<0.4% of 0-250 deg C span  
T/C-K type =<0.4% of 0-600 deg C span  
T/C-R type =<0.4% of 0-1000 deg C span

CJC accuracy (for thermocouples) shall be  $\leq 1^{\circ}\text{C}$

(b) For dual-input type:

RTD =<0.25% of 0-250 deg C span  
T/C-K type =<0.2% of 0-600 deg C span  
CJC accuracy (for thermocouples) shall be  $\leq 1^{\circ}\text{C}$

### 6.3.9 Specification for Flow Elements & Flow Meters

#### i) Orifice plate

Sr No.	Features	Essential/Minimum Requirements
1	Type	Concentric as per ASME PTC-19.5 (Part-II), ISO 5167
2	Material	316 SS
3	Thickness	3 mm for main pipe diameter up to 300 mm and 6 mm for main pipe dia above 300 mm.
4	Material of branch pipe	Same as main pipe
5	Root valve type	Globe
6	Root valve material	316 SS
7	Root valve size	1 / 2 inch or 1 inch (as applicable)
8	Impulse pipe of same material up to root valve	Required
9	Tapping	Flanged weld neck or D & D/2 with 3 pairs of tapping (as applicable).



10	Beta Ratio	0.34 to 0.7
11	Beta Ratio calculation to be submitted	Yes
12	Assembly drg. and flow Vs DP Curves	Yes
13	Accessories	Root valves, flanges, Vent/drain hole (as required)
<p>Bidder shall submit certified flow calculation and differential pressure vs. flow curves for each element for Owner's approval. Sizing calculation, precise flow calculation for all the flow elements, fabrication and assembly drawings and installation drawings shall be submitted for Owner's approval. One Flow element of each type shall be calibrated in the test laboratory for validation of commutated flow calculations.</p>		

ii) **Flow nozzle**

Sl. No.	Features	Essential/Minimum Requirements
1.	Type	Long radius, welded type as per ASME PTC- 19.5 (Part-III) or BS-1042 or ISO 5167
2	Material	316 SS
3	Thickness	Suitable for intended application.
4	Material of branch pipe	Same as main pipe
5	Root valve type	Globe
6	Root valve material	316 SS
7	Root valve size	1 inch
8	Impulse pipe of same material up to root valve	Required
9	Tappings	Flanged weld neck or D & D/2 with 3 pairs of tapping (as applicable).
10	Beta Ratio	Around 0.7
11	Beta Ratio calculation to be submitted	Yes
12	Assembly drg. and flow Vs DP Curves	Yes
13	Accessories	Root valves, vent and drain hole.
<p>Bidder shall submit certified flow calculation and differential pressure vs. flow curves for each element for Owner's approval. Sizing calculation, precise flow calculation for all the flow elements, fabrication and assembly drawings and installation drawings shall be submitted for Owner's approval. One Flow element of each type shall be calibrated in the test laboratory for validation of commutated flow calculations</p>		



iii) **Rotameters**

Sl. No.	Features	Essential/Minimum Requirements
1	Type	Variable area metal tube
2	Fluid media	Water/oil
3	Tube body	SS316
4	Material of float	316 SS
5	Indicator	Linear scale
6	Accessories	Flange, orifice in case of bypass Rota meter (for line size above 100 mm)
7	Housing protection class	IP-65
8	Accuracy	+ 2% of measured value

iv) **Sight Flow Glass Indicators**

Type/Construction	:	Flapper type.
Materials		
Body	:	Carbon steel/SS316 as per process requirement
Glass	:	Toughened Borosilicate
Gaskets	:	Neoprene
Bolts & nuts	:	SS
Flappers / Rotating Wheel	:	316 SS
Flappers / Rotating Wheel holder	:	304 SS
Process Connection	:	SW
Accessories	:	Scale, Bolts, Nuts, Cover plates and Gaskets as required
Tests	:	Tested at two hundred (200) percent of the maximum process Pressure

v) **Process Actuated Switches**

Sr No	Features	Essential/Minimum Requirements		
		Pressure/Draft Switches/ DP Switches	Temperature switches	Level switches
.				



Standard Technical Specification for Retrofit of Wet Limestone Based Flue Gas Desulphurisation  
(FGD) System in a Typical 2x500 MW Thermal Power Plant  
Section- 6 (Control & Instrumentation Works)

1	Sensing Element	Piston actuated for high pressure and diaphragm or bellows for low pr./ vacuum	Vapor pressure sensing, liquid filled bellow type with SS bulb and capillary (10 m minimum)	Float type for applications as decided by owner during detailed engineering. Capacitance/Conductivity/Ultrasonic type for acid and alkali application. RF/ Ultrasonic type for other application.
2	Material of sensing element & movement.	316 SS	Bulb 316 SS/ capillary 304 SS	316 SS
3	End connection	½ inch NPT (F)	½ inch NPT (F)	Manufacturer standard
4	Over range proof pressure	150% of max. design pr	-	150% of max. design pressure
5	Repeatability	+ 0.5% of full range		
6	No. of contacts	2 Nos. +2NC. SPDT/ DPDT snap action dry contact. Auto reset with internal adjustable snap action micro switch.		
7	Rating of contacts	60 V DC, 6 VA as per PLC requirement		
8	Set point	Provided over full range. Differential shall be adjustable.		
9	Dead band adjustment	Adjustment up to 10% at set points.		
10	Enclosure	Die cast Aluminum with stoved enamel black finish/SS316, Weather and dust proof as per IP-65. Epoxy/ PU painting shall be provided for corrosive atmosphere.		
11	Accessories	Siphon, snubber, chemical, pulsation dampers as required by process.	Thermo well of 316 SS and packing glands	All mounting accessories

Notes:-

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





- 2) Pressure / Diff Pressure switches for very low pressure / DP measurements can have sensor material other than SS316 e.g. silicon etc., if the offered material is suitable for that application and the offered product is standard product of the manufacturer for very low pressure applications.
- 3) Repeatability can be up to +/-1% of full range in case of switches with diaphragm seals or very low pressure/DP range.

vi) **Conductivity Type Level Switch**

Type	:	Conductivity discrimination.
Mounting	:	Flanged – on standpipe.
Probe MOC	:	Stainless steel with high purity ceramic.
Probe rating	:	> Maximum design pressure of vessel.
Input	:	Four independent channel with selectable Switching threshold for water conductivity.
Relay Output	:	Four isolated output relays for Hi, Lo, Hi-Hi, Lo-Lo.
Contact type & rating	:	2SPDT or 1 DPDT @ 5A 30V DC.
Power supply	:	Dual 230V AC, 50 Hz, 1Ph from UPS.
Enclosure	:	Corrosion resistant & wall mounting type. IP-65 or better (Explosion proof For NEC Class-1/2, Division 1 area)/ flame proof (IEC-79.1, Part I). As applicable).
Accessories	:	<ol style="list-style-type: none"><li>i. PTFE cable from probe to electronics unit. Electronic unit shall be separate. Head mounted electronic unit is not preferred.</li><li>ii. Mounting accessories</li><li>iii. standpipe</li><li>iv. Washer &amp; gasket</li></ol>
Test pressure	:	Two times rated pressure

vii) **Capacitance Type Level Switch**

Type	:	Capacitance type
Probe	:	a) Rod or suspended electrode



- b) Rope type probes may be used only where required probe length is greater than 3 meters.

Probe Mounting	:	Stainless steel 1-1/2 ANSI RF Flange / 3/4" NPT (M)
Material of construction	:	316 SS
Insulation	:	PTFE Part/Full as per service.
Enclosure	:	Powder/Epoxy coated Die cast Aluminum. with neoprene gasket conforming to IP-65. (Explosion proof for NEC Class-1/2, Division 1 area)/ flame proof (IEC-79.1, Part I). As applicable).
Ambient temperature	:	0-60 °C.
Mounting	:	On Top
Supply voltage	:	230V AC, 50Hz from UPS / 24V DC
Relay output	:	2SPDT
Contact rating	:	5A min. at 240V AC on resistive load
Response time	:	100 m sec or better
Cable connection	:	Plug in type
Accessories	:	Counter flange, Cable gland, prefab cable and stainless steel name plate engraved with alpha-numeric.

### 6.3.10 Analysers

The following type of analyzers as required shall be provided:

- i) Flue gas sulphur di- oxide analyzer.
- ii) pH analyzer.

#### 6.3.10.1 Sulphur Dioxide (SO<sub>2</sub>) Analyser

Technical specification for SO<sub>2</sub> analysers shall be as specified in Cl. No. 6.8.



### 6.3.10.2 pH Analyser

S.No.	Features	Essential/Minimum Requirements
1	Output signals	
	Analog	4-20 mA DC galvanically isolated. If analyser provides superimposed HART signal on 4-20 mA DC output, It shall also be connected to PC based station.
	Binary	2 NO + 2 NC for high alarm
2	Zero & span Adjustment	To be provided with range selection facility.
3	Ambient temp.	50°C
4	Indication	Digital Alphanumeric Display. Display of reading in engineering units shall be provided.
5	Enclosure Type/Material	Weather & Dust proof (IP 65) Die cast Aluminium/SS.
6	Type of Electronics	Microprocessor based with self diagnostic.
7	Digital Signal transmission	HART/RS 485 Port Modbus Protocol/Ethernet TCP/IP protocol.
8	Calibration	Auto & Manual (from Remote)
10.	Others	i) All interconnection tubing and cabling between probe and analyser/ analyser panel and cabling from analyser/ analyser panel are to be provided by the Bidder. ii) All the calibration gases required for one year continuous operation shall be provided. The calibration gas container material shall not contaminate the calibration gas.
12	Compliance to standards	USEPA, TUV, MCERTS or equivalent standards.
13	Type of Technology	In situ type.
14	Type of pH	: Cell - flow through
15	Accuracy	: < $\pm$ 1% of reading
16	Range	: 0 - 14 pH freely programmable
17	No. of steams	: Single
18	Temp. compensation	: Automatic

### 6.3.11 Solenoid Valves

Solenoid valves shall fulfill the following requirements:

1. Type 2/3/4 way with body material of SS 316/Forged Brass and epoxy



painting (depending on the application subject to Owner's approval during detailed Engg.). Material of Wetted parts shall be SS316.

2. Power supply 230VAC UPS.
3. Plug and socket electrical connection.
4. Insulation: Class 'H'.

#### 6.3.12 Electrical Actuators

- i) The actuators shall have integral starters alongwith overload relays with built in SPP (single phasing preventer). A 415, 3 phase 3 wire power supply shall be given to the actuator from contractor's switch board through a switch fuse unit. Control voltage of the motor starter shall be 110 V AC / 24 V DC, derived suitably from 415V power supply. In case supplier's standard control voltage for open/close contactors is 110V AC, the same is acceptable if suitable up to - isolation circuit is provided with coupling relays for 24 V DC command inputs.
- ii) Open/close command termination logic with position and torque limit switches, positioner circuit shall be suitably built in the PCB inside the actuator.
  - (a) For binary drive, open/close command and status thereof and disturbance monitoring signal (common contact for overload, thermostat, control supply failure, L/R selector switch at local, other protections operated) shall be provided.

Interface with the control system shall be through hardwired signal only. Interposing relays provided (with coil burden 2.5 VA) in the actuator shall be energized to initiate opening and closing, by 24V DC signal from the external control system.
  - (b) For modulating drive, the command to actuator shall be in form of 4-20mA signal. The necessary positioning circuit and motor protection shall be provided
  - (c) Open/close command termination logic shall be suitably built inside actuator.
- iii) The actuators shall be rated for supply voltage & frequency: 415V +/- 10%, 3- phase, 3 wire 50Hz +/-5%. Sizing for open/close at rated speed against designed differential pressure at 90% of rated voltage. For isolating service, three successive open-close operations or 15 mins, whichever is higher. For regulating service, 150 starts per hour or required cycles, whichever is higher.
- iv) Four nos. (2 each in open and close position) position limit switches and two nos. (one in open and other in close direction) torque switches each



having two nos. NO and two nos. NC contacts shall be provided. A single shaft shall actuate all contacts of limit switches at each position.

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

### **6.3.13 Belt Protection Equipment**

#### **6.3.13.1 Pull chord Switch**

Pull chord type (manually reset type) emergency stop switches shall be located on both sides of belt conveyors along the walkways for the entire length of conveyors for emergency stopping of conveyor. The enclosure shall be of cast aluminum with degree of protection IP-65. Local pull chord actuation shall be provided by means of mechanical flap. Each switch shall have two NO and two NC contacts, which shall be wired out to the terminal block. The terminal block shall have facilities of cable looping. Adequate length of rope and all accessories shall be furnished.

#### **6.3.13.2 Belt Sway Switches**

Belt sway switches of self resetting type shall be furnished at periodic intervals to limit belt sway to permissible extent. The enclosure shall be of cast aluminum having degree of protection of IP-65. Each switch shall have two NO and two NC contacts one for alarm and one for trip, which shall be wired up to terminal block. The terminal block shall have facilities for cable looping. The roller length of the switch shall be at least 150 mm. Belt sway switches shall also be provided at HGTU & VGTU to detect excessive belt away.

#### **6.3.13.3 Zero Speed Switch**

Zero speed switch shall be non-contact (proximity) type electronic switch. Mounting arrangement/ location shall be such that operation, effective sensing distance, sensitivity etc. shall not be effected by accumulation of dust on rotating part or surface of probe. Adequate mechanical protection by means of non-metallic shields shall be

provided on top of the switch to prevent any damage due to falling Limestone/ metallic pieces etc. Each switch shall have two NO and two NC contacts wired out to the terminal blocks. The monitoring unit shall have cast aluminum body having IP-65 degree of protection.

#### 6.3.13.4 Chute Blockage Switches

One no. chute blockage switch of proven type shall be provided at a suitable height on each leg of the conveyors discharge chute, vibrating screening feeders bypass chutes, crusher feeding chutes, tripper discharge and feeding chutes nearest to the skirt boards. Chute blockage switch shall trip the feeding conveyor in case of Chute blockage and protect the feeding conveyor equipment. The switch and its operating arrangement shall be suitable for working in dusty areas. The minimum degree of protection of switch shall be IP-65. Local indication of chute blockage switch actuation shall also be provided. Location of chute block switch shall be such that washing does not affect it.

Sensing arrangement shall be provided in the PLC based control system for detecting the presence of material on the belt which shall in turn be used for operating solenoid valves of dust suppression/extraction system elaborated elsewhere. The arrangement shall detect three events simultaneously: (i) belt loaded, (ii) belt running at more than preset speed and (iii) preset initial start delay.

6.3.13.5 One number Trip indicator panel per conveyor, which shall display the exact number of safety switches (pull cord or belt sway switches) operated in a loop of conveyor considering 10% spare switches shall also be provided. It shall also monitor the condition of field cable connecting the switches in series & generate signal, if field cable is found broken or short. LCD display shall be provided with each trip indicator for details like fault location, fault indication, etc. Each event/trip shall be recorded in the trip indicator and PLC.

### 6.4 CONTROL VALVES, ACTUATORS AND ACCESSORIES

#### 6.4.1 Control Valves

##### i) General Requirements

- a) The control valves and accessories equipment furnished by the Bidder shall be designed, constructed and tested in accordance with the latest applicable requirements of code for pressure piping ANSI B 31.1, the ASME Boiler & pressure vessel code, Indian Boiler Regulation (IBR), ISA and other standards specified elsewhere as



well as in accordance with all applicable requirements of the Federal Occupational Safety and Health Standards, USA or acceptable equal standards.

- b) All the control valves and accessories offered by the Bidder, shall be from reputed, experienced manufacturers of specified type and range of valves.

ii) **Control Valve Sizing and Construction**

- a) The design of all valve bodies shall meet the specification requirements and shall conform to the requirements of ANSI (USA) for dimensions, material thickness and material specification for their respective pressure classes.
- b) The valve sizing shall be suitable for obtaining rated flow conditions with valve opening at 70%- 80% of total valve stem travel and minimum flow conditions with valve stem travel not less than 10% of total valve stem travel. All the valves shall be capable of handling at least 120% of the required rated flow. Further, the valve stem travel range from minimum flow condition to rated flow condition shall not be less than 50% of the total valve stem travel. The sizing shall be in accordance with the latest edition of ISA on control valves. While deciding the size of valves, Bidder shall ensure that valves port outlet velocity does not exceed 8 m/sec for liquid services, 150 m/sec. for steam services and 50% of sonic velocity for flashing services. Bidder shall furnish the sizing calculations clearly indicating the outlet velocity achieved with the valve size selected by him as well as noise calculations, which will be subject to Purchaser's approval during detailed engineering.
- c) Control valves of steam and water applications shall be designed to prevent cavitation, wire drawing, flashing on the downstream side of valve and downstream piping. Thus for cavitation/flashing service, only valve with anti cavitation trim shall be provided.
- d) All control valves shall have leakage rate as per leakage Class-IV as minimum.
- e) The control valve induced noise shall be limited to 85 dBA at 1 meter from the valve surface under actual operating conditions. The noise abatement shall be achieved by valve body and trim design and not by use of silencers.

iv) **Valve Construction**

- a) All valves shall be of globe body design & straightaway pattern with single or double port unless otherwise specified or as recommended by the manufacturer as per process requirement. Rotary valve may



alternatively be offered when pressure and pressure drops permit.

- b) Valves with high lift cage guided plugs & quick change trims shall be supplied in case of globe type valves.
  - c) Cast iron valves are not acceptable.
  - d) Bonnet joints for all control valves shall be of the flanged and bolted type or other construction acceptable to the Purchaser. Bonnet joints of the internal threaded or union type will not be acceptable.
  - e) Plug shall be one-piece construction either cast, forged or machined from solid bar stock. Plug shall be screwed and pinned to valve stems or shall be integral with the valve stems.
  - f) All valves connected to vacuum on downstream side shall be provided with packing suitable for vacuum applications (e.g. double vee type chevron packing).
  - g) Valve characteristic shall match with the process characteristics.
  - h) Flanged valves shall be rated at no less than ANSI press class of 300 lbs.
- v) **Valve Materials**

The control valve body & trim material shall be generally as given below:

S. No.	Service	Body material	Trim material
1	Non-corrosive, non-flashing and non-cavitation service.	Compatible with piping material	316 SS with stellite faced guide posts and bushings
2	Severe flashing/cavitation services.	Alloy steel as per ASTM-A 217 Gr.WC9	400 series SS or equivalent to suit the specific requirement

**Note** : Valve body rating shall meet the process pressure and temperature requirement as per ANSI B16.34.

However, Bidder may offer valves with body and trim materials better than specified materials.

vi) **End Preparation**

Valve body ends shall be either butt welded/socket welded, flanged (Rubber lined for condensate service) or screwed as finalized during detailed engineering and as per Purchaser's approval. The welded





ends wherever required shall be butt welded type as per ANSI B 16.25 for control valves of sizes 65 mm and above. For valves size 50 mm and below welded ends shall be socket welded as per ANSI B 16.11 Flanged ends wherever required shall be of ANSI pressure-temperature class equal to or greater than that of control valve body.

#### 6.4.2 Valve Actuators

- i) All Control Valves shall be furnished with Pneumatic Actuators. The Bidder shall be responsible for proper selection and sizing of valve actuators in accordance with the pressure drop and maximum shut off pressure and leakage class requirements. The valve actuators shall be capable of operating at 60 deg C continuously.
- ii) Valve actuators and stems shall be adequate to handle the unbalanced forces occurring under the specified flow conditions or the maximum differential pressure specified. An adequate allowance for stem force, at least 0.15 Kg/sq.cm. per linear millimeter of seating surface, shall be provided in the selection of the actuator to ensure tight seating unless otherwise specified.
- iii) The travel time of the pneumatic actuators shall be as per process requirement.

#### 6.4.3 Control Valve Accessory Devices

- i) All pneumatic actuated control valve accessories such as air locks, hand wheels/ hand-jacks, limit switches, pneumatic positioners, E/P Converters, diffusers, external volume chambers, position transmitters (capacitance or resistance type only), reversible pilot for positioners, tubing and air sets, solenoid valves and junction boxes etc. shall be provided as per the requirements.
- ii) Modulating valves shall be supplied with microprocessor based Smart Positioners with IP-65 housing and having non-contact type position sensing with 4-20mA output signal.

#### 6.4.4 Tests

All valves shall be tested in accordance with the quality assurance programme agreed between the Purchaser and Contractor which shall meet the requirements of IBR (if applicable) and other applicable codes mentioned elsewhere in the specifications. The tests shall include but not be limited to the following:

- i) Nondestructive test as per ANSI B-16.34.
- ii) Hydrostatic shell test in accordance with ANSI B 16.34 prior to seat leakage test.
- iii) Valve closure test and seat leakage test in accordance with ANSI- B 16.34 and as per the leakage class.



- iv) Functional test: The fully assembled valves including actuators control devices and accessories shall be functionally tested to demonstrate times from open to close position.
- v) CV test: CV test shall be carried out as type test on each size, type and design of the valves as per ISA 75.02 standard and test report shall be furnished for Purchaser's approval (if valid type test is not available).

## **6.5 POWER SUPPLY SYSTEM**

### **6.5.1 General**

- i) The Contractor shall furnish all the equipment and accessories required for completeness of the power supply system whether these are specifically mentioned herein or not. All the equipments and sub systems offered shall be from reputed experienced manufacturers. All system cabinets, enclosures, & distribution boards shall be manufactured, assembled, wired and fully tested as a complete assembly as per the requirements of this specification at the manufacturer's works.
- ii) The Contractor shall furnish all required equipment cubicles and wiring required for conversion and/or stabilization of the power sources provided by the Employer to all other levels which may be necessary for meeting the individual requirement of equipment/system furnished by him including the panel/desk mounted equipment.
- iii) Parallel redundant 230 V AC to 24 V DC convertor with automatic 50% load sharing & 125 % capacity shall be provided for 24 V DC power supply in each cubicle separately as per requirements. The UPS power supply to Parallel redundant 230 V AC to 24 V DC convertor shall be extended thru redundant UPS feeders. The system shall provide for 230 V AC/24 V DC convertor Fail alarm, 24 V DC under voltage alarm, 24 V DC over voltage alarm etc.

### **6.5.2 Uninterruptible Power Supply (UPS) System**

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

- i) The kVA rating of UPS shall be as required by expected loads and include 10% spare capacity guaranteed at 50 deg C ambient. The UPS shall have an over load capacity of 125 % rated capacity for 10 minutes and 150 % rated capacity for 10 seconds. The inverter shall have sufficient capability to clear fault in the maximum rated branch circuit. The sizing of UPS shall



- be based on the power factor of the loads being fed subject to a maximum of 0.8.
- ii) Each of the two sets of 2x100% redundant chargers shall be sized to meet the 100% UPS load plus recharge the fully discharged battery within 8 hours.
  - iii) The UPS battery shall have sufficient amp-hour capacity to supply 100% full load current of UPS for 60 minutes. A drop of 4V from battery room to the inverter input will be considered for design.
  - iv) The UPS system shall be capable of operating without D.C. battery in circuit under all conditions of load and the performance of various components of UPS like inverter, charger, static switch etc. shall be guaranteed without the battery in circuit.
  - vi) The UPS system design shall ensure that in case of failure of mains input power supply to one of the chargers, the other charger whose mains input power supply is healthy, shall feed to one or both the inverters as the case may be as per manufacturer's standard practice & continue to charge the D.C. battery at all load conditions. The Bidder should note that this situation should not in any way lead to the discharge of the D.C. Battery.

### 6.5.3 Static Inverters

- i) The static inverter shall be solid state type using proven pulse width modulation (PWM)/quasi square wave/step wave technique. The inverter equipment shall include all necessary circuitry and devices to conform to requirements like voltage regulation, current limiting, wave shaping, transient recovery, automatic synchronization etc. The steady state voltage regulation shall be  $\pm 1\%$  and transient voltage regulation (on application/removal of 100% load) shall be  $\pm 20\%$ . Time to recover from transient to normal voltage shall not be more than 50 m sec. Frequency regulation for all conditions of input supplies, loads and temperature occurring simultaneously or in any combination shall be better than  $\pm 0.5\%$  (automatically controlled). The total harmonic content shall be 5% maximum and content of any single harmonic shall be 3% maximum. The inverter efficiency shall be at least 85% on full load and 80% on 50% load. The synchronisation limit for maintenance of synchronisation between the inverter and standby AC source shall be 48-52Hz, field adjustable in steps of 0.5 Hz.
- ii) All necessary equipment shall be provided to protect the inverter against overload, short circuit and 100% loss of load.
- iii) Inverter equipment shall include all solid state circuitry and devices including stable oscillator etc. to enable inverters to operate satisfactorily in parallel sharing mode each inverter taking 50% load during normal operation. In case of failure of either inverter, 100% load shall automatically be transferred to healthy inverter without any break and degradation in the

quality of UPS output and disconnecting the faulty inverter automatically.

- iv) The inverter failure shall be alarmed and the healthy inverter shall get synchronizing signal from the standby AC source and remain synchronized within the set limits. The limits for the synchronisation between healthy inverter and standby AC source shall be field adjustable.
- v) On failure of both inverters, the loads shall be transferred to standby AC power without a break if within synchronisation limits. However, such transfer shall be inhibited, during operation of inverter on its internal oscillator, to standby AC source frequency being beyond the synchronisation limits. Provision of asynchronous transfer with a break in case of inverter being out of synchronisation limits shall also be there with standby source.

#### **6.5.4 Static Switch and Manual Bypass Switch**

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

#### **6.5.5 Step Down Transformer and Voltage Stabiliser**

The transformer shall be of low impedance type and the rating shall be such that extremely fast fault clearance is achieved even in the largest rated branch circuit. The overload capacity of the transformer/stabilizer shall not be less than 300% for 200 ms. The stabilizer shall employ silicon solid state circuitry and the output voltage regulation shall be  $\pm 2\%$ . The efficiency of the stabiliser shall be 95% or better.

#### **6.5.6 AC Distribution Board (ACDB)**

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

- 6.5.7 The UPS, system equipment and the complete system shall have surge withstanding capability (SWC) to meet the requirements of ANSI C 37.90a – IEEE Standard 472 –1974. UPS should be provided with Class C type surge protection device. The Class C type surge arrester should be single MOV type, pluggable, should have fault indication and should be tested as per IEC 61643-1 to withstand 40kA 8/20  $\mu$ s pulse. The arresters should have potential free contact to ensure maintainability.

- 6.5.8 One complete set of all accessories and devices required for maintenance and testing of batteries shall be supplied and same shall include at least the following :



1	Hydrometer	5 Nos.
2	Set of hydrometer syringes suitable for the vent holes in different cells	5 Nos.
3	Thermometer for measuring electrolyte temperature	5 Nos.
4	Specific gravity correction chart	5 Nos.
5	Wall mounting type holder made of teak wood for hydrometer & thermometer	5 Nos.
6	Cell testing voltmeter (3-0-3 V)	5 Nos.
7	Alkali mixing jar	5 Nos.
8	Rubber apron	5 Nos.
9	Pair of rubber gloves	5 Nos.
10	Set of spanners	5 Nos.
11	No smoking notice for each battery room	2 Nos.
12	Goggles (industrial)	5 Nos.
13	Instruction card	10 Nos.
14	Minimum and maximum temperature indicator for battery room	1 set
15	Cell lifting facility	1 No.

#### 6.5.9 Battery Health Monitoring System (BHMS)

One set of Online Battery Health Monitoring System (BHMS) shall be provided to monitor the health of UPS battery bank. The BHMS shall be microprocessor based intelligent system capable of calculating the net charge of Battery bank, deterioration of batteries in battery bank during the charge/discharge cycles and actual efficiency of the batteries. It shall continuously monitor each cell in the battery bank to identify deterioration in the cell prior to failure.

#### 6.5.10 Battery Racks

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

### 6.6 PROCESS CONNECTION PIPING

The bidder shall provide, install and test all required material for completeness of impulse piping system, sample piping system and air piping system as per the requirements for the connection of instruments and control equipment to

the process and make the system complete. The bidder shall furnish during detailed engineering all relevant drawings, material and technical specifications of various items service wise for Purchaser's approval.

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

#### 6.6.1 Impulse Piping, Tubing, Fittings, Valves and Valve Manifolds

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

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



### 6.6.2 Sample Piping System

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

### 6.6.3 Air Supply Piping

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

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

- ii) For individual supply line and control signal line to control valve, 1/4 inch size light drawn tempered copper tubing conforming to ASTM B75 shall be used. The thickness of copper tubing shall not be less than 0.065 inch and shall be PVC coated. The fittings to be used with copper tubes shall be of cast brass, screwed type.
- iii) All other air supply lines of 1/2 inch to 2 inch shall be of carbon steel hot dipped galvanized inside and outside as per IS-1239, heavy duty with threaded ends. The threads shall be as per ASA B.2.1. Fittings material shall be of forged carbon steel A234 Gr. WPB galvanized inside and outside, screwed as per ASA B2.1. Dimensions of fittings shall be as per ASA B16.11 of rating 3000 lbs.
- iv) For air supply to various devices mentioned above, the bidder shall provide 2 inch size GI pipe header(s) with isolation valve. From 2 inch header, 1 inch sub-header(s) shall be branched off at required locations with isolation valve. From 1 inch sub-header, branch line of 1/2 inch, with isolation valve shall be provided up to various devices. Similar system is to be followed for service air required for intermittent purging in the Local Instrument Enclosures (LIEs) etc.



- v) Instrument air filter cum regulator set with mounting accessories shall be provided for each pneumatic device requiring air supply. The filter regulators shall be suitable for 10 kg/ sq.cm max. inlet pressure. The filter shall be of size 5 microns and of material sintered bronze. The air set shall have 2 inch size pressure gauge and built in filter housing blowdown valve.
- vi) All the isolation valves in the air supply line shall be gate valves as per ASTM B62 inside screw rising stem, screwed female ends as per ASA B2.1. Valve bonnet shall be union type & trim material shall be stainless steel, body rating 150 pounds ASA. The valve sizes shall be 1/2 inch to 2 inch.
- vii) **Purge Air Connection for Air and Flue Gas Applications**
  - a) The continuous purging with instrument air shall be done, for all air and flue gas measurements excepting instrument air and service air instruments, at the process source connection end. Necessary arrangements required for continuous purging shall be provided inside all the air and flue gas enclosures.
  - b) For intermittent purging with service air, necessary arrangements inside all the air and flue gas enclosures shall be provided. The SS three way valve provided in the SS tubing shall be used for isolating the transmitter and connecting the service air quick disconnect line.

#### 6.6.4 Installation and Routing

##### 6.6.4.1 Instrument Piping System

- i) For steam and liquid measurements, the impulse pipe should preferably slope downwards from source connection to instrument and instrument shall be installed below the source point. If due to any reason instrument is installed above the source point, the impulse pipe should slope upwards continuously and a 'pigtail' should be provided at the instrument to assure a water seal for temperature protection. For vacuum measurements instrument shall be installed above source point and impulse pipe should slope upwards.
- ii) Impulse piping for air and flue gas shall slope upwards and instrument shall be installed above source point. If this requirement cannot be met special venting or drain provision shall be provided with vent and drain lines along with isolation valves and other accessories including drain pipes. This drain is to be connected to plant drain through open funnel also.
- iii) All impulse piping shall be installed to permit free movement due to thermal expansion. Wherever required, expansion loops shall be provided. Expansion joints shall be provided wherever required.





- iv) Colour coding of all impulse pipes shall be done by the bidder in line with the colour coding being followed for the parent pipes.

#### 6.6.4.2 Instrument Air & Service Air Piping/ Tubing System

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

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

#### 6.6.5 Piping/ Tubing Support

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

#### 6.6.6 Shop and Site Tests

- i) General Requirements

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

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

- ii) Hydrostatic Testing

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

- iii) Air Testing

All air headers & branch pipes shall be air tested by pressure decay method as per ANSI B31.1. Flexible hoses and short signal tubing shall be tested at normal pressure for leakage. Long signal tubing shall be



tested by charging each tube with air at 2 kg/ sq. cm. through a bubbler sight glass.

## **6.7 FGD CONTROL DESK, SYSTEM CABINETS, LOCAL PANELS & TRANSMITTERS ENCLOSURES/ RACKS**

### **6.7.1 General**

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



### 6.7.2 FGD Control Desk

- i) FGD control desk shall be free standing table top type with doors at the back and shall be constructed of 3 mm thick CRCA steel plates. All operators TFTs & keyboards shall be mounted on this desk. PA system hand-sets, telephone sets shall also be mounted. Very few auto-manual stations & PB stations and lamps may also be mounted on the control desk, if found necessary. The desk shall be arranged in an continuous arc shape. The exact profile of the desk, dimension and the radius of curvature shall also be finalised during detailed engineering stage.
- ii) The exact dimensions, material, construction details etc. of Control Desks, panels etc. shall be as per the actual requirement and shall be finalised during detailed engineering. The general arrangement of the desks, panels shall also be finalised during detailed engineering, subject to Purchaser's approval.
- iii) The bidder must pay particular attention in the positioning of desk mounted OWS in relation to control room lighting in order to minimise reflections.
- iv) For panels, desks mounted instruments/ devices, etc. which are to be powered from UPS, all required conversion of interface equipment, accessories to make such devices compatible with UPS supply shall be provided. All necessary hardware like input switches, fuse unit for each feeder as well as switch fuse unit for each instrument/ device on the power supply line shall be provided. From UPS, two feeders shall be provided along with suitably rated MCB and provision of fast auto changeover of UPS feeders. Power supply distribution scheme shall be as approved by the purchaser during detailed engineering stage.

### 6.7.3 Cabinets, Enclosures, Panels

- i) The cabinets, panels shall be provided with eye bolts for lifting.
- ii) Sheet steel thickness for local panels, system cabinets shall not be less than 1.6 mm unless otherwise specified.
- iii) All panels, enclosures, system cabinets, marshalling cabinets shall be provided with a minimum of 20% spare terminations and system cabinets shall be provided with spare space for 20% additional modules fully wired with connectors etc. in excess of the total requirement of the system design when the cabinets are delivered. The spare space capacity shall be distributed evenly throughout the cabinets.

### 6.7.4 Local Instrument Enclosure and Racks

- i) The local instrument enclosures and racks shall be free standing type constructed of suitable 3 mm thick channel frame of steel and shall be provided with a canopy to protect the equipment mounted in racks from



- falling objects, water etc. The canopy shall not be less than 3 mm thick steel, and extended beyond the ends of the rack. Bulk heads, especially designed to provide isolation from process line vibration shall be provided. Exact fabrication details shall be as finalised during detailed engineering stage. The junction box for racks also shall conform to IP 55 protection class.
- ii) Transmitters and switches, devices, etc. mounted in the field shall be suitably grouped together and mounted in local instruments enclosures/ racks. These local instrument enclosures and racks shall be furnished as per the actual requirements finalised during detailed engineering stage. The exact grouping of instruments in a particular instrument enclosure/instrument rack shall be as finalised during detailed engineering stage subject to the purchaser's approval.
  - iii) The local instrument enclosures shall be constructed of 1.6 mm sheet plate and shall be of modular construction with one or more modules and two end assemblies bolted together to form an enclosure. Channel and frame shall be 3 mm thick. Double inter locking doors shall be provided. The doors shall be the three-point locking type constructed of not less than 1.6 mm thick steel. Doors shall have concealed quick removal type pinned hinges and locking handles. Door locks shall accept the same key. Gaskets shall be used between all mating sections to achieve protection class of IP-55.
  - iv) Vibration dampeners shall be installed for supporting each enclosure.
  - v) The internal layout shall be such that the impulse piping/ blowdown lines are accessible from back doors of the enclosure and the transmitters etc. are accessible from front side for easy maintenance.
  - vi) Each transmitter enclosure housing instruments requiring purge air for continuous air purging, shall be provided with common purge air header, redundant air filter regulators of sufficient capacity, required pressure gauges, valves, fittings, SS tubings and individual purge meters for each purge line etc. as required and indicated in Instrument Installation drawings enclosed herewith.
  - vii) A 15 mm NB service air header shall be furnished in each enclosure housing instruments requiring intermittent purging. The header shall be furnished complete with a pressure regulating valve, pressure gauge, and quick disconnect connections. A hose for connecting each header to the draft instrument line four- way valves shall be furnished. The hose shall be self-storing nylon tubing having a burst pressure of 15 kg/sq.cm. The size of the hose shall be 1/2" minimum. The service air header shall originate at a bulkhead penetration or fitting located on one of the bulkhead plates.



## 6.8 CONTINUOUS EMISSION MONITORING SYSTEM

6.8.1 Flue gas analyzers shall be provided for stack continuous emission monitoring system (CEMS). The stack emission monitoring system comprising of carbon mono oxide, SO<sub>x</sub> /NO<sub>x</sub>, dust/opacity analyzer, stack gas flow & mercury analyzer. All gas analyzer signals shall be connected to FGD PLC as well as to existing DDCMIS.

- i) All flue gas analyzers at stack shall be located at an elevation or as per pollution control board norms and shall be accessible for maintenance.
- ii) All output signals of all stack monitoring analyzers shall be hardwired and connected to FGD PLC as applicable for monitoring, archiving and report generation for environmental monitoring authorities. The OWS shall be equipped/loaded with necessary boiler/ stack emission monitoring system's calculations and report generation software packages for generation of report for submission to environmental monitoring authorities.
- iii) Each analyser shall be independent and shall not share power supply processor etc. with other analyser except compressor for purging air. Separate compressor shall be provided as a part of CEMS.
- iv) In addition to continuous environment monitoring system, manual sampling provision for flue gas monitoring should be provided as per latest Regulation of CPCB/SPCB in the stack along with necessary provision of platform, lighting facility, safety rails and ladders etc. complete in all respect.
- v) The gas analyzers shall also follow the latest norms of Central Pollution Control Board/ SPCB. The measurement shall also conform to EPA, TUV, MCERTS or equivalents regulations.
- vi) Power supply to CEMS shall be from FGD plant UPS only.
- vii) Output of CO/ SO<sub>x</sub> & NO<sub>x</sub>/ CO<sub>2</sub>/ Dust monitors/ Stack flow analyser shall be normalized for Temperature, Pressure, Water vapour etc. This facility should be available in the respective gas analyzer.
- viii) Weather protection against direct sunlight, rains etc. for flow meter, local display/local indicators shall be provided.

6.8.2 The CEMS shall comprise of following equipment for each unit:

- i) SO<sub>2</sub>/NO<sub>x</sub> analyser
- ii) CO analyser
- iii) CO<sub>2</sub> analyser
- iv) Flue gas flow meter
- v) Flue gas temperature measurement
- vi) Stack opacity monitor



vii) Mercury analyser

6.8.3 Common Requirements for all Analysers:

Sl. No.	Features	Essential/Minimum Requirements
1	Output signals	
	Analog	4-20 mA DC galvanically isolated.
	Binary	2 NO + 2 NC for high alarm
2	Zero & span Adjustment	To be provided with range selection facility.
3	Ambient temp.	50° C
4	Indication	Digital Alphanumeric Display. Display of reading in engineering units shall be provided.
5	Enclosure Type/Material	Weather & Dust proof (IP 65) Die cast Aluminum/SS.
6	Type of Electronics	Microprocessor based with self diagnostic.
7	Digital Signal transmission	HART/RS 485 Port Modbus Protocol/ Ethernet TCP/ IP protocol for communication of stack emission data to CEMS OWS to be provided by Bidder.
8	Calibration	Auto & Manual (from Remote)
9	Others	i) All interconnection tubing and cabling between probe and analyser/ analyser panel and cabling from analyser/ analyser panel to DCS.  ii) All the calibration gases required for one year continuous operation shall be provided. The calibration gas container material shall not contaminate the calibration gas.
10	Location of probes	On stack at approximate elevation of 35 m.
11	Compliance to standards	USEPA, TUV, MCERTS or equivalent standards
12	Type of Technology	SO <sub>2</sub> /NO <sub>x</sub> : Hot-extractive sampling type/ Dilution Extractive/ In- situ (Path) type  CO: Hot-extractive sampling type/ Dilution Extractive/ In-situ (Cross-duct) type. (can be combined with SO <sub>2</sub> /NO <sub>x</sub> )  CO <sub>2</sub> : Hot-extractive sampling type/ Dilution Extractive/ In-situ (Cross-duct) type (can be combined with CO or SO <sub>2</sub> /NO <sub>x</sub> above).  Stack Opacity: In situ (Path) type.



		For Hot-extractive sampling type and Dilution extractive type systems, the entire system including analysers, sample handling/conditioning system etc. offered shall be sourced from/assembled at Original Analyser manufacturer(OAM) works i.e., all components involved shall be imported or sourced from OAM only and no indigenous component shall be used.
13	Contractual conditions for CEMS system	Warranty:- as per plant warranty period.  Availability of valid data: AT least 90% of time during warranty period. For this purpose, Bidder may take necessary steps to ensure availability.
14	System capability	Application software shall have the following capabilities:- <ul style="list-style-type: none"><li>- Visualisation of acquired values of data from all analysers</li><li>- Average computation of data (programmable time like 30min, 1 hour, 24 hours, 48 hours or 1 week)</li><li>- Trend representation of raw, and averaged data (trend time period shall be freely selectable)</li><li>- Archiving in simple formats like MS Excel etc.</li><li>- Alarm setting and annunciation</li><li>- Calibration procedures</li><li>- Normalisation of emission data</li><li>- Annual cumulative mass of pollutants using flue gas flow and emission values</li><li>- Capabilities of comparison of data w.r.t. standard/ threshold values.</li><li>- Providing remote access to calibration and configuration.</li><li>- Channel configuration for range, unit etc.</li><li>- Data storage capacity.</li><li>- Auto Report generation.</li><li>- Diagnostics.</li><li>- Data transmission.</li><li>- All the necessary algorithms shall be provided to achieve system capability.</li></ul>



**6.8.4 Specific requirements for Hot-extractive sampling type SO<sub>2</sub>/NO<sub>x</sub>, CO<sub>2</sub> & CO analysers:**

Description	SO <sub>2</sub> Analyser and NO <sub>x</sub> Analyser cum monitor (combined)	CO <sub>2</sub> Analyser	CO Analyser
Type of Instrument	Sampling type - Hot Extractive type	Hot-Extractive	Hot-extractive type
Principle of Measurement	Radiation absorption	NDIR absorption	NDIR absorption
Measurement Range	0-300 ppm/ 0-1500ppm Selectable	0 to 40% (fully selectable)	0-200 ppm to 0-1000 ppm Programmable.
Accuracy	+/- 1% of F.S.	+/-2% of measured	+/- 2 % of F.S.
Linearity	+/- 1% of F.S.	+/- 1% of F.S.	+/- 1% of F.S.
Repeatability	< 1% of Span	< 0.5% of Span	< 1% of Span
Response time(up to 90% of full scale)	< 5 seconds	< 5 seconds	< 5 seconds
a) Temperature Drift	+/- 2% / 10 deg.C	+/-1% in 24 hrs	+/- 2% / 10 deg.C
b) Zero Drift	< 1% span/week	< 1% span/week	< 2% span/week
c) Span Drift	< 1% of measured value/ week	< 1% of measured value/ week	< 1% of measured value/ week
Operating Temperature Range	0-300 deg.C	0-300 deg.C	0-300 deg.C
Filter	Ceramic 3.5 micron	Ceramic 3.5 micron if extractive type	Ceramic 3.5 micron
Accessories for purging system	Purging system (Auto Scavenging facility)	Purging system (Auto Scavenging facility)	Purging system (Auto Scavenging facility)
Temperature	Temperature of the sample shall be controlled before analyser as per manufacturer's standard.	Temperature of the sample shall be controlled before analyser as per manufacturer's standard.	Temperature of the sample shall be controlled before analyser as per manufacturer's standard.





### 6.8.5 Specific requirements for Dilution Extractive type SO<sub>x</sub>/NO<sub>x</sub>/CO<sub>2</sub> & CO Analysers

The sampling system shall consist of in-situ dilution probe, dilution probe controller, sample conditioning system like air drier and filters etc. and other accessories meeting the following requirements as a minimum. All system components and accessories required for completion of this system shall be furnished although these may not be individually specified herein.

- i) Modular Electronic Design.
- ii) Heatless Air dryer with inlet filter, chemical scrubbers to remove traces of NO<sub>x</sub>/CO<sub>2</sub>/SO<sub>2</sub> from air and accumulator.
- iii) Self test facility with screen display.
- iv) Protection of instrument in case ambient or surrounding temp going high beyond stipulated limit.
- v) The following are the minimum requirement for the probe:-
  - Flange and counter flange for inserting probe
  - Coarse and Fine filters
  - Critical orifice
  - Automatic blow back or purging facility
  - SS316L probe material
- vi) Further dilution probe controller shall be provided with the ability to control dilution ratio.
- vii) Unheated umbilical chord to be provided for transportation of the diluted sample, zero air, vacuum pressure, and calibration gas. This chord has to be a single bundle in FRLS PVC outer. The sample line has to be of PTFE.

The design of the Dilution Extractive type system shall be satisfying the following requirements:

Description	SO <sub>2</sub> Analyser	NO <sub>x</sub> Analyser	CO <sub>2</sub> Analyser	CO Analyser
Principle of measurement	Pulsed/UV Fluorescence technology.	Chemi luminescence technology	Gas Filter correlation	Gas Filter Correlation technology
Measurement Range	0-1500 ppm selectable	0-500ppm	0 to 40% (fully selectable)	0-200 ppm to 0-1000ppm Programmable
Probe operating temp	0-300 <sup>o</sup> C	0-300 <sup>o</sup> C	0-300 <sup>o</sup> C	0-300 <sup>o</sup> C



Zero drift	< 1 ppb/ day	< 0.5 ppb/ day	≤ 1 ppm/ day	< 0.1 ppm/day
span drift	(+/- 1%F.S./ day)	(+/- 1%F.S./ day)	(+/- 2%F.S./ day)	(+/- 1%F.S./ day)
Lower detection limit.	≤ 1.0 ppb	≤ 0.4 ppb	≤ 1 ppm	0.05ppm
Response time up to 95% of full scale)	100 sec.	60 sec.	90 seconds	60 seconds
Accuracy/ Precision.	+/- 1%	+/- 1%	+/- 1%	+/- 1%
Linearity	(+/- 1% Full scale)	(+/- 1% Full scale)	(+/- 1.5% Full scale)	+/- 1% of F.S.
Operating Temp for analyser	5 <sup>o</sup> C - 40 <sup>o</sup> C	5 <sup>o</sup> C - 40 <sup>o</sup> C	5 <sup>o</sup> C - 40 <sup>o</sup> C	5 <sup>o</sup> C - 40 <sup>o</sup> C

**6.8.6 Specific requirements for in-situ (Path) type SO<sub>2</sub>/NO<sub>x</sub>, CO<sub>2</sub> & CO analysers :-**

Description	CO Analyser cum monitor	SO <sub>2</sub> /NO <sub>x</sub> Analyser cum monitor	CO <sub>2</sub> Analyser cum monitor
Principle of Measurement	IR absorption	Differential Optical Absorption Spectroscopy	Differential Optical Absorption Spectroscopy
Measurement Range	0-200, 0-1000 ppm, programmable.	0-300 ppm/ 0-1500ppm Selectable.	0-40% (fully selectable)
Accuracy	± 5% of F.S.	≤ 2% of measured value for SO <sub>2</sub> and ± 5% for NO <sub>2</sub>	≤ 2% of measured value
Linearity	± 2% of F.S.	± 1% of measurement range	± 1% of measurement range
Repeatability	< 0.5% of Span		
Response time(up to 90% of full scale)	< 5 seconds		



a) Temperature Drift	Automatic temp compensation		
b) Zero Drift	<1% span/week		
c) Span Drift	< 1% measured value / week		
Operating Temperature	0-300°C	0-300°C	0-300°C
Accessories for purging system	Purging system to be provided with heavy duty blowers/ plant air and shutter mechanism for automatic isolation of lens during purge air failure.	Purging system to be provided with heavy duty blowers/ plant air and shutter mechanism for automatic isolation of lens during purge air failure.	Purging system to be provided with heavy duty blowers/ plant air and shutter mechanism for automatic isolation of lens during purge air failure.
Temperature	Automatic temperature control to be provided	Automatic temperature control to be provided	Automatic temperature control to be provided

**6.8.7 Specific requirements for particulate emission (dust density stack opacity) monitor:-**

Sl. No.	Features	Essential/Minimum Requirements
1	Type of Instrument	In-Situ dry type visible light (through LED) stack
2	Principle of Measurement	Transmission and absorption
3	Measurement Range	0 to 999mg/m <sup>3</sup> , (Programmable)
4	Accuracy	2% of F.S.
5	Linearity	± 1% of F.S.
6	Repeatability	< 1% of Span
7	Response time(up to 90% of full scale)	< 5 secs
8	a) Temperature drift	± 1% in 24 hrs
9	b) Zero Drift	< 1% span/week
10.	c) Span Drift	< 1% measured value/week



11	Operating temperature range	0-300 deg. C
12	Filter	To be provided
13	Accessories purging system	Purging system to be provided with heavy duty blowers/ plant air and shutter mechanism for automatic isolation of lens during purge air failure.
14	Temperature compensation/ measurement	Temperature compensation to be provided. Temperature measurement using thermocouple and transmitter with a 4-20mA flue gas temp signal to PLC to be provided in addition to Opacity monitor.

#### 6.8.8 Specific requirements for continuous on- line mercury analyser:-

Sl. No.	Features	Essential/Minimum Requirements
1	Measurement	Elemental, Ionic & Total mercury
	Measurement principle	Atomic absorption spectrometry
2	Measuring range	0–100 µg/Nm <sup>3</sup>
3	Measuring principle	Cold Vapor Atomic Fluorescence
4	Flue gas temperature	0–250°C minimum. Probe material shall be as approved by owner.
5	Measuring outputs	2 x 0 / 4–20 mA, RS 232, RS 485 & Ethernet port
6	Digital outputs	4 relay outputs
7	Digital inputs	1 potential free outputs
8	Accuracy	< 1% of measuring range
9	Minimum Detectable limit	< 1 µg/Nm <sup>3</sup>
10.	Temporary change of sensitivity/Reference point drift	< ± 2% of measuring range per month
11	Temporary change of zero offset/Zero Point drift	< ± 1.4% of measuring range per month, zero correction (automatic)
12	Power supply	230 VAC, 50 Hz, from Plant UPS
13	Display	LCD display
14	Special Requirements	Non Interference with So <sub>2</sub> , NO <sub>x</sub> , CO and any other chemical components.



15	Bus Protocol	MODBUS/TCP-IP protocol to be connected to CEMS OWS.
16	Accessories	Automatic purging system, Automatic dilution system, Automatic calibration system, filters etc.
17	Consumables	For one year operations in addition to mandatory spares.

#### 6.8.9 Ultrasonic Flow Meter for Flue Gas Flow in Stack:

Sl. No.	Features	Essential/Minimum Requirements
1	Type	Transit time Ultrasonic meter
2	Mounting Style	Transducers on the duct/stack
3	Transducers	Single pair of Corrosion resistant material to be provided
4	Zero and Span	To be provided
5	Flow measurement	Instantaneous Flow rate as well as totalized flow
6	Power supply Distribution	To be arranged by the Bidder.
7	Output: Analogue  Binary  Communication ports	Isolated 4-20mA linear outputs to DDCMIS.  RS485/ Ethernet communication link with MODBUS/OPC protocol to be connected to CEMS OWS station  Hand held terminal port
8	Display/Indication	Flow meter with LCD screen backlight based local display and keypad. If required, transmitter shall be suitably located away from the sensor for better access and visibility.
9	Recording / Totalizing/Loggin	To be provided
10	Diagnostics	False signal tolerance , power supply failure etc
11	Protection class	IP-65 or better, Weather protection against direct sunlight, rain etc. for Flow meter and suitable for Cooling water for Transducer
12	Ambient temperature	-20 deg to +60 deg C
13	Accuracy	<+/- 2%
14	Electrical	Plug and socket



15	Accessories	All mounting hardware required like clamping fixtures, mechanism to remove the transducers online, interconnecting cables to DDCMIS, cables, flexible conduits, junction boxes etc.  Purging arrangement for Cleaning sensors to be provided. Material of all fittings shall be SS 316.
16	Software features	Compensation for temperature and pressure and any cross path errors.  Programming, configuration, shall be possible from front panel.

6.8.10 Sampling type /Dilution extractive type systems shall be provided with dual sample probes along with all required accessories such as redundant heavy duty pumps with continuous rated motors, moisture detection facility, pre-fabricated heated (for sampling type only) sample lines from probes to analyser panel, solenoid valves, filters, coolers along with level switch in gas coolers for auto draining purpose and flow meter etc. as applicable.

## 6.9 INSTRUMENTATION CABLES

### 6.9.1 General Requirements

- i) The bidder shall supply, erect, terminate and test all instrumentation cables for control and instrumentation equipment/devices/systems included under bidder's scope.
- ii) Any other application where it is felt that instrumentation cables are required due to system/operating condition requirements, are also to be provided by the bidder.
- iii) Other type of cables like co-axial cables for system bus, cables for connection of peripherals etc. (under Bidder's scope) are also to be furnished by the Bidder.
- iv) Bidder shall supply all cable erection and laying hardware like cable trays, supports, flexible conduits, cable glands, lugs, pull boxes etc. on as required basis for all the systems covered under this specification.

### 6.9.2 Instrumentation Cable Specifications

- i) All the instrumentation cables i.e. twisted and shielded multipair cables, compensating cables, pre fabricated cables etc. shall be flame retardant low smoke (FRLS) type. The Cables shall be provided in non returnable drums. The drum length shall be 1000m (+/-5%) up to & including 8 pairs and 500 m (+/- 5%) above 8 pairs.
- ii) Voltage grade of the instrumentation cables shall be 225V (peak value).



- iii) All instrumentation cables covered in this specification shall comply with VDE 0815, VDE 0207, Part 4, Part 5, Part 6, VDE 0816, VDE 0472, SEN 4241475, ANSI MC 96.1, IS-8784, IS-10810 (latest editions) and its amendments read along with this specification.
- iv) The conductor shall be of minimum 0.5 sq.mm size, high conductivity, multi-stranded copper for all types of instrumentation cables.
- v) The insulation of individual conductor shall be extruded PVC meeting the requirements of VDE 0207 Part 4 compound Y I3. The outer sheath of instrumentation cables shall be extruded PVC (compound YM1) as per VDE 0207 Part 5 and shall be of flame retardant low smoke (FRLS) type. The cable shall be provided with marking including manufacturer's name, insulation material, conductor size, no of pairs, voltage ratings, type of cable etc. Progressive sequential marking of the length of the cable at every one meter & progressive markings to read 'FRLS' at every 5 meters shall be provided on the outer sheath of all instrumentation cables. Pairs of Cables shall be identified by colour coding & colour banding. The colour of outer sheath shall be sky blue so that C&I cables are easily distinguished from other cables.

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

- vi) All instrumentation cables shall be provided with overall shielding. However multipair cables carrying analog signals shall be provided with individual pair shielding in addition to overall shielding. Shielding shall be of Aluminium-Mylar tape with 100% coverage and with at least 20% overlapping. The thickness of individual pair shield shall be 28 micron (minimum) and that of overall shield shall be 55 microns (minimum). Separate drain wires for individual pair shield (wherever applicable) as well as overall shield shall be provided. Drain wire shall be of seven (7) strand 20 AWG (0.51 sq. mm) tin coated copper conductor. Maximum lay of individual twisted pair shall be 50 mm. Bidder to ensure that individual core diameter shall be suitable for maxi-termi connection. Insulation thickness of individual core shall be between 0.28 and 0.35 mm for 0.5 mm<sup>2</sup> cables and 0.35 to 0.45 mm for 1.31 mm<sup>2</sup> cables.
- vii) The outer sheath of the instrumentation cables shall meet the following minimum requirements:
  - (a) An oxygen index of not less than 29% and a temperature index of not less than 250 deg. C as per ASTM D-2863.
  - (b) Maximum acid gas generation by weight as per IEC-754-I shall



not be more than 20%.

- (c) Smoke density rating shall not be more than 60% during smoke density test as per ASTM-D-2843. The results of smoke density test shall be plotted on a curve indicating light absorption v/s time as per ASTM-D 2843. The average area under the curve (smoke density rating) shall not be more than 60%.
- (d) Complete cable assembly shall pass Swedish Chimney test as per SEN-4241475 and flammability test as per IEEE-383.

The thickness of outer sheath shall be as per the guidelines given in VDE 0816. Thickness of outer sheath shall not be less than 1.8 mm in any case. Allowable tolerance of overall diameter of the cables shall be +/-2 mm max. over the declared value in technical data sheets. The variation in diameter and the ovality at any cross section shall not be more than 0.1 mm.

- viii) All instrumentation cables shall be suitable for continuous operation at 70 deg. C, except for high temperature resistant teflon insulated cables which shall be suitable for continuous operation at 205 deg. C. The cables shall be suitable for laying in wet or dry locations in trays, conduits, ducts, trenches and underground buried installations.
- ix) The thermocouple extension cables shall be of single/multi pair, twisted & shielded, PVC insulated, FRLS PVC sheathed and compatible for the type of thermocouples employed. The material of conductor shall be as per ANSI MC-96.1.
- x) Cable parameters such as mutual capacitance between conductors, conductor resistance, insulation resistance, characteristic impedance, cross talk and attenuation figures at 20 deg. C ( $\pm 3$  deg. C) for various types of cables as applicable shall be as specified under table 10.1.
- xi) Identification of the cores & pairs shall be done with suitable colour coding & band marking as well as by numbering of cores/pairs as per VDE: 0815. The details of colour coding etc. shall be as approved by Purchaser during detailed stage.
- xii) The bidder shall furnish all documentary evidence including cross-sectional drawings, test certificates to substantiate the suitability of cables offered for different applications. The bidder shall also clearly bring out the application wise details for each type of cable offered.
- xiii) All prefabricated cables shall have 10% spare cores which will not be connected to pin connectors.
- xiv) Cable Parameters

Table –
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Standard Technical Specification for Retrofit of Wet Limestone Based Flue Gas Desulphurisation  
(FGD) System in a Typical 2x500 MW Thermal Power Plant  
Section- 6 (Control & Instrumentation Works)

Parameter/ Type of Cable	Individual and overall shielded (Type F)	Overall Shielded (Type-G)	Individual and overall shielded Teflon Coated (Type-I)	Compensating cables (with/without Teflon coating) (Type A,B,C)
Conductor Resistance (max.)	73.4 ohm/km (loop)	73.4 ohm/km (loop)	73.4 ohm/km (loop)	
Insulation resistance	100 M ohm/ km	100 M ohm/ km	100 M ohm/ km	100 M ohm/ Km
Cross-Talk figure at 0.8 kHz	60 dB	60 dB	60 dB	60 dB
Charact- eristic impedan ce	320 ohm	340 ohm	320 ohm	
Attenuati on at 1 kHz	1.2 dB/km	1.2 dB/km	1.2 dB/km	

xv) Description of various type of cables

Type	Conductor Size	Description
F	0.5 mm <sup>2</sup>	Multi pair individual pair & overall shielded twisted pair armored instrumentation cable (2/4/8/12/24/ 48 pair) for analog signals with stranded copper conductor.
G	0.5 mm <sup>2</sup>	Multi pair overall shielded & twisted pair armored instrumentation cable (2/4/8/12/24/48 pair) for binary signals with stranded copper conductor.
I	0.5 mm <sup>2</sup>	Type F/ Type G cable with heat resistant teflon insulation & outer-sheath for high temperature application.



Control Cable	1.5/2.5 mm <sup>2</sup>	Multicore having overall shielding & specification similar to Instrumentation cable except insulation thickness and voltage grade which shall be 1100 V.
Std.	As per specific standard/ requirement for each application	Multi core/ Multi pair shielded cable for system specific cables like System Bus cable, Bus communications cable etc. as applicable.

### 6.9.3 Instrumentation Cable Interconnection and Termination Philosophy

The cable interconnection philosophy to be adopted shall be such that extensive grouping of signals by large scale use of field mounted Group JBs at strategic locations (where large concentration of signals are available, e.g. switchgear) is done and consequently cable with higher number of pairs are extensively used. The details of termination to be followed are mentioned below.

Application		Type Of Termination		Type Of
FROM (A)	TO (B)	END A	END B	
Valves/ Dampers drives (Integral Junction	Marshalling cubicle/local group JB/Termination/ Control	Plug in connector	Post Mounted Maxi termi/ cage	G
Transmitter s,	Integral Juncti on box	Plug in connector	Maxitermi/ cage clamp (Rail mounted)	F
MCC/SWG R	Marshalling Cubicle/local group JB/ Termination/ Control cabinets/	Maxitermi/ cage clamp (Rail Mounted) type.	Post mounted Maxi termi/ cage clamp	G



Standard Technical Specification for Retrofit of Wet Limestone Based Flue Gas Desulphurisation (FGD) System in a Typical 2x500 MW Thermal Power Plant  
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Local Junction box, MCC/SWG R	Group JB	Maxitermi/cage clamp (Rail Mounted) type.	Maxitermi/cage clamp (Rail mounted)	G
Field mounted switches	Group JB	Maxitermi/cage clamp (Rail Mounted) type.	Maxitermi/cage clamp (Rail mounted)	G
Internal Marshalling Termination of Cabinet	Electronic system cabinet	Post mounted Maxi termi/cage clamp type.	Post mounted Maxi termi/cage clamp type.	F,G
Marshalling Termination in Cabinet	Desk mounted equipments	Post Mounted Maxi termi/cage clamp type.	Plug in connector/Cage clamp Type (rail mounted).	F,G (with connector at one end)
Motor current transducer in MCC	PLC system	Post Mounted Maxi termi/cage clamp type	Plug in connector/Cage clamp type (rail mounted)	F
DDCMIS/ PLC cabinets	OWS, Printers etc.	Plug in connector	Plug in connector	Mfr.'s Standard. However, connection between PLC and the remote I/Os shall be through fibre optic cable by Bidder if length is >300 M & coaxial cable if length <300 M



Detectors/ Any loop device	Detector / Isolator/ Interface unit	-	-	Shielded, Twisted, PVC Cu. FRLS cables type "S" Refer Note 3 below.
Detector/ Isolator/ Interface Unit	JB			Shielded, Twisted, PVC Cu. FRLS cables Type "S" Refer Note 3 below.
JB	Fire alarm Panel			Shielded, Twisted, PVC Cu. FRLS cables Type "S" Refer Note 3 below.

Notes:

1. 10% spare pair shall be provided for all cables having more than four pairs.
2. For analog signals, individual pair shielding & overall shielding & for Binary signals, only overall shielding of instrumentation cables shall be provided.
3. Type "S" cable shall satisfy requirements of Article 760 NFPA 70.
4. Short term fire proof cables shall be Mineral insulated copper conductor and copper sheathed type satisfying requirements of Fire resistance, safety in the industrial application areas mentioned in the specification and also, shall be approved by UL standards and certified by LPCB.

#### 6.9.4 Fibre Optical Cables

- i) Fiber Optic cable shall be 4/8/12 core, corrugated steel taped armoured, fully water blocked with dielectric central member for outdoor/indoor application so as to prevent any physical damage. The cable shall have multiple single-mode fibres as required by the communications system so as to avoid the usage of any repeaters. The core and cladding diameter shall be  $9\pm 1$  micrometers and  $125\pm 1$  micro-meters

respectively. The outer sheath shall be Flame Retardant, UV resistant properties and identified with the manufacturer's name on it.

- ii) The cable core shall have suitable characteristics and strengthening for prevention of damage during pulling viz. Steel central member, Loose buffer tube design, 4 fibers per buffer tube (minimum), Interstices and buffer tubes duly filled. The cable shall be suitable for a maximum tensile force of 2000 N during installation, and once installed, a tensile force of 1000 N minimum. The compressive strength of cable shall be 3000 N minimum. The operating temperature shall be  $-20$  deg C to  $70$  deg C.
- iii) All testing of the fiber optic cable being supplied shall be as per the relevant IEC, EIA and other international standards.
- iv) Bidder to ensure that minimum hundred (100) percent cores are kept as spares in all types of optical fibre cables.

#### 6.9.5 Terminal Blocks

- i) All terminal blocks shall be rail mounted/post mounted, cage clamp type/maxi-termi type (MTP) with high quality non-flammable insulating material of melamine suitable for working temperature of  $105$  deg. C. The terminal blocks in field mounted junction boxes, CJC boxes, instrument enclosures/racks, etc., shall be suitable for cage clamp/ MTP connections. The terminal blocks in Control Equipment Room logic/termination/marshalling cubicles shall be suitable for post mounted maxi- termi/cage clamp connection at the field input end. The terminal blocks for PLC input/output connections from/to SWGR/MCC, Actuators with Integral Starter (for coupling relays and check back signals of  $11$  kV and  $3.3$  kV auxiliaries, LT drives/valves & dampers/solenoids, CT & VT, etc.) shall be provided with built in test and disconnect facilities complete with plug, slide clamp, test socket, etc.
- ii) All the terminal blocks shall be provided complete with all required accessories including assembly rail, locking pin and section, end brackets, partitions, small partitions, test plug bolts and test plug (as specified above for SWGR connections) transparent covers, support brackets, distance sleeves, warning label, marking, etc.
- iii) The marking on terminal strips shall correspond to the terminal numbering on wiring diagrams. At least 20% spare unused terminals shall be provided everywhere including local junction boxes, instrument racks/enclosures, termination/marshalling cabinets, etc. All terminal blocks shall be numbered for identification and grouped according to the function. Engraved labels shall be provided on the terminal blocks.



- iv) The terminal blocks shall be arranged with at least 100 mm clearance between two sets of terminal blocks and between terminal blocks and junction box walls.

#### 6.9.6 Internal Panels/Cabinets/System Cabinets Wiring

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

#### 6.9.7 Cable Installation and Routing

- i) All cables assigned to a particular duct/conduit shall be grouped and pulled in simultaneously using cable grips and suitable lubricants. Cables removed from one duct/conduit shall not be reused without approval of Purchaser.



- ii) Cables shall be segregated as per IEEE Std.-422. In vertically stacked trays, the higher voltage cable shall be in higher position and instrumentation cable shall be in bottom tier of the tray stack. The distance between instrumentation cables and those of other systems shall be as follows :
  - a) from 11 kV/6.6 kV/3.3 kV tray system - 914 mm
  - b) from 415V tray system - 610 mm
  - c) from control cable tray system - 305 mm
- iii) Cables shall terminate in the enclosure through cable glands. All cable glands shall be properly gasketed. Fire proof sealing to prevent dust entry and propagation of fire shall be provided for all floor slots used for cable entrance.
- iv) All cables shall be identified by tag nos. provided in Purchaser's approved format at both the ends as well as at an interval of 5 meters.
- v) Line voltage drop due to high resistance splices, terminal contacts, insulation resistance at terminal block, very long transmission line etc. shall be reduced as far as practicable.
- vi) The cables emanating from redundant equipment/devices shall be routed through different routes.

#### 6.9.8 Cable Laying, Accessories & Fittings

- i) Bidder shall supply and install all cable accessories and fittings like cable glands, grommets, lugs, termination kits etc. on as required basis.
- ii) Cables shall be laid strictly in line with cable schedule.
- iii) Indelible tags to be provided at all terminations, on both sides of wall or floor crossing, on each conduit/duct/pipe entry/exit, and at every 20 m in cable trench/tray.
- iv) Cable tray numbering and marking to be provided at every 10m and at each end of cable way & branch connection.
- v) Joints of cable shall not be permitted.
- vi) Buried cable protection to be provided with concrete slabs; route markers at every 20 meters along the route & at every bend.
- vii) At road crossings, cables to pass through buried high density PE pipes encased in RCC. At least 300 mm clearance shall be provided each between HT Power & LT Power cables and LT Power & LT



control/instrumentation cables.

Spacing between cables of same voltage grade shall be in accordance with the derating criteria adopted for cable sizing.

- viii) All cable associated with the unit shall be segregated from cables of other units. Interplant cables of station auxiliaries and unit critical drives shall be segregated in such a way that not more than half of the drives are lost in case of single incident of fire.
- ix) All cables laid on trays shall be neatly dressed up & suitably clamped/tied to the tray. For cables in trefoil formation, trefoil clamps shall be provided.
- x) Optical Fibre Cables shall be buried in a separate trench approximately at 1 meter depth & to be laid in 2" GI/ rodent proof HDPE conduits covered with sand, brick, and soil along the pipe line route. For crossing roads, to be laid in GI/ rodent proof HDPE conduits with sand filling at bottom and sand, soil filling at top with cement concrete.
- xi) Bidder shall supply and install all cable accessories and fittings like Light Interface Units, Surge suppressors, Opto isolators, Interface Converters, Fiber Optic Card Cage, Fiber Optic Line Driver, Modem (for Optical Fiber Cables), cable glands, grommets, lugs, termination kits etc. on as required basis.
- xii) Bidder shall furnish two completely new sets of cable termination kits like crimping tools, maxi-termi/wire-wrap tools etc. which are required for maintenance of the system.

#### 6.9.9 Field Mounted Local Junction Boxes

- i) No. of ways 12/24/36/48/64/72/96/128 with 20% spare terminals.
- ii) Material and Thickness 4mm thick fibre glass reinforced polyester.
- iii) Type Screwed at all four corners for door. Door handle shall be of SS. Self locking with common key. Door gasket shall be of synthetic rubber.
- iv) Mounting clamps and accessories Suitable for mounting on walls, columns, structures etc. The brackets, bolts, nuts, screws, glands and lugs required for erection shall be of brass, included in Bidders scope of supply.
- v) Type of terminal blocks Rail mounted maxi termi or cage-clamp type suitable for conductor size up to 2.5 mm<sup>2</sup>. A M6 earthing stud shall be provided.





- (vi) Protection Class IP:65 minimum

#### 6.9.10 Conduits

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

### 6.10 TYPE TEST REQUIREMENTS

#### 6.10.1 General Requirements

- i) The Contractor shall furnish the type test reports of all type tests as per relevant standards and codes as well as other specific tests indicated in this specification. A list of such tests are given for various equipment in subsequent table and under the item Special Requirement for Solid State Equipments/ Systems. For the balance equipment instrument, type tests may be conducted as per manufactures standard or if required by relevant standard.
- ii) Out of the tests listed, the Bidder/ sub-vendor/ manufacturer is required to conduct certain type tests specifically for this contract (and witnessed by Employer or his authorized representative) even if the same had been conducted earlier, as clearly indicated subsequently against such tests.
- iii) For the rest, submission of type test results and certificate shall be acceptable provided.
  - a. The same has been carried out by the Bidder/ sub-vendor on exactly the same model /rating of equipment.
  - b. There has been no change in the components from the offered equipment & tested equipment.
  - c. The test has been carried out as per the latest standards along with amendments as on the date of Bid opening but not more than five (5) year back.
- iv) In case the approved equipment is different from the one on which the type test had been conducted earlier or any of the above grounds, then the tests have to be repeated and the cost of such tests shall be borne by the Bidder/ sub-vendor within the quoted price and no extra



cost will be payable by the Employer on this account.

### 6.10.2 Special Requirement for Solid State Equipment/ Systems

- i) The minimum type test reports, over and above the requirements of above clause, which are to be submitted for each of the major C&I systems Analyzer instruments, various PLCs etc. shall be as indicated below:

a) Surge Protections for Solid State Equipment/ Systems

All solid state systems/ equipment shall be able to withstand the electrical noise and surges as encountered in actual service conditions and inherent in a power plant. All the solid state systems/ equipment shall be provided with all required protections that needs the surge withstand capability as defined in ANSI 37.90a/ IEEE-472. Hence, all front end cards which receive external signals like Analog input & output modules, Binary input & output modules etc. including power supply, data highway, data links shall be provided with protections that meets the surge withstand capability as defined in ANSI 37.90a/ IEEE-472. Complete details of the features incorporated in electronics systems to meet this requirement, the relevant tests carried out, the test certificates etc. shall be submitted along with the proposal. As an alternative to above, suitable class of IEC-60255-4 which is equivalent to ANSI 37.90a/ IEEE-472 may also be adopted for SWC test.

- b) Dry Heat test as per IEC-68-2-2 or equivalent.  
c) Damp Heat test as per IEC-68-2-3 or equivalent.  
d) Vibration test as per IEC-68-2-6 or equivalent.  
e) Electrostatic discharge tests as per IEC 61000-4-2 or equivalent.  
f) Radio frequency immunity test as per EN 50082-2 or equivalent.  
g) Electromagnetic immunity as per EN 61131-2 or equivalent.  
h) Test listed at item no. v, vi, vii, above are applicable for front end cards only as defined under item (i) above.

### 6.10.3 Type Test Requirement for C&I Systems

<u>Sl. No.</u>	<u>Item</u>	<u>Test Requirement</u>	<u>Standard</u>	<u>Test To Be Specifically Conducted</u>	<u>Approval Req. on Test Certificate</u>	<u>Remarks</u>
1	2	3	4	5	6	7
i)	Elect. Metering instruments	As per standard ( col 4)	IS-1248	No	Yes	



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ii)	Electronic transmitter	As per standard ( col 4)	BS-6447/ IEC-770	No	Yes	
iii)	Dust emission monitor	Degree of protection test	IS-2147	No	Yes	
iv)	Instrumentation Cables- Twisted & Shielded			Yes	Yes	
v)	Pressure gauge	Degree of protection test	IS-2147	No	No	
		Temp interference test	IS -3624	No	No	
vi)	Temperature gauge	Degree of protection test	IS-2147	No	No	
vii)	Pressure & DP switch	Degree of protection test	IS-2147	No	No	
		As per standard (col 4)	BS 6134	No	No	
viii)	Level switch	Degree of protection test	IS-2147	No	No	
ix)	Conductivity level switch	Degree of protection test	IS-2147	No	Yes	
x)	Battery charger (Including chargers of UPS )	Degree of protection test	IS-2147	No	Yes	
		Short circuit current capability	IEC-146-2	No	Yes	
		Temp rise test without	Approved procedure, IEC 146-2	Yes	Yes	



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		redundant fans				
		SWC test	Approved procedure,	No	Yes	
		Efficiency/ PF	IEC-146-2, IEC146	Yes	Yes	
		Audible noise test	IEC 146-2	No	Yes	
		Fuse clearing capability	Approved procedure	No	Yes	
		Relative harmonic content	Approved procedure	No	Yes	
		Radio interference	IEC 146-4	No	Yes	
		Over Load test on inverter & charger.	Approved procedure	No	Yes	
		Restart test	IEC 146-2	No	Yes	
		Output voltage tolerance	Approved procedure	No	Yes	
		Output voltage harmonic content	Approved procedure	No	Yes	
		Insulation test	IEC 146	No	Yes	
		Load tests	Approved procedure	Yes	Yes	
		Preliminary light load test	IEC 146	No	Yes	
		Current division/ voltage division	IEC 146-2	No	Yes	
xi)	Battery	As per standard (col 4)	IEC-623 / IS-10918 for Ni-Cd IS-1652 for Plate Lead Acid IS-1651 for Lead Acid	No	Yes	



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xii)	Control valves	CV Test	ISA 75.02	Yes*	No	
xiii)	Voltage stabilisers	Over load test	Approved procedure	No		
		Temp rise test without redundant fans	Approved procedure	No		
		Input voltage variation test	Approved procedure	No		
xiv)	Flow Nozzles & Orifice plate	Calibration	ASME PTC, BS 1042	Yes*	No	
xv)	PLCs	All tests as per IEC-1131	IEC-1131			
xvi)	LIE / LIR / Junction Box	Degree of protection test	IS-2147	Yes	Yes	
xvii)	Flue gas O2 Analyser	Degree of protection test	IS-2147	No	Yes	
xviii)	Flue gas SO2 Analyser	Degree of protection test	IS-2147	No	Yes	

\* In case valid type test certificate is not available.



## SECTION-7

### CIVIL WORKS

#### 7.1 GENERAL

7.1.1 The specification for civil works covers all the civil works required for installation/retrofitting of Limestone based FGD Plants inside the premises of existing Thermal Power Plants. The specifications are intended for the general description of the work, materials quality and workmanship. The specifications are not, however, intended to cover the minute details.

Wherever references to Indian Standard Codes are made, they shall refer to the latest edition/ version of the same as exist one month before the due date of submission of tenders.

#### 7.1.2 Nature of Work

The works to be performed under these specifications shall include complete design, preparation of construction drawings of reinforcement, placement drawings, bar bending schedule based on the drawings approved for construction, preparation of fabrication drawings based on design/drawings and getting the same approved by the Purchaser and also execution of works including/providing all materials labour, scaffolding, power, fuel, construction equipments, tools and plants, supplies, transportation, storage supervision and all incidental implied or necessary for successful completion of the work including construction, supervision and in strict accordance with approved drawings and these specifications and with inspection and testing standard.

The work shall also involve the dismantling of existing R.C.C. foundation, pedestals, structures etc. without blasting/ disturbing the nearby foundations/ structures at the interface of existing power plant and proposed FGD plant or at any other place for accommodating the facilities of FGD plant. Dismantling works shall be done as per the strict instruction of the Purchaser.

The bidders are advised to visit the project site to acquaint themselves of the actual site conditions before submission of the bids.

#### 7.1.3 Scheme

The proposed scheme and technical details of FGD system are described elsewhere in Technical specification.

#### 7.1.4 Layout and Levels

The layout and levels of all structures etc. shall be made by the Contractor at his own cost from the general grid of the plot and bench marks given by the



purchaser and under no circumstances shall be removed or disturbed any permanent marks without approval of the purchaser.

### 7.1.5 Construction Method

The Bidder shall submit along with his offer drawings, Bar Chart, Schedule, list of construction equipment's and manpower to be deployed and a write-up to indicate broadly how he intends to execute the work. These shall form part of this tender.

## 7.2 BASIC DESIGN CRITERIA

### 7.2.1 Basis of Design

All structures will be designed for the following loads: -

7.2.1.1 **Dead load:** Self-weight of structures plus weight of equipment including impact/dynamic loads.

7.2.1.2 **Live load:** The following live loads shall be adopted in addition to equipment and machinery loads as per IS: 875 (latest revision) including up-to-date amendments:

- |   |  |
|---|--|
| a) Roofs                                  | = 150 kg/sqm, for accessible roof<br>= 75 kg/sqm, for inaccessible roof                        |
| b) Office rooms                           | = 250 kg/sqm   |
| c) Floors<br>operational &<br>Maintenance | = 500 kg/sqm (Minimum) or as required from<br>maintenance requirements whichever is<br>higher. |
| d) Chequered plate floor                  | = 500 kg/sqm   |
| e) Stairs & Balconies                     | = 500 kg/sqm   |
| f) Platforms, walkways<br>grating floors  | = 500 kg/sqm   |

Any other load required for servicing, maintenance and erection shall be taken in addition to above loads. Further, if erection load on any floor or part thereof is more than the live load specified above, that floor including beams shall be designed for the erection load.

**Note:** No reduction in live loads due to number of floors shall be allowed in design.



7.2.1.3 **Wind load:** Wind loads on structures shall be calculated as per provisions of IS-875 (Part-3) including up-to-date amendments.

7.2.1.4 **Seismic load:** Seismic load shall be calculated for analysis & design as applicable by seismic coefficient/response spectrum method as per IS: 1893 (latest revision) including up-to-date amendments. The Importance factor for all structures shall be taken as 1.50.

7.2.1.5 **Dust load:** All buildings and structures shall be designed for a dust load of 50 kg/sqm.

7.2.1.6 **Thrust load:** All pipes and its foundation at bends shall be designed for thrust load as per latest edition of IS: 5330.

7.2.1.7 **Impact load:** The minimum impact factor to be used in design shall be as follows:

- |   |   |
|---|---|
| (a) Crane Girder:   | As per IS: 875 or manufacturer's data.            |
| (b) Rotary equipment and reciprocating equipments supported by steel or concrete structures | As per manufacturer's recommendations & IS: 2974. |
| (c) For pulley block  | 10% for manual and 25% for electrical             |

#### 7.2.1.8 **Thermal load**

Expansion & contraction due to changes in temperature of the materials of a structure shall be considered and adequate provision made in the design for the effects produced. The maximum variation of temperature for location of building shall be obtained from the India n Metrological Department for that particular locality.

The co-efficient of expansion for steel shall be considered as 0.000012 per °C per meter and the coefficient of expansion for concrete shall be 0.00001 per °C per meter.

#### 7.2.1.9 **Surge loads**

The surge effect of cranes in the lateral & longitudinal horizontal shall be considered as per manufacturer's recommendations and relevant IS codes.

#### 7.2.1.10 **Loads on underground structures**

The underground structures shall be designed for lateral thrust due to earth pressure, sub-soil water pressure (if any). In addition, a minimum surcharge load of 2.0 tonne per sq.m. shall also be considered. The structures/foundations shall be checked for buoyancy effect due to sub-soil water table.





- 7.2.1.11 **Increase in allowable stresses:** While designing structures for wind and seismic loads, the permissible stresses in materials and safe bearing capacity of soils may be increased as allowed by relevant I.S. Codes.
- 7.2.2 **Safe bearing capacity of soil:** Before submitting the tender, the tenderer should familiarize himself with the site conditions and shall satisfy himself about nature of soil, bearing capacity etc. and furnish all inclusive rates of various items of work below ground level. **The report of soil investigation of existing power plant is available with the Purchaser, which can be seen by the bidders with prior appointment.** However, the contractor shall carry out soil investigation after award of work for determining the safe bearing capacity of the soil including sub-soil water level and for deciding the type of foundations to be provided for various structures of FGD Plant.
- 7.2.3 The owner shall not, under any circumstances, pay any extra charge after the acceptance of the contract, in case the contractor is found to have misjudged the soil conditions including sub-soil water level at the site of work at a latter date.
- 7.2.4 **DESIGN CRITERIA**
- 7.2.4.1 The design of R.C.C. structures will be carried out as per code of practice for plain and reinforced concrete for General Building Construction IS:456 (latest edition). The design of liquid retaining R.C.C. structures shall be carried out as per latest edition of IS: 3370 (Part I to IV).
- 7.2.4.2 The steel structures shall be designed and fabricated as per latest edition of IS: 800 entitled 'Code of Practice for use of Structural Steel in General Building Construction' and other relevant IS Standards.
- 7.2.4.3 The building shall conform to local by laws, rules and regulations for industrial buildings and also to IS: 1256 (latest revision).
- 7.2.4.4 The machine foundations shall be designed in accordance with latest edition of IS: 2974. The vibration isolation system may be provided for Booster Fans, limestone crushers, Ball Mills or any other heavy vibratory equipment as specified elsewhere in the specifications.
- 7.2.4.5 The permissible settlement for foundations of FGD plant shall be as per relevant IS codes and differential settlement shall be as per IS: 8009 unless required otherwise by the manufacturer of any equipment.
- 7.2.4.6 All Control Room Buildings shall be air-conditioned and shall have provision for false ceiling and anodized aluminium doors & windows. All windows in air conditioned buildings shall be double glassed
- 7.2.5 **DESIGN CALCULATIONS AND DRAWINGS:** All drawings and design calculations (six sets) for civil & structural works shall be submitted by the contractor for the approval of owner/Consultants. No construction shall commence prior to approval of the relevant design and construction drawings.



## 7.2.6 AS MADE DRAWINGS

One set of tracing in linen, three sets of paper prints and two sets of microfilming of all approved construction/ fabrication/ architectural drawings showing the work exactly as made shall be delivered to the owner/ consultant within one month of completion of the work at site.

## 7.3 TECHNICAL SPECIFICATION FOR EARTH WORK

### 7.3.1 GENERAL

This shall include all works involved in excavation for all leads and lifts, dressing of soil, shoring, filling around foundations and trenches, carting of sand or good quality earth if required for filling, disposal of residual earth at a place as directed by the Purchaser. The contractor must satisfy himself of the character and volume of all works under this item and expected surface and/or sub-soil water to be encountered.

### 7.3.2 EXCAVATION

7.3.2.1 The contractor shall control the grading in the vicinity of all excavations so that the surface of the ground will be properly sloped or diked to prevent surface water from running into the excavated areas during construction.

7.3.2.2 Sides and bottoms of excavation shall be cut sharp and true to the slopes indicated in the drawing. Under-cutting shall not be permitted. Earth **side** of excavation shall not be used in lieu of formwork for placement of concrete unless authorised in special cases, by the Purchaser where limitation of space for larger excavation necessitates such a decision.

7.3.2.3 When machines are used for excavation, the last 300mm before reaching the required level shall be excavated by hand or by such equipment that will leave the soil at the required final level, in its natural condition. Similarly, excavation by hand may be required close to existing installation.

7.3.2.4 Suitability for bearing of the bottoms of excavations shall be determined by the Purchaser.

7.3.2.5 The bottoms of excavations shall be trimmed to the required levels and when carried below such levels due to contractor's fault, the excess depth shall be filled up to the required level at the Contractor's cost with cement concrete not leaner than M-10 grade or richer as directed by the Purchaser in each individual case.

7.3.2.6 Excavated material shall be placed beyond 1.5m from the edge of the pit or half the depth of the pit whichever is more or farther away if directed by the Purchaser.

7.3.2.7 All excavations for installation of underground facilities such as piping, power lines, ducts, drain lines, earthing mat etc. shall be open cuts.



7.3.2.8 Excavation for foundation where specified shall be carried out at least 100mm below the bottom of structural concrete and then brought to the required level by placing lean concrete of M-10 (1: 3: 6) with aggregates of 40mm maximum nominal size.

7.3.2.9 For the purpose of excavation of earthwork, the term soil shall apply to all kinds of soil containing any percentage of Kanker, moorum or/and shingle etc. Any buried structures or foundations or reinforced/un-reinforced cement concrete found at site during excavation shall also be removed/dismantled, if required, without any extra cost to the purchaser.

### 7.3.3 **DISPOSAL OF SURPLUS EARTH**

The contractor shall arrange to transport the surplus excavated soil remaining after backfilling to the disposal place inside the project area, as directed by the Purchaser.

### 7.3.4 **EXCAVATION BELOW WATER TABLE**

7.3.4.1 The contractor shall acquaint himself with the existing water table condition at site before starting of work and shall make all requisite arrangements for dewatering like well-point system, boring of tube wells if required, numbers of installation of sump pumps etc.

7.3.4.2 The Contractor shall de-water and maintain the water table below the bottom of the excavated level during excavation, concreting, water proofing treatment and backfilling and shall continue the arrangements till the completion of all works up to 1.0m above the water table is achieved.

7.3.4.4 All costs for the ground water control for keeping the construction pits dry shall be included in the relevant excavation item except otherwise indicated.

### 7.3.5 **BACKFILL**

7.3.5.1 The Contractor shall furnish all labour, equipment and materials required for complete performance of work in accordance with the drawings and as described herein.

7.3.5.2 After completion of foundation footings and wall and other constructions below the elevation of the final grades and prior to backfilling, all forms, temporary shoring, timber etc. shall be removed and the excavation cleaned of all trash, debris and perishable materials.

7.3.5.3 Backfilling shall be done with inorganic materials obtained from the excavation or borrow pits, if suitable, and subject to the approval of the Purchaser.

7.3.5.4 Backfill shall be placed in horizontal layers not exceeding 20cm in thickness. Each layer shall be compacted with proper moisture content with such equipment as may be required to obtain a density requirement as per standard proctor test conforming to IS 2720.



7.3.5.6 Backfill adjacent to pipes shall be hand placed free from stones, concrete etc. compacted uniformly on both sides of the pipe and where practicable to a depth of 300mm over the top of pipes.

7.3.5.7 On completion of structures, the earth surrounding them shall be accurately furnished to the specified line and grade. Finished surface shall be free of irregularities and separations and shall be within 50mm of the specified level.

### 7.3.6 EXCAVATION IN TRENCHES FOR PIPES, CABLES

Excavation not exceeding 1.50 m or 10m<sup>2</sup> in plan to any depth in trenches shall be described as trenches for pipes, cables etc. Returning, filling and ramming (after pipes and cables are laid) and removal of surplus soil shall form part of this work.

#### 7.3.6.1 Width of Trench

For depth up to 1.0m, the width shall be arrived by adding 25cm to the external diameter of pipe (not socket). When pipe is laid on concrete bed/ cushioning layer, the width shall be pipe diameter plus 25 cm or the widths of concrete bed/ cushioning layer whichever is more.

For depths exceeding 1.0m, an additional width of 5 cm/m depth for each side of trench shall be taken i.e. diameter of pipe + 25cm +(2 x 5) cm

When more than one pipe, cable, conduit are laid, the diameter taken shall be the horizontal distance from outside to outside of outermost pipes, cable etc.

#### 7.3.6.2 Bedding for pipe

The bedding surface shall provide firm foundation of uniform density throughout the length of the culvert, shall conform to the specified levels and grade, and shall be of one of the following two types as specified on the drawings:

(i) First class bedding:

Under first class bedding, the pipe shall be evenly bedded on a continuous layer of well compacted approved granular material, shaped concentrically to fit the lower part of the pipe exterior for at least ten per cent of its overall height or as otherwise shown on the drawings. The bedding material shall be well-graded sand or another granular material passing 4.75mm sieve. The thickness of the bedding layer shall be as shown on the drawings and in no case shall it be less than 75mm.

(ii) Concrete cradle bedding:

When indicated on the drawings or directed by the Purchaser, the pipe shall be bedded in a cradle constructed of concrete having a mix not leaner M20



### **7.3.6.3 Filling**

7.3.6.3.1 Normally excavated earth shall be used for filling. In case earth contains deleterious salts it shall not be used. Where excavated material is rock, the boulders shall be broken into pieces not bigger than 15 cm & mixed with fine materials of decomposed rock, murrum or earth as available to fill up voids.

7.3.6.3.2 Filling the trenches for pipes shall start after the joints of pipes etc. are tested & passed. Where the trenches are excavated in soil, the filling shall be done with earth on the sides & top of pipes in layers not exceeding 20 cm watered & rammed and consolidated.

7. 3.6.3.3 In case of excavation of trenches in rock the filling up to a depth of 30 cm above the crown of the pipe shall be done with fine material such as earth, murrum or pulverised decomposed rock as available. The remaining depth shall be done with rock filling or boulders of size not exceeding 15cm.

### **7.3.6.4 Shoring & Timbering**

7.3.6.4.1 All trenches exceeding 2.0m in depth shall be shored & timbered as determined by the Purchaser. The above requirements do not apply in cases where the sides of the trenches are sloped to within 1.5m of bottom.

7.3.6.4.2 Approved quality SAL wood shall be used for shoring and timbering a trench.

### **7.3.7 MISCELLANEOUS**

7.3.7.1 The Contractor shall take adequate safety measure around the excavated pit by providing fencing and sufficient illumination with red lights during night to avoid accident in the excavated areas.

7.3.7.2 If any materials like steel pieces, parts of any equipment etc. are found during excavation, the matter shall be brought to the notice of the Purchaser immediately and the same shall be deposited in the project's store by the Contractor at his own cost. Any finds of archaeological interest such as relics of antiquity, coins, fossils or other articles of value shall be delivered.

## **7.4 TECHNICAL SPECIFICATION FOR CEMENT CONCRETE**

### **7.4.1 GENERAL REQUIREMENTS**

This covers Cement Concrete, plain or reinforced for general use, and the requirements for concrete materials, their storage, grading, mix design, strength and quality requirements, pouring at all levels, reinforcements, protection, curing, form work, finishing, painting, admixtures, inserts and other miscellaneous works. The provision of the latest revision of IS 456 – 2000 shall be complied with unless permitted otherwise-



## 7.4.2 MATERIALS

### 7.4.2.1 Cement

Cement used shall be ordinary Portland cement of 43 grade or 53 grades conforming to IS 8112 and IS 12269 (latest edition) or Portland pozzolana cement conforming to IS 1489 (latest edition). Sulphate resistant cement conforming to IS: 12330 shall be used in concrete mixes when concrete is exposed to sulphate attack. Rapid hardening Portland cement can be used under special circumstances, if permitted by the Purchaser.

### 7.4.2.2 Aggregates

All aggregates shall conform to the provisions and tests methods of IS 383 (latest revision) and/or IS: 515 (latest revision). Samples of aggregates proposed to be used shall be submitted free of charge in sufficient quantities to the Purchaser with sieve analysis data for his approval. Approved samples will be reserved by him for his future reference.

### 7.4.2.3 Coarse Aggregates

The maximum size of coarse aggregate shall be as follows:

For thin RCC members with very narrow shape	: 10mm
For Reinforced Concrete including foundations	: 20mm
For ordinary Plain Concrete	: 20mm
For Lean Concrete	: 40mm (max.)

Crushed aggregate shall be crushed rock. Grading of coarse aggregates for a particular size shall generally conform to relevant IS codes.

### 7.4.2.4 Fine aggregates (Sand)

Coarse and fine sand shall be well graded within the limits by weight as specified in IS: 383 (latest revision). Fineness modulus shall not vary by more than plus or minus 0.20 from that of the approved sample. Fineness modulus for sand should not be less than 2.5.

Crushed stone sand or crushed gravel sand as per IS: 383 may be used where availability of river sand is scarce.

### 7.4.2.5 Admixtures

The use of admixtures in concrete for promoting workability, improving strength, entraining air or for any other purpose may be used only with the approval of the Purchaser. Addition of admixture should not reduce the specified strength of concrete in any case. The admixtures used shall conform to IS 9103 (latest edition).

### 7.4.2.6 Chloride Content

In case of chloride content greater than 0.6 % kg/m<sup>3</sup> in soils/additional protection shall be provided by the use of chemically resistant stone facing or layer of plaster of paris covered with suitable fabric such as jutex.



### 7.4.3 **Water**

Water shall be clean, fresh and free from organic or other deleterious matters in solution or in suspension in such amounts that may impair the strength or durability of the concrete. Potable water is generally satisfactory. IS 3025 and IS 3550 (latest edition) may be followed for testing, if required. The permissible limit of solids shall be within limits corresponding to table-I of IS 456 (latest edition).

### 7.4.4 **Formwork material**

Formwork shall be composed of steel and/or best quality shuttering wood of non-absorbent type. Hard woods shall be used as caps and wedges under or over posts. Plywood or equivalent shall be used where specified to obtain smooth surfaces for exposed concrete work. Struts shall generally be mild tubes and strong sal-ballahs 150mm in diameter or above. Bamboos, small diameter ballahs etc. shall not be used unless approved by the Purchaser in specified cases.

### 7.4.5 **Storage of Materials**

7.4.5.1 Storage of materials shall be as described in IS: 4082. All materials shall be so stored as to prevent deterioration or intrusion of foreign matter and to ensure the preservation of their quality and fitness for the work.

7.4.5.2 General storage shall be carried out by the Contractor in a manner affording convenient access for identification and inspection at all items. The storage facilities shall be subject to approval of the Purchaser.

### 7.4.6 **Grade of Concrete**

#### 7.4.6.1 **General**

Concrete shall be design mix and in grades designated as M-15 and above as specified in IS 456 (latest edition). In case of liquid retaining structures, IS: 3370 (latest edition) shall be followed. Lean concrete shall be M-10 mix with aggregate of nominal size 40mm maximum or as indicated in drawings. Nominal mix is recommended only when accurate control is impracticable and not necessary.

#### 7.4.6.2 **Nominal mix concrete**

7.4.6.2.1 If nominal mix concrete is allowed by the Purchaser, it shall be used only for the concrete of grade lower than M-20.

7.4.6.2.2 Concrete mix proportions and minimum cement content for design mix concrete shall be as per IS: 456(latest edition).



7.4.6.2.3 If nominal mix concrete made in accordance with the proportions given in Table-9 of IS:456-2000 for a particular grade does not yield the specified strength and fails to satisfy the requirements of "Acceptance criteria for concrete" as specified under clause 16 of IS: 456-2000, the cement content shall be increased as directed by the Purchaser to obtain a specified strength at no extra cost to the Purchaser.

#### 7.4.6.3 Design mix concrete

7.4.6.3.1 This concrete shall be used on all concrete works, except where specified otherwise. Design mix concrete for use in plain and reinforced concrete structures shall be in grade M-20 and above, with minimum cement content as prescribed in IS: 456(latest edition).

7.4.6.3.2 The minimum grade of concrete for plain concrete shall be M-15. The minimum grade of reinforced cement concrete shall be M-25 for all substructure and superstructure except that for equipment foundation or water retaining structures where minimum grade of concrete is taken as M30.

7.4.6.3.3 Maximum Cement Content: Cement content not including fly ash and ground granulated blast furnace slag in excess of 450 kg per cubic metre should not be used unless special considerations have been given in design to increased risk of cracking due to drying shrinkage.

7.4.6.3.4 The mix proportions for all grades of concrete shall be designed as per IS: 456(latest edition).

#### 7.4.7 Mixing and Placing of Concrete

##### 7.4.7.1 General

Concrete shall not be placed in any unit of the work until after the forms, bracing, reinforcing steel and other preparations for casting have been approved by the Purchaser and approval given to proceed with the casting.

##### 7.4.7.2 Mixing

7.4.7.2.1 Concrete shall be mixed till there is a uniform distribution of materials and shall be discharged completely before the mixer is recharged. Mixing shall be done in a mechanical mixer. The mixer shall be rotated at a speed recommended by the manufacturer and mixing shall be continued for at least two minutes after all materials are in the drum. For batches larger than 0.75 cum. mixing time shall be increased by 15 seconds for each additional 0.75 cum. or fraction thereof. All concrete shall be discharged within 3minutes after the introduction of mixing water to the cement and aggregates or the introduction of cement to the aggregate unless a different time is specified by the Purchaser.

7.4.7.2.2 All hardened concrete and foreign materials shall be removed from the inner surfaces of mixing and conveying equipment. All conveyances, buggies and barrows shall be thoroughly cleaned at frequent intervals during the placing of





concrete. Concrete shall be rapidly handled from the mixers to the place of final deposit and shall not be delivered by spout or trough nor dumped into carriers with a free fall from the mixer of more than 1.5 meter.

7.4.7.2.3 Each time the work stops, the mixer shall be thoroughly cleaned and when the next mixing commences, the first batch shall have 10% additional cement at no extra cost to the owner to allow for loss in the drum.

7.4.7.2.4 The workability of the concrete shall be checked at frequent intervals by slump test, where facilities exist and if required by the Purchaser, alternatively the compacting factor test in accordance with IS: 1199 be carried out.

#### 7.4.7.3 **Transporting, placing, compacting & curing**

7.4.7.3.1 Procedure for transporting, placing, compacting and curing shall conform to IS: 456 (latest edition). The placing of concrete shall be a continuous operation with no interruption in excess of 30 minutes between the placing of continuous portions of concrete.

7.4.7.3.2 Concrete shall not ordinarily be placed under water. In unavoidable cases, such concreting shall be done only with, the specific approval of procedure and application by the Purchaser. Additional cement shall be to the extent of 10% and relevant clauses of IS: 456 (latest edition) adhered to.

7.4.7.3.3 To secure maximum density and eliminate formation of all pockets, the concrete shall be thoroughly vibrated by mechanical vibrator and worked around all reinforcement, embedded facilities and into corners of forms during and immediately after placing.

7.4.7.3.4 Retamping of concrete or mortar which has partially hardened shall not be permitted.

7.3.7.3.5 Normally no concreting shall be done at night, however in case concreting during night becomes necessary proper lighting arrangement shall be made beforehand for concreting to continue at night.

#### 7.4.8 **Construction Joints**

7.4.8.1 Construction joints must be approved before concrete is poured and shall comply with IS 11817 (latest edition).

7.4.8.2 Concreting shall be carried out continuously up to construction joints.

7.4.8.3 Construction joints shall be located at accessible locations to permit cleaning out laitance, cement slurry and unsound concrete in order to create rough/uneven surface.

7.4.8.4 At location of high Shear resistance, a shear key is to be provided.

7.4.8.5 The vertical construction joint in a RCC wall should be formed at pre-determined position with a temporary particle board form work having suitable openings for



the continuity of reinforcement. This particle board shall be removed after the concrete has set-in sufficiently to retain its verticality and shape, before concreting is resumed in the adjacent portion.

7.4.8.6 Construction joint between floor and vertical wall of water tank shall be provided with PVC water stops. Concurrence and approval of the Purchaser will have to be obtained before providing such joints.

#### 7.4.9 Inserts

The embedded portion of all anchors, anchor bolts, inserts, pipe, conduit, sleeves, floor angles, frames, nosing bolts etc. shall be black without any coating or painting. All the inserts to be cast into the concrete shall be placed in correct position before pouring. Block-outs and openings shall be kept wherever required.

#### 7.4.10 Cleaning and Finishing

Except where a special finish is called for, all exposed concrete shall be finished as follows:

7.4.10.1 All fins and other projections shall be neatly chipped, rubbed down and made smooth; form oil shall be entirely removed by stiff fiber brushes. The use of acid shall not be permitted. All exposed corners shall be slightly rounded or chamfered. Air holes, cavities and similar imperfections shall be first saturated with water and filled with a mortar mixture of the same composition as that used in the concrete. After initial set of mortar, the surface shall be rubbed down with burlap. A stucco coat shall be allowed to be applied to the surfaces. The inside surfaces shall be ground smooth with carborundum stone.

7.4.10.2 Except where a separate finish is to be applied, or where a trowel finish is called for horizontal concrete surfaces shall be floated.

7.4.10.3 Where a trowel finish is called for the surface shall be floated and steel troweled after achieving initial set to prevent excess fine materials from working to the surface. The finish shall be brought to a smooth dense surface free from defects and blemishes. No dry cement nor mixture of dry cement and sand shall be done after the concrete is so hard that no mortar accumulates on the trowel and a ringing sound is produced as the trowel is drawn over the surface.

#### 7.4.11 Curing

7.4.11.1 Unless otherwise specified all concrete shall be cured by keeping all exposed surfaces, edges and corners continuously moist for at least seven days for ordinary Portland cement after being placed, by spraying, ponding or covering with waterproof paper or moisture retaining fabric. In case where mineral admixtures or blended cements are used, minimum period of curing shall be increased to 10 days.

7.4.11.2 For the concrete containing, Portland pozzolana cement, blended cement, period of curing shall be extended to 14 days.



#### 7.4.12 Form Work

- 7.4.12.1 Forms shall be true to the shape, lines and dimensions of the concrete work. Reference shall be made to IS: 14687 regarding design, detailing etc. All details of formwork, placing, tying etc. shall be subject to the approval of the Purchaser.
- 7.4.12.2 For concrete surfaces are to be finished smooth, the lining of forms shall be of smooth non-absorbent lining material. All edges of panels shall be square and straight in both directions, and all panels shall match perfectly in length, width and alignment as required.
- 7.4.12.3 All forms shall be thoroughly cleaned and sufficiently tight to prevent the loss of liquid from the concrete.
- 7.4.12.4 Form lumber may be reused, provided that it is true, unwrapped, thoroughly clean and without broken or damaged edges and equal in use in every respect to a new lumber. All reform lumber shall have the contact surfaces recoiled or re-coated with an approved composition prior to usage.
- 7.4.12.5 Contractor shall keep an accurate record of the date on which the concrete is cast for each part of the work and the date upon which the formwork is removed.
- 7.4.12.6 In normal circumstances and where ordinary Portland cement is used and adequate curing is done, forms may generally be removed after the expiry of the followings:
- |   |              |
|---|--------------|
| a) Walls, columns and vertical faces      | 16 to 24 hrs |
| b) Slabs (props left under)               | 3 days       |
| c) Beam soffits (props left under)        | 7 days       |
| d) Removal of props under slabs:          |              |
| Spanning up to 4.5m                       | 7 days       |
| Spanning over 4.5m                        | 14 days      |
| e) Removal of props under beams & arches: |              |
| Spanning up to 6m                         | 14 days      |
| Spanning over 6m                          | 21 days      |
| f) Cantilever slab                        | 14 days      |

For cement other than ordinary portland cement, the stripping time required as per 7.4.12.6 shall be suitably modified as per Purchaser instruction.



#### 7.4.12.7 (i) Dimensional Tolerance for formwork:

The Tolerances on the shapes, lines and diversion are given below:

- |  |  |
|--|--|
| a) Sectional dimensions of Columns & beam. | +12mm & -6mm.  |
| b) Plumb                                   | 3mm for every metre. Max. 10mm for the concrete structure. |
| c) Levels & heights                        | ± 5mm before any deflection has taken place.               |
| d) Unevenness of any surfaces              | ± 3 mm   |
| e) Length and breadth                      | ± 12mm   |
| f) Diagonals                               | ± 15mm   |

#### (ii) Dimensional Tolerance for setting out

- |  |         |
|--|---------|
| a) Building                                | ± 10mm  |
| b) Pipe and channels                       | ± 20mm  |
| c) Underground lines, off shore structures | ± 100mm |

#### 7.4.13 Bending and Placing of Reinforcement

The reinforcements shall be bent and fixed in accordance with procedure specified in IS: 2502 (latest edition). Only fusion bonded epoxy coated bars shall be used for all buildings, structures and foundations. Plastic coated binding wire shall be used for epoxy coated bars.

#### 7.4.14 Testing and Acceptance Criteria

##### 7.4.14.1 General

The testing shall be carried out either at Purchaser's laboratory at site or at any other approved Government Laboratory in accordance with the relevant Indian Standards and as supplemented herein for the following items. The mould and material for cubes and cylinder shall be supplied by the Contractor, who shall also arrange to transport the cubes/cylinders to the laboratory at his cost. Samples should be taken in presence of the representative from the Owner and the Contractor. The contractor shall submit to the Purchaser the test results in triplicate within three days (3) after completion of test.

##### 7.4.14.2 Cement

- i) All deliveries of cement shall be accompanied by certified mill test report and shall include all the physical and chemical properties as required by relevant IS codes.
- ii) The manufacturer's test certificate will normally be accepted as proof of compliance with the specifications, but the Purchaser may order further tests as specified in appropriate Indian standards.



- iii) The information such as date of manufacture, date of original loading, destinations enroute, intended date of delivery to site, shall be provided for all cement shipments (either whole or part).

#### 7.4.14.3 Aggregates

The aggregates shall be tested as and when required by the Purchaser in accordance with IS: 2386 (Part-I to VIII). The aggregates shall comply with the requirements of IS-383 as far as possible preference shall be given to natural aggregates.

#### 7.4.14.4 Water

Sampling and testing of water being used for concrete work as per IS: 3550 will be carried out at regular intervals and wherever directed by the Purchaser. The permissible limit for solids shall be as per table-I of IS-456 (latest edition). Water used for mixing is also suitable for curing concrete however, they should not produce any objectionable stain. The pH value of water shall not be less than 6.

#### 7.4.14.5 Admixtures

Tests for establishing the various properties of any admixtures which may be required to be added shall be carried out by the contractor free of charge to the owner. Admixture shall comply with IS-9103. Admixtures should not impair durability of concrete nor combine with constituent from harmful compounds nor increase the risk of corrosion. The workability, compressive strength and slump, loss of concrete with & without the use admixtures shall be established during trial mix.

#### 7.4.14.6 Concrete

- i) The sampling of concrete, making the test specimen and testing procedure etc. shall be in accordance with IS: 1119 and IS: 516. The size of the specimen shall be 15cm cube. Normally only compression tests shall be performed but under special circumstances the Purchaser may require other tests to be performed in accordance with IS: 516.
- ii) Procedure laid down otherwise in IS: 456 shall be followed for sampling and strength test of concrete.
- iii) The acceptance criteria for the compressive strength shall be as per clause 16 of IS :456 -2000.
- iv) Concrete of each grade shall be assessed separately.
- v) Concrete shall be assessed daily for compliance.
- vi) Concrete is liable to be rejected if it is porous or honey combed its placing has been interrupted without providing a proper construction joint; the reinforcement has been displaced beyond the tolerances specified or construction tolerances have not been met. However, the hardened



concrete may be accepted after carrying out suitable remedial measures to the satisfaction of the Purchaser.

- vii) In case of doubt regarding the grade of concrete used, either due to poor workmanship or based on the results of cube strength tests, compressive strength tests of concrete on the basis of clause no.17.4 and/or load tests as per clause 17.6 of IS 456-2000 shall be carried out and on the basis of result of such test structure shall be accepted or rejected by the Purchaser.
- viii) The entire cost of load testing shall be borne by the Contractor. If a portion of the Structure is found to be unacceptable, it shall be dismantled and replaced by a new structure as per specification. The entire cost of dismantling and replacement and restoration of the site shall be borne by the Contractor.

## **7.5 TECHNICAL SPECIFICATIONS FOR REINFORCEMENT**

### **7.5.1 Reinforcement**

7.5.1.1 Reinforcing steel shall be clean and free from loose mill scales, dust, loose rust and coats of paints, oil, grease or other coatings, which may impair or reduce bond. It shall conform to the following:

- (i) Mild steel & medium tensile steel bars shall conform to Grade-I of IS: 432 Part-1 (latest).
- (ii) High strength steel bars shall conform to IS 1786 (latest) of grade Fe 415, Fe- 500 or Fe 500D.
- (iii) Structural steel conforming to Grade-A of IS: 2062 (latest).
- (iv) Hard-drawn steel wire fabric conforming to IS: 1566 (latest).

7.5.1.2 All steel reinforcements, including and above 6mm diameter shall necessarily be of tested quality. The untested steel reinforcement shall not be allowed to be used.

7.5.1.3 Reinforcement accessories shall be furnished by the contractor. Binding wire shall be plastic coated wire quality not less than No. 16 swg. (1.65mm dia). Bar support, chairs and bolsters as required and as approved by the Purchaser shall be sufficiently strong to support the steel reinforcement properly. The cost of all reinforcement accessories shall be included in the price bid.

7.5.1.5 Contractor shall fabricate and place reinforcement to shapes and dimensions, as per IS: 2502 "Code of Practice for Bending and Fixing Bars for concrete Reinforcement" (latest) and as indicated in approved drawings of the contractor. The reinforcement shall be either plain corresponding to grade Fe– 250 for M.S. and Fe– 415, Fe500/Fe500D for HYSD bars or deformed steel bars conforming to relevant I.S. specifications. However, the minimum elongation for Fe– 415, Fe500/Fe500D shall be as per IS 1786.



- 7.5.1.6 The contractor shall prepare bar bending schedule on the basis of the approved drawings marked released for construction and submit the same for approval to the Purchaser. No work shall be commenced without the approval of the Schedule.
- 7.5.1.7 Any adjustments in reinforcement to suit field conditions and construction joints other than shown on approved drawings shall be subject to approval of the Purchaser.
- 7.5.1.8 The contractor shall adhere strictly to requirements for concrete cover over steel reinforcement, protection of bars for bonding with future extensions, columns, ties, splices, laps, spacer bars, temperature reinforcement, mesh reinforcement and other items in connection with proper placing.
- 7.5.1.9 Reinforcement shall be placed accurately, tied or welded securely at intersections and splices and held in position with spacers or other approved supports during concrete placement. The wire ends should point away from surface.
- 7.5.1.10 Fusion bonded epoxy coated reinforcement bars shall be used in case of coastal plants or where subsoil has sulphate or chloride above permissible limit.
- 7.5.1.11 Plastic coated binding wire shall be used for epoxy coated bars.
- 7.5.1.12 Coated binding wire shall be incorporated into the spacer blocks to enable them to be securely attached to the horizontal or vertical bars and the contractor shall demonstrate both that the blocks are of requisite strength and that the means of attachment to the reinforcement are adequate.
- 7.5.1.13 Binding wire shall be annealed iron wire quality not less than No. 16 swg (1.65mm dia). Bar supports, chairs, spreaders, spacers and bolsters shall be sufficiently heavy to support the reinforcement steel properly and shall be approved by the Purchaser.
- 7.5.1.14 Each consignment of the reinforcement shall be accompanied by the test certificate by the manufacturer showing that the steel has been tested and analysed and that such tests and analysis comply in all respects with the standards. Following tests shall be carried out on the reinforcement.
- (i) Cast analysis (ii) Carbon equivalent value (iii) Tensile strength, yield stress, elongation (iv) Bend test (vi) Bond classification.
- 7.5.1.15 Epoxy coating of reinforcement**
- (a) The contractor shall furnish written certification from the coating applicator that the coated bars were cleaned, coated and tested in accordance with the requirement of the specifications of IS 13620-93. Each batch shall be given test certificate for adhesion, coating thickness and continuity of coating.



- (b) Coating materials shall be heat cured epoxy resin powders applied by electrostatic spray process. The minimum thickness of coating shall be 250 micrometer.
- (c) Reinforcement required to the bent shall be bent cold and in such a manner and using plastic or rubber coated formers that there is no direct steel/rebar contact and that neither bar nor coating is in any way damaged, all in accordance with the recommendations of the coating factory and to the approval of Purchaser. After cutting and bending, each bar shall be thoroughly inspected and any damage repaired. As a precaution, the external surfaces of all bends shall receive two coats of liquid repair material, as shall the last 100 mm of each end of each bar. All repairs and precautionary coating shall be carried out by liquid repair epoxy material as per manufacturers specifications.

7.5.1.16 Rejection: The Purchaser at his discretion may order random testing of reinforcement steel and in an event of any failed test reject an entire lot notwithstanding the manufacturers or coating applicators certificates.

#### **7.5.2 Erection of Steel Embedded Parts Including Anchor Bolts, Anchors, Openings, Sleeves, Inserts and Other Built-In- Fixtures**

7.5.2.1 For erection of steel embedded parts, the Contractors shall provide necessary temporary bracing or supports to ensure proper installation of the materials. All materials shall be erected in the true location as shown in the drawing, plumb and level. The exposed surface of embedded steel parts like threads etc. shall be protected for rusting and tempering.

7.5.2.2 The contractor shall provide openings, grooves, etc. in concrete work as required for erection of equipment and structures.

7.5.2.3 The contractor shall erect all embedded parts in accordance with the construction drawings and specifications including setting materials in concrete or grouting pieces in place, furnishing all labour, scaffolding, tools and services necessary for incidental to its transporting, unloading, storing, handling and erection.

7.5.2.4 Exposed surface of embedded materials are to be painted with one coat of approved anti-corrosive paint and/or bituminous paint without any extra cost to the Purchaser.

### **7.6 TECHNICAL SPECIFICATION FOR BRICK MASONRY WORKS**

#### **7.6.1 General Requirements**

7.6.1.1 Masonry products such as face bricks, common bricks and tiles shall be products of producers or suppliers approved by the Purchaser.

7.6.1.2 All materials shall be delivered to the site, stored and handled so as to prevent inclusion of foreign substances, damage by breakage, exposure to the weather





and contact with the soil. Cementitious materials shall be delivered in unbroken containers or packages and stored in weatherproof enclosures.

### 7.6.3 **Materials**

7.6.3.1 Cement shall be ordinary portland cement of 43 grade or 53 grade conforming to IS 8112 and IS 12269 (latest edition) respectively or Portland Pozzolana cement conforming to IS 1409 (latest).

7.6.3.2 Water for mortar shall be clean and potable and free of salts, iron and injurious amounts of organic matter.

7.6.3.3 Sand having fineness modulus not less than 2.25 shall conform to the requirements of IS: 650 (latest edition) The grading of sand for use in masonry mortar shall be as per IS: 2116 and IS : 383 (latest edition).

7.6.3.4 Common bricks and face bricks shall conform to the requirements of IS: 1077 (latest edition) and shall be of uniform colour, strength and size. Bricks shall not absorb more than 20% of their own dry weight when soaked in water.

7.6.3.5 Crushing strength of class designation 10 bricks and brick tiles shall not be less than 100 kg/sq.cm. and of class designation 7.50 bricks not less than 75 kg/sq.cm.

7.6.3.6 Fly ash bricks shall be used to increase the fly ash utilization in line with requirement of MoEF&CC notification in this regard. Fly Ash bricks requirements shall comply to IS: 12894 – 2002. The minimum average wet compressive strength of fly ash bricks shall not be less than 7.5 N/mm<sup>2</sup> and water absorption ratio shall not be more than 20% by weight after immersion in cold water for 24 hours.

7.6.3.7 Wall ties shall be 6mm mild steel "U" or "Z" shaped 50mm less in depth than the width of the wall into which they are built, spaced 400mm centers vertically or provided at every fifth course.

7.6.3.8 Reinforcement for masonry walls wherever required shall be of mild steel 6mm plain rods, welded/tied to the wall ties at every fifth course of brick work.

7.6.3.9 Samples of all materials shall be submitted for the approval of the Purchaser.

7.6.3.10 Mortar of specified proportions as shown in the drawings shall be mixed by volume with just enough water added to produce a workable mixture. Only freshly prepared mortar shall be used. Mortar shall conform the requirements of IS: 1925 (latest edition).

### 7.6.4 **Bonds and Coursing**

7.6.4.1 All masonry walls shall be laid with horizontal courses level and true in English bond. All masonry units shall be laid up in full beds of mortar with all units butted solidly against adjacent units with mortar in between.



- 7.6.4.2 All masonry units having appreciable water absorption potential shall be soaked as per relevant IS code.
- 7.6.4.3 Vertical surfaces of all masonry walls and partitions shall be plumb and true to line on uneven surface with maximum total variation of 25mm in any plane or 12.5 mm in 5 meters.
- 7.6.4.4 Where two walls meet or intersect, the masonry course shall be carried up together, bonding at least fifty percent of the units at the intersection.
- 7.6.4.5 Horizontal surfaces of masonry not being worked on shall be protected from the natural elements by the use of non-staining waterproof coverings, properly secured in place.
- 7.6.4.6 Brick tiles where shown in drawings shall be laid with staggered vertical joints and shall be bonded to the brick walls.
- 7.6.4.7 Masonry in contact with structural steel including beams and columns, shall be anchored to the steel works as indicated in the drawings.
- 7.6.5 Built- In- Works**
- 7.6.5.1 Built-in-works shall be carried out as per instructions communicated by the Purchaser during or before the work is taken up.
- 7.6.5.2 Door frames shall be set plumb and accurately aligned and checked for proper position
- 7.6.5.3 Anchors for door frames, copings, bonding walls to concrete and structural steel and other anchors shall be securely and accurately located and installed.
- 7.6.5.4 Water-proofing membrane within masonry walls, where required shall be carefully installed in accordance with the relevant section in these specifications.
- 7.6.5.5 Steel lintels and base plates shall be set over doors or other openings where required. The lintels or lintel plates shall be set in cement mortar grout.
- 7.6.5.6 All structural steel members enclosed or in contact with masonry work shall be water-proofed with a heavy coating of asphaltic mastic of approved quality.
- 7.6.6 Masonry Joints**
- 7.6.6.1 All joints in masonry wall surfaces to receive cement plaster shall be raked out to a depth of 12mm to create mechanical bond for the plaster finish.
- 7.6.6.2 Joints in exterior walls to be left exposed shall be neatly tooled with a weathered joint.
- 7.6.6.3 Where masonry shuts penetrating built-in-terms such as doors frames etc. the joints shall be 6mm wide and raked to a depth of 20mm for subsequent caulking.



### **7.6.7 Cleaning**

- 7.6.7.1 All exposed brickwork shall be scrubbed down with clean water and rinsed thoroughly.
- 7.6.7.2 All work stained or discoloured during the process of cleaning shall be replaced by the Contractor at his own expenses.
- 7.6.7.3 Green work shall be protected from the effects of sun, rain etc. by suitable covering. All the masonry work shall be kept constantly moist on the faces for a period of seven days.
- 7.6.7.4 The contractor shall carry out all scaffolding and planking necessary for efficient execution of work at all levels.
- 7.6.7.5 At the end of construction, the contractor shall ensure proper plugging of all openings made for supporting the scaffolding.

## **7.7 TECHNICAL SPECIFICATIONS FOR DAMP PROOF COURSE**

### **7.7.1 Cement Concrete Layer**

- 7.7.1.1 This shall consist of cement concrete 1:2:4 (1 cement: 2 coarse sand: 4 stone aggregate of 12.5mm nominal size) equivalent to grade M-15 of 50mm thickness.
- 7.7.1.2 The surface of the brick work shall be levelled and prepared before laying the cement concrete. Edges of DPC shall be straight and even. The side shuttering shall consist of steel forms and shall be strongly and properly fixed so that it does not get disturbed during compaction and mortar does not leak through. The concrete mix shall be of workable consistency and dense. When the side shutterings are removed, the surface should come smooth without any honey combing.

### **7.7.2 Curing**

The DPC shall be cured for at least 7 days after which it shall be allowed to dry.

### **7.7.3 Application of Hot Bitumen**

Cement concrete shall be allowed to dry for 24 hours after curing and apply a coat of residual petroleum bitumen of grade VG-10 having penetration 80/100 of approved qualities and hot bitumen at the rate of 1.7 kg/sq. meter shall be applied over the dried surface of cement concrete properly cleaned with brushes and finally with a cloth soaked in Kerosene oil. The bitumen shall be applied uniformly so that no blank spaces are left anywhere.

## **7.8 TECHNICAL SPECIFICATIONS FOR PLASTERING AND POINTING**

### **7.8.1 Plastering**



### 7.8.1.2 **Materials**

7.8.1.2.1 Cement shall be ordinary portland cement of 33 grade or 43 grade or 53 grade conforming to IS: 269, IS:8112 & IS:12269 (latest edition) respectively or Portland Pozzolana cement conforming to IS:1489 (latest edition).

7.8.1.2.2 Water shall be clean, potable and free from salt, acid and injurious amounts of organic matter.

7.8.1.2.3 Sand shall be clean, fine, sharp siliceous particles free from loam, clay, salts and organic matter and shall conform to the requirement of IS: 1542 (Latest edition) and shall be within limits of grading zone IV or zone V.

### 7.8.1.3 **Mortar**

Specified mortar shall be used.

### 7.8.1.4 **Preparation of surfaces**

Dust and mortar powder shall be brushed out of the joints. The surface shall be thoroughly washed with water, cleaned and kept wet before plastering is commenced.

### 7.8.1.5 **Plastering process**

7.8.1.5.1 Brick walls shall be provided with 12 mm thick plaster on even surface and 15mm thick plaster on rough face with 1:4 cement mortar (1 cement : 1 Coarse Sand & 3 Fine sand).

7.8.1.5.2 Plastering shall be started from the top & worked towards the ground. The mortar shall be applied in uniform layers throughout the surface and neatly worked over by wooden trimmers. The surface shall be made even and the finishing completed within half an hour of the addition of the water to the dry mortar.

7.8.1.5.3 All corners, angles and junctions shall be truly vertical or horizontal as the case may be and shall be neatly finished. Rounding of corners and junctions where required shall be done without any extra payment.

7.8.1.5.4 No portion of surface shall be left out initially to be patched up later on.

7.8.1.5.5 Any crack which may appear on the surface and all portions which sound hollow whereas tapped or are found to be soft or otherwise defective, shall be cut out & redone as directed by the Purchaser.

### 7.8.1.6 **Curing**

Curing shall be started as soon as the plaster has hardened sufficiently not to be injured. The plaster shall be kept wet for a period of at least 7 days. During this period it shall be adequately protected from the sun, rain and other damages.

### 7.8.2 **Pointing**



### 7.8.2.1 General

Pointing shall be of the type specified such as 'flush', 'ruled', 'cut', or 'weather struck' and 'raised' or 'cut' etc.

### 7.8.2.2 Process of pointing

7.8.2.2.1 All joints shall be raked to such a depth that the minimum depth of the new mortar measured from either the sunk surface of the finished pointing or from the edge of the rake shall not be less than 12mm. Mortar of specified mix only shall be used.

7.8.2.2.2 The mortar shall be pressed into the raked out joint with a pointing trowel either flush, sunk or raised according to the type of pointing required. The mortar shall not spread over the corner, edges, surfaces of the masonry. The pointing shall then be finished with the proper tool as required for the particular kind of pointing specified. The superfluous mortar shall then be cut off from the edges of the lines and the surface of the masonry shall also be cleaned off all mortar. The finish shall be such that the pointing is of exact size and shape and edges shall be straight, neat and clean.

### 7.8.2.3 Curing

The pointing shall be kept wet for 7 days. During this period, it shall be suitably protected from all damages. The pointing lines shall be truly horizontal and vertical except where the joints are slanting as in Random Rubbles Masonry. Lines of joints from different directions shall meet neatly at the junctions instead of crossing beyond.

## 7.9 TECHNICAL SPECIFICATION FOR FLOORING

### 7.9.1 Concrete Floors

7.9.1.1 The concrete floors in the ground floor having earthen sub-grade but excluding toilet rooms (Flooring of toilet rooms shall be with Vitrified Ceramic Anti-skid tiles of approved size and make) shall comprise the following:

- (i) 100mm thick sand filling. In case of weak soils, 200 mm compacted stone soling shall be provided.
- (ii) 100mm thick cement concrete 1:3:6 (1 cement: 3 coarse sand and 6 graded stone aggregate 10mm & below).
- (iii) 38mm thick cement concrete 1:2:4 (1 cement: 2 coarse sand: & 4 graded stone aggregate 10mm and below).

7.9.1.2 The concrete floors in the intermediate floors of the building except toilet rooms shall consist of:

- i) 38mm thick C.C. 1:2:4 (1 cement: 2 coarse sand: 4 granite stone aggregate 10mm nominal gauge) with 20mm normal size.



- ii) 12mm thick surface hardening treatment, as per specification clause no. 7.9.2

#### 7.9.1.4 Materials

All materials such as cement, fine & coarse aggregates and water shall be as per standard already stipulated.

#### 7.9.1.5 Sand filling under floors

Clean sand free from dust, organic matter and other foreign materials obtained locally and approved by the Purchaser shall only be used. The sand shall be laid, watered and compacted with hand rammers to the required level and slope. Crushed stone sand or crushed gravel sand as per IS: 383 may be used where availability of river sand is scarce.

#### 7.9.1.6 Installation/laying

7.9.1.6.1 For R.C.C. slabs which are to receive a separate topping the surface treatment shall be as follows. When the structural slab has partially hardened so that it will not retain the impression of a broom it shall be brushed with steel bristle broom removing all laitance and scum. The brooming shall expose some of the aggregates and score the material to provide a mechanical bond for the topping material.

7.9.1.6.2 The mixed concrete of proper consistency shall be laid on cement concrete sub-grade after cleaning the sub-grade of all dirt and loose material & applying a neat cement slurry of mix 1:1 (1 cement and 1 coarse sand). The concrete floor shall be laid in panels of size 1m x1m. Alternative panels shall be laid on one day followed by the other group of alternate panels the next day. The edges of the panels shall be supported by 3mm thick glass strips.

7.9.1.6.3 The concrete shall be laid gently in the panels and tamped with wooden mallets till a cream of mortar covers the structure.

7.9.1.6.4 The junction of floor and walls, floors and skirting shall be rounded off as directed without any extra payment. The dado shall be of 21mm thick cement mortar 1:3 (1 cement: 3 coarse sand) a floating coat of neat cement up to a 2.10 high. The finished surface shall be cured as per IS specifications.

### 7.9.2 Floor Hardening Treatment

#### 7.9.2.1 Materials

All materials such as cement, fine and coarse aggregates and water shall be as per standards already stipulated. Metallic hardener of approved quality only shall be used.

#### 7.9.2.2 Application



7.9.2.2.1 A sub-grade 38mm thick of CC 1:2:4 (1 cement: 2 coarse sand: 4 Stone aggregate 20mm nominal size) shall be laid in proper grade on which hardening as specified herein shall be laid before the sub-grade sets.

7.9.2.2.2 The surface hardening treatment to the flooring shall consist of laying a 12mm thick concrete of mix 1:2 (1 cement hardner mix and 2 stone aggregate 6mm nominal size by volume with which metallic/synthetic compound of approved quality shall be mixed with cement in the ratio of 4:1 (4 cement and 1 metallic hardener) by weight. The ingredients shall be mixed dry before water is added. All the operations described under concrete floors shall be followed in laying the surface hardening treatment.

### 7.9.2.3 Curing

Curing shall commence only when the top layer has hardened minimum of ten days & should continue for minimum of ten days.

## 7.9.3 Acid/Alkali Resistant Flooring

### 7.9.3.1 General

This covers the requirements to complete the acid/alkali resistant floor laid over a uniform sub-grade of concrete 1:2:4 either of PCC or RCC to make the thickness of acid/alkali floor 100mm. Floor shall be provided with three coats of bituminous acid/chemical resisting paint. Over this, shall be provided 12mm thick chemical resisting bitumastic laid in 6mm layers. Floor and curb shall be covered by acid /alkali resisting bricks/tiles of 75mm/40 mm thickness. The joints, 6mm wide, which shall be raked for a depth of 20mm, shall be pointed with acid/alkali resisting cement.

### 7.9.3.2 Materials

7.9.3.2.1 **Bituminous acid resisting paint:** The material shall be such a composition that it will meet the requirement of IS: 157 (latest edition). Material shall be tested as per standards prescribed in IS: 157. This is generally of heavy grade bituminous corrosion (acid/alkali) resisting paint. It shall have smooth and uniform consistency. Its drying time shall not be more than 8 hours. Its finish shall be smooth, glassy and elastic.

7.9.3.2.2 **Acid/alkali resistant bitumastic:-** Chemical resistant bitumastic shall consist of an acid-proof inorganic filler and blended bitumen. Bitumen shall be of grade 90/15 and 15 conforming to IS: 702 (latest edition). This acid/alkali resistant bitumastic shall be solid at ordinary temperature. It shall become paste on heating and shall be troweled to concrete in 6mm layers. It shall be resistant to Acid/Alkali. It shall be non-porous and its density shall be about 2250 kg/Cu.m.

### 7.9.3.2.3 Acid/alkali resistant bricks and tiles

(a) **Bricks:** These bricks are made of raw materials, such as clay or shale of suitable composition with low lime and iron content, felsper, flint or sand



and vitrified at high temperature in ceramic kilns. Finished brick when fractured shall appear fine-grained in texture, dense and homogenous. The brick shall be sound, true to shape, flat and free from flaws and other manufacturing defects affecting their utility. Bricks shall conform to Class-I of I.S. 4860(latest) specifications for acid/alkali resistant bricks.

- (b) Tiles:-** Vitreous Ceramic tiles shall be made of materials like clay, felspar quartz, tale and vitrified at high temperature in ceramic kilns and kept unglazed so as to prevent from slipperiness when laid on floor. Tiles shall conform to IS: 4457(latest edition).

**7.9.3.2.4 Acid resistant mortar:** - This shall be of silicate type mortar and resistant to most acids except hydrofluoric and phosphoric acid. This is an intimate mixture of chemically inert solid filler, a setting agent contained in filler and a liquid silicate binder. When filler and binder are mixed at ordinary temperature, a trowelable mortar is formed which hardens by chemical reaction between the joint.

Mortar shall conform to IS: 4832 (Part-I)(latest edition). Its flexural strength (7 days) shall not be less than 35 kg/sq.cm. Its compression strength (7 days) shall not be less than 100 kg/sq.cm.

**7.9.3.2.5 Acid/alkali resistant cement:-** It shall be supplied in powder and syrup form to meet the requirements of acid and alkali resistance. It shall be resistant to sulfuric acid, hydrochloric acid, sodiumhydroxide, calciumhydroxide and other chemicals. Its tensile strength shall not be less than 35 kg/sq.cm. Its compressive strength shall not be less than 140 kg/sq.cm ( 7 days) and 350kg/sq.cm (28 days). It shall meet the requirements of IS: 4832 Part-I and IS: 4443 (latest edition).

## **7.10 TECHNICAL SPECIFICATION FOR WATER PROOFING OF ROOFS**

### **7.10.1 General**

It covers all works for water proofing with Glass Fibre based Felt of type 2 and Grade-1 conforming to IS: 7193 –2013 with alternate layers of hot bitumen.

### **7.10.2 Specification**

The minimum weight of glass fiber tissue shall be 40 gm/m<sup>2</sup> and nominal thickness of 0.5 ± 0.1 mm. Blown bitumen shall conform to IS 702:1988 or residual bitumen conforming to IS 73:1992 may be used as bonding material.

### **7.10.3 Application**

Application of Water Proofing Nine Course Extra Heavy Treatment.

- i) Provide suitable slope on the roof (say 1 in 20) with PCC 1:2:4. Heat insulation shall be provided wherever indicated.





- ii) Clean the surface (to be made waterproof) with wire brush and plaster with 12-mm thick cement mortar 1:4 (1 cement: 4 fine sand).
- iii) Clean the plastered surface and prime with bitumen primer at the rate of 0.4 kg/sq.m.
- iv) Apply first coat of hot bitumen @ 1.2 kg/sq.m (min) conforming to IS : 702.
- v) Embed the first layer of glass fiber base felt Type-2 Grade-1.
- vi) Apply second coat of hot bitumen @ 1.2 kg/sq.m (min).
- vii) Embed the second layer of glass fiber base felt type-2 Grade-1.
- viii) Apply third coat of hot bitumen @ 1.2 kg/sq.m (min).
- ix) Embed the third layer of glass fiber base felt Type-2 Grade-1.
- x) Apply fourth coat of hot bitumen @ 1.2 kg/sq.m (min).

#### 7.10.4 Surface Finish

The surface should be finished with brick tiles 40 mm thick laid in cement mortar 1:3 (1 cement :3 coarse sand).

#### 7.10.5 Guarantee

A written guarantee for the water tightness shall be given for a minimum period of 10 years.

### 7.11 TECHNICAL SPECIFICATION FOR STEEL DOORS, PANEL DOORS, STEEL WINDOWS, VENTILATORS AND ROLLING SHUTTERS

#### 7.11.1 Steel Doors And Panel Doors

##### 7.11.1.1 Steel doors

##### 7.11.1.1.1 Materials

Steel sections used for fabrication of doors, windows, ventilators etc. shall be standard rolled sections specified in IS 1038 and IS: 1361. Steel sheets for frames, shutters etc. shall be of gauge mentioned in this specification. The hot rolled steel sections shall conform to IS:7452 (latest edition). Fire check doors shall conform to IS:3614 (latest edition). Hardware and fixtures of the best quality from approved manufacturers shall only be used.

##### 7.11.1.1.2 Fabrication of door frames

Frames shall be fabricated as per IS: 4351 (Latest edition). They shall be mortised, reinforced, drilled and tapped for hinges and lock and bolt strikes. Where necessary frames shall be reinforced for door closer.



### 7.11.1.1.3 Fabrication of single sheet door shutters

Single sheet doors shall be made from best quality 18-G mild steel sheets and shall present a flush surface on the outside. The inside shall be stiffened with semitubular edge and central stiffening rail which shall carry the lock and other fixtures.

Doors shall be mortised, reinforced, drilled and tapped in shop for hinges, locks and bolts. They shall also be reinforced for closer push-plates and other surface hardware where necessary. Any drilling and tapping required for surface hardware shall be done at site.

Wherever required provisions shall be made for fixing glazing, vision panels, etc. Glazing moulding shall be 18 G steel and suitable for fixing 5.5mm glass.

### 7.11.1.2 Panel doors

7.11.1.2.1 The panel inserts shall be 12mm thick solid board made out from seasoned Deodar wood.

7.11.1.2.2 The stiles and rails of panel doors shall be made out of seasoned Deodar wood. The size of stiles and rails, lock rails and bottom rails shall be 100 mm x 35mm. There should be two panels and the center lock rail should be covered with aluminum sheet on both the sides.

7.11.1.2.3 Paint for priming shall be formulated from basic lead sulphate paste in oil, and two coats of synthetic enamel paint shall be applied as per clause 1.02.3.

### 7.11.1.2.4 Fittings for fixtures for doors:

Except otherwise specified or indicated on the drawings, trim and finishes for fittings shall be as follows:

- i) All exposed fittings (namely lower bolts, sliding bolts, butt hinges, door handles and knobs), other than butts, hinges and door closer shall be of oxidised mild steel.
- ii) Each door shall consist of following fittings:
  - a) For single shutter
    1. Lower bolts = 2 Nos.
    2. Sliding bolts = 1 No.
    3. Door handles = 2 Nos.
  - b) For double shutter
    1. Lower bolts = 3 Nos.
    2. Sliding bolts = 1 No.
    3. Door handles = 3 Nos.



## 7.11.2 Steel Windows and Ventilators

### 7.11.2.1 Materials

- i) Frames and sash for windows and ventilators shall be of standard rolled steel sections for industrial buildings and shall conform in all respects to requirements of IS Code 1361 (latest edition).
- ii) The windows where openable shall be provided with cam handles 2 Nos., tower bolts 2 Nos. and stays 2 Nos. All these fittings shall be of oxides of iron of appropriate size, quality and shall be subject to the approval of the Purchaser.
- iii) Windows operations, except as otherwise indicated, shall be by means of cam handles of approved design and construction.
- iv) All the windows and ventilators in the ground floor level shall be provided with MS Grills of approved design.

### 7.11.2.2 Installation

7.11.2.2.1 Windows shall be set plumb and true, properly aligned and securely anchored in place.

7.11.2.1.2 Ventilator where openable shall be correctly balanced with uniform tension to hold ventilator in any open position and they shall be equipped with limit stop and alignment guides as approved. All ventilators shall be correctly adjusted before glazing and rechecked after glazing.

7.11.2.1.3 The contractor shall properly protect windows and ventilators during construction and shall thoroughly clean all plaster, mortar or other foreign material from them at the completion of all building operation

7.11.2.1.4 All metal in windows and ventilators shall be given a priming coat of red lead and two coats of synthetic enamel paint of approved quality.

## 7.11.3 Glass and Glazing Work

### 7.11.3.1 Materials

7.11.3.1.1 Glass shall be of a quality of 4mm thickness 10 kg/m<sup>2</sup> clear double strength conforming to IS: 1761 (latest edition).

7.11.3.1.2 Glass on windows/ventilators shall be fixed with steel sections by counter sunk screws.

7.11.3.1.3 Glazing compound shall be Bostic single part silicon sealant, which shall be applied along the periphery of the glass.

## 7.11.4 Glazing works



7.11.4.1 The sizes of glass panels and proper edge clearance shall be determined by measuring the actual unit to receive the glass.

7.11.4.2 The installed glass shall bear the manufacturer's label indicating the type, thickness and quality of the applied materials.

7.11.4.3 Moveable sections shall be kept closed and locked until glazing compound has sufficiently set.

7.11.4.4 Upon completion of the works, all glass surfaces shall be thoroughly cleared of all labels, and other defacement. Cracked, broken and imperfect glass shall be replaced at no additional cost to the owner.

7.11.4.5 The glasses on all windows and ventilators shall be fixed in such a way. That then replacement can be done from inside the buildings where they are provided.

#### 7.11.5 **Rolling Shutters**

The rolling shutters shall be of mechanically operated type and shall be complete with hood, guides, springs, bearing etc. Suitable provisions for automatic tripping of motor/motors in case of jamming or over loading shall be provided. In case of electrically operated shutters, these shall also be capable of being operated mechanically by two men. Shutter shall conform to IS: 6248-1971 (latest edition).

### 7.12 **TECHNICAL SPECIFICATIONS FOR PLINTH PROTECTIONS**

#### 7.12.1 **Materials**

##### 7.12.1.1 **PCC (M-20) topping**

After the sub-grade has been compacted thoroughly, PCC (M-20) topping shall be laid with thickness (75 mm) of cement concrete floors with a minimum outward slope of 1 in 48.

##### 7.12.1.2 **Peripheral U-drain**

The peripheral U-drain shall have a minimum depth of 200 mm at the beginning and width sufficient to carry the rainwater. It shall have suitable longitudinal slope and shall be properly linked to the nearest storm water drain. This drain shall have U-shaped bottom made of PCC (M-20). The side walls of the drain shall be of brick walls (II class) of suitable height and width in 1:6 cement mortar duly plastered exposed surfaces (15 mm thick) in 1:4 cement mortar.

### 7.13 **TECHNICAL SPECIFICATION FOR MISCELLANEOUS STEEL**

#### 7.13.1 **Materials**



7.13.1.1 Miscellaneous steel parts shall include all items such as anchor bolts, pipe sleeves, puddle flange through floors and walls, equipment mounting plates/frames, steel pieces set in concrete for frames and support frames, concrete inserts, expansion bolts etc. Miscellaneous steel shall be furnished by the contractor, detailed and fabricated by him in accordance with the requirements as indicated in the detailed drawings.

#### **7.14 TECHNICAL SPECIFICATION FOR PAINTING, ACRYLIC EMULSION (INTERIOR)/WEATHER PROOF ACRYLIC EMULSION (EXTERIOR) PAINT**

7.14.1 The walls & ceiling shall be provided with Acrylic emulsion paint (interior) of reputed make over prepared base. The outer face of building shall have peach colour weather proof acrylic (exterior) paint. Columns, beams parapet and plastered area shall have mid cream colour weather proof acrylic emulsion (exterior) paint. All the steel work shall have first quality paints of approved make/shades. The boundary wall shall be provided with weather proof acrylic emulsion (exterior) paint. All fire fighting MS pipes shall have post office red colour paint.

##### **7.14.1.1 Materials**

The Acrylic interior emulsion and weather proof exterior acrylic emulsion paints shall be of superior quality. The material should be brought to site in sealed condition and stored properly. All paints and allied materials shall be of 1st quality manufactured by standard firms. and meet the requirements of following Indian Standards for metallic surfaces and shall be of approved brands and manufacturer and of approved shade. a) Primer for Iron, steel etc. shall be conforming to IS: 2074. The primer shall be ready mixed primer. b) Synthetic enamel paint shall be conforming to IS: 117, IS: 133 and IS: 137 of first quality.

##### **7.14.1.2 Application**

###### **a) Acrylic interior emulsion/weather proof acrylic emulsion:**

Two to three coats shall be applied over a priming coat as detailed below:

###### **(i) Preparation of surface**

For new work the surface shall be thoroughly cleaned of dust. In case of previously painted surface, it shall be thoroughly scraped to remove loose or flaking material, dust, grease and dirt. Ensure that the surface is free from fungus, algae and moisture. Treat the infected surface with a liberal coat of fungal solution, if required. Apply a coat of suitable cement primer solvent/water thinnable followed by wall putty of same make or wall cement putty, if required to level the dents and make surface uniform. Sand the surface with emery paper no. 180 and wipe clean. Apply another coat of primer and allow drying. Sand the surface gently with emery paper no. 320 and wipe clean. For parapet walls and horizontal surface apply 3 coats on freshly plastered wall after necessary priming coats.

###### **(ii) Priming coat**



The priming coat shall be done with matching brand by thinning with 100% volume/weight with clean water followed by two coats of topcoat. Manufacturer guidelines may be followed.

- (iii) Minimum time interval of at least 6 hours maximum upto 7 days shall be allowed between successive coats to permit proper drying of preceding coat.

#### **b) Painting**

- (i) All rust & scale be removed by scrapping or by brushing with steel wire brush.
- (ii) The primer coat shall be allowed to dry before painting is started.
- (iii) The putty around glass panes shall also be painted.
- (iv) The additional coats of paint etc. shall be provided if required for the required finish as per Executive Engineer/ Civil Works Division.

#### **7.14.2 Water Proof Cement Paint**

##### **7.14.2.1 Materials**

Water proofing cement paint of approved quality and shade and conforming to IS 5410 shall be used in original. The cement paint shall be brought to site of work by contractor in sealed containers.

##### **7.14.2.2 Preparation of surfaces**

7.14.2.2.1 The surface shall be thoroughly cleaned of all water droppings, dust, foreign material, grease etc. by brushing and washing. All patches and cracks in the surface shall be repaired to make the surface smooth. The surface shall be wetted thoroughly with clean water before the application of paint.

7.14.2.2.2 To avoid cracking and flaking, working in the sunshine shall be avoided. In dry weather, the surface after application shall be lightly sprayed with water to keep the surface moist.

##### **7.14.2.3 Application**

7.14.2.3.1 The cement paint shall be mixed with water and prepared in accordance with the manufacturer's instructions. Only that much quantity of paint shall be mixed at a time which is sufficient for an hour's work.

7.14.2.3.2 The paint shall then be applied on the surface by means of brushes in horizontal and vertical strokes which together shall constitute one coat. Subsequent coats shall be applied after the previous one has set at least for 24 hours. Before application of second or subsequent coat the surface of the previous coat shall not be wetted.

7.14.2.3.3 To avoid cracking and flaking, working in the sunshine may be avoided. In dry weather the surface after application shall be lightly sprayed with water to keep it wet.

#### **7.14.2 Synthetic Enamel Paint**



#### 7.14.2.1 **Materials**

The synthetic enamel paint shall conform to IS:2932 (latest edition) for exterior finish and IS:3537 (latest edition) for interior work.

#### 7.14.2.2 **Surface preparation**

7.14.2.2.1 The surfaces to be painted shall be thoroughly brushed to remove accumulated dust and all loose or powdered material. A coat of ready mixed alkali resistant primer conforming to IS: 109 shall then be applied over the prepared surface. The next lay, a second but a slightly heavier coat of primer shall be applied.

#### 7.14.2.2.2 **Application**

- (a) UNDER COAT : One coat of specified ordinary paint corresponding to IS:2932 or IS:2933 (latest edition) suited to shed of top coat, shall be applied and rubbed with finest grade of wet abrasive to ensure smooth even surface.
- (b) TOP COAT : Top finishing coat of synthetic enamel paint of desired shade shall be applied after the under coat is thoroughly dry.

### 7.15 **TECHNICAL SPECIFICATION FOR GROUTING**

#### 7.15.1 **General**

This the work of grouting of blockouts, foundation bolt holes and space between bottom of base plate and top of foundation concrete and any other work required for grouting.

#### 7.15.2 **Materials**

7.15.2.1 Cement: used shall be ordinary Portland cement 43 grade or 53 grade conforming to IS:8112 and IS:12269 (latest edition) respectively issued by the Purchaser.

7.15.2.2 Sand shall conform to the stipulations contained in IS-383 (latest edition) and shall have a fineness modulus not exceeding 3 and not less than 2.5.

7.15.2.3 Water shall be clean and fresh and shall be of potable quality.

7.15.2.4 Aluminum powder or anti-shrinkage admixture of standard brand from a reputed manufacturer shall be used. Instead, shrinkomp by ACC Ltd or equivalent, which is a ready mix concrete containing cement can also be used. Materials to be used shall be got approved by the Purchaser prior to their use on work.

7.15.2.5 The blockouts and bolt holes which have to be grouted shall be cleaned thoroughly by use of compressed air immediately before taking up the grouting operation.



- 7.15.2.6 Grouting shall be adopted for filling blockouts, foundation bolt holes and space between the underside of base plates and top of foundation concrete. Mortar made up of cement and sand in the proportion of 1:1 by weight and blended with aluminium powder (about 0.005% by weight of cement) or anti-shrinkage admixture in a suitable proportion to the cement mortar in accordance with the recommendation of the manufacturer and subject to the approval of Purchaser, shall be used.
- 7.15.2.7 Cement, sand and aluminium powder or approved anti-shrinkage admixture shall first be blended thoroughly in the required proportion. The mortar shall then be prepared by mixing with a quantity of water, which will produce a sufficiently workable mix to enable complete and proper compaction of the mortar.

## **7.16 TECHNICAL SPECIFICATION FOR SUPPLY, FABRICATION AND ERECTION OF STRUCTURAL STEEL**

### **7.16.1 Design & Detailing**

- 7.16.1.1 Structural steel design shall be carried out as per I.S. –800.
- 7.16.1.2 Lateral forces along the length of building will be resisted by bracings. The transverse lateral loads will be resisted by stiff jointed frame action. Additional bracings or moment connection will be used to assure stability of the structures.
- 7.16.1.2 Steel will conform to grade -A of I.S. 2062 (latest) for rolled steel members or plates upto 20mm thickness. For plates above 20mm thickness steel conforming to grade -B (killed and normalized) of IS- 2062 shall be used except for crane girders where grade-C (IS-2062) steel shall be used. Steel shall be procured from approved main producers.
- 7.16.1.3 Chequered plates shall conform to I.S. 3502 and minimum thickness of chequered plates for flooring, covers etc. shall be 6mm O/P.
- 7.16.1.4 Shop connections shall be welded and field connections will generally be bolted unless specified otherwise. Field bolts wherever provided shall be high tensile bolts of dia 20mm or more. The bolted joints shall be designed for friction type connection and the HT bolts shall be tightened to develop the required pretension during their installation. Nominal connections in the field like purlins, stairs etc. will be done by 16mm dia. M.S. black bolts (minimum property class 4.6) conforming to I.S. 1363. All removable type connection shall be with bearing type HT bolts of grade 8.8.
- 7.16.1.5 For all field connections whether welded or bolted, 80% of the shop design strength shall be considered.
- 7.16.1.6 Design of connection.
- i) Connection of vertical bracings with connecting member and diagonal of truss members shall be designed for full tension capacity of the member.





- ii) Size of fillet weld for flange to web connection for built up section shall be as follows.
  - a) Full shear capacity or actual shear whichever is more for box section.
  - b) 80% of full shear (if indicated on drawing) or 0.5 times of the web thickness whichever is more for I – section. The weld shall be double fillet.
  - c) All welds shall be continuous. The minimum size of fillet weld shall be 6mm.
  - d) Shear connection shall be designed for 75% of section strength or actual shear for rolled sections and 80% of section strength or actual shear whichever is higher for built up section or rolled section with cover plates.
  - e) Moment connection between beam and column shall be designed for 100% of the moment capacity of the beam section.
- iii) All butt welds shall be full penetration butt welds.
  - a) The connection between top flange and web of the crane girder shall be full penetration butt weld and for bottom flange connection may be fillet weld.
  - b) Connection of base plate and gusset members with columns shall be done considering that the total load gets transferred through weld.
  - c) Splicing: All splicing shall be full strength. Field splicing shall be done with web/flange cover plates. For exceptional cases the field splicing shall be designed for 50% of load carried by cover plates and remaining 50% of load through full penetration butt weld. Shop splicing for all sections other than rolled sections shall be carried out by full penetration butt welds with no cover plates. Splicing for all rolled sections shall be carried out using web and flange cover plates.

#### 7.16.2 Test At Works and Test Certificate

7.16.2.1 The contractor shall arrange for all materials procured by him to be tested as and when required and in the presence of the representative of Purchaser if so desired.

7.16.2.2 Test samples shall be cut out of the materials from the location indicated by the Purchaser and samples shall be prepared in accordance with the requirements of Indian Standard specification for conducting such tests. For each set of tests three samples shall be taken for tensile strength test and bend test.



7.16.2.3 Copies of all test certificates relating to materials procured by the Contractor for the works shall be forwarded to the Purchaser.

#### 7.16.4 Fabrication

7.16.4.1 The fabrication works shall be carried out generally in accordance with IS: 800 as well as the stipulation contained in these specifications. All materials shall be completely fabricated at site fabrication yard and finished with proper connection materials for ready assembly at erection site.

7.16.4.2 All steel materials shall be straight and free from bends or twists, if the sections are distorted or twisted during transit, storage etc., they shall be straightened and/or flattened by straightening machine at ambient temperature though minor kinks or bends may be corrected by limited heating under careful supervision, without any extra cost to the Purchaser.

7.16.4.3 The permissible fabrication deviation of structural steel work shall be within the limits as mentioned in IS:7215 (latest edition).

#### 7.16.5 Bending

The bending of plates and sections to specially required shapes shall be done either on appropriate machine or by angle smithy and black smithy work carried out manually on bending plate.

#### 7.16.6 Cutting

Cutting may be effected by shearing, cropping, sawing or by gas cutting by mechanically controlled torch. Gas Cutting by hand may only be used when specifically authorised in writing by the Purchaser. The edges of all plates shall be perfectly straight and uniform throughout. Shearing, cropping and gas cutting shall be clean squares and free from distortion and burrs and should the Purchaser find it necessary, the edges shall be ground afterwards by the Contractor without any extra cost to the Purchaser.

#### 7.16.7 Grinding

All the edges cut by flame shall be ground before they are welded.

#### 7.16.8 Clearance

The erection clearances for cleated ends of members connecting steel to steel shall not be greater than 2mm at each end unless specifically approved by the Purchaser, in which case suitably designed seatings shall be provided.

#### 7.16.9 Holes

7.16.9.1 Holes for bolts shall not be formed by a gas cutting process except in special cases with specific permission of the Purchaser.

7.16.9.2 To facilitate grouting and escape of air holes shall be provided wherever necessary in column bases.



7.16.9.3 Wherever a horizontal member is likely to collect water suitable holes for drainage shall be provided.

7.16.9.4 Contractor shall have to drill holes/set backs for other works connected with his works at no extra cost.

#### 7.16.10 Notches

The ends of all joist, beams and girders shall be cut truly square unless required otherwise and joist flanges shall be neatly cut away or notched where necessary the notches being kept as small as possible. Corners of such notches in flange shall be shaped to a radius of 50mm.

#### 7.16.11 Assembly

The component parts shall be assembled in such a manner that they are neither twisted nor otherwise damaged and shall be so prepared that the specified camber, if any, is provided. In order to minimise distortion in a member the component parts shall be positioned by using clamps, clips, dogs, jigs and other suitable means and fasteners (bolts and welds) shall be used in a balanced pattern. If the individual components are to be bolted, parallel and tapered drifts shall be used to align the parts so that the bolts can be accurately positioned.

#### 7.16.12 Bolting

7.16.12.1 Every bolt shall be provided with a steel washer under the nut so that no part of the threaded portion of the bolt is within the thickness of the parts bolted together.

7.16.12.2 All bolts and nuts shall be of steel with well formed hexagonal heads unless specified otherwise forged from the solid and shall be dipped in hot boiled linseed oil as soon as they are made. The nuts shall be good fit on the bolts and two clear threads shall show through the nut when it has been finally tightened up.

#### 7.16.13 Stairs, Railing and Ladders

7.16.13.1 All stairs and intermediate landings shall be constructed to size, dimensions and design, as indicated on the detailed drawings. Each stairway shall be fabricated as a complete unit which shall include struts, hangers, posts, cross bracing, cleats and accessories, as required for connection to structural steel framing and concrete.

7.16.13.2 Gratings for stair treads and landings shall be of rectangular pattern to match floor grating as specified.

7.16.13.3 Stair treads shall be furnished complete with punched and slotted carrier plates attached ready to bolt to stair stringers tread shall be provided with an approved type anti-slip nosing set flush with the stair tread.

7.16.13.4 Grating treads and gratings for landings of interior stairs shall be paint finished as specified for floor gratings.



7.16.13.5 Pipe hand rails, as specified in detailed drawings, shall be assembled with flush type fittings and welded joints, ground and polished smooth. Railings shall be provided with all necessary fittings, posts, brackets bolts, plates and similar accessories and shown on the approved drawings and as required for proper installation.

7.16.13.6 Vertical ladders shall be as called for on the approved drawings. The ladders shall be provided with support arms formed of bend steel plate or chip angles. Where shown on the drawings, the ladders shall have loose neck supports designed to form hand grabs and end brackets for fastening to abutting construction. Maximum deviation in the linear dimensions of railing, stairs and ladders from the approved dimensions shall not exceed 12 mm.

#### 7.16.14 Foundation Bolts

7.16.14.1 **Foundation bolts shall be embedded in first stage concrete. The bolts shall preferably be provided in pipe sleeves permitting adjustments in the proper alignment of these bolts to match holes in the column bases otherwise templates shall be used for proper alignment of the bolt. The grouting shall be carried out after second stage concrete.**

7.16.14.2 The contractor shall be responsible for the correct alignment and levelling of all steelwork on site and to ensure that the columns are in plumb. The permissible erection tolerances for the structural members shall be as given in the table below:

**Table 7.1: Permissible Erection Deviation of Structural Steel**

Sl. No.	Type of structures & construction	Nature of deviations	Value of deviation
1.	Columns	a) Shifting of columns axis with respect to marked axis (in the lower section). b) Deviation of column axis from vertical (in upper section). i) Heights of columns up to 10m ii) Height of column more than 10m. c) Deflection of column.	$\pm 5$ mm  10mm  1/1000 of col. height but not more than 35 mm.  $\pm 1/1000$ of col. height but not more than 15 mm.  $\pm 5$ mm.



		d) Deviation of bearing surface of col. from design level.	
2.	Trusses, collar beams, beams of purlines	a) Deviation in levels of supporting joints of trusses, joints of trusses and collar beams. b) Deviation of upper chord (in the middle of span) from vertical planes, running through center of supports c) Deflection of straight section of compression chord from the plane of truss, collar beam or girder. d) Deviation in distance between purlins.	$\pm 20$ mm  1/250 of structure height  1/1500 span but not more than 10 mm.  $\pm 5$ mm.

### 7.16.15 Fabrication Drawings

7.16.15.1 The fabrication works shall be started only after the fabrication drawings showing complete details of each steel member, its joint/connection, weld length, etc. are prepared and got approved by the Purchaser.

7.16.15.2 The fabrication drawings shall be based on the design drawings approved by the Consultants and in accordance with IS: 800 (latest revision).

## 7.17 TECHNICAL SPECIFICATIONS FOR SAND FILLING

### 7.17.1 General Requirements

7.17.1.1 Sand shall be clean and free from dust, organic and foreign matters subject to approval of Purchaser.

7.17.1.2 The spaces for filling shall be cleaned of all debris, bricks bats etc. The filling shall be done in layers not exceeding 20 cm each layer. Consolidation of each layer shall be done by flooding with water. The surface of the consolidated sand shall be dressed to required level or slope. Concreting of floor above sand filling shall not be started till the Purchaser has inspected and approved of the sand filling.

## 7.18 TECHNICAL SPECIFICATIONS FOR PIPES AND PIPE FITTINGS

### 7.18.1 General

This covers the installation of the various pipes, viz. (i) rain water pipes, (ii) water supply pipes and fittings (comprising of GI pipes and sockets, Brass fittings) (iii) cast iron and spun iron pipes and fittings, (iv) Stoneware pipes and (v) concrete pipes for catering to the requirements of internal and external arrangement for water supply and drainage in buildings/structures as specified.

### 7.18.2 Materials, Installation and Testing



7.18.2.1 All materials shall conform to the relevant IS specifications. Samples of all materials, before actual use, shall be shown to the Purchaser and got approved by him.

7.18.2.2 Before installation of the pipes and their fittings the contractor shall submit his plans and drawings for execution of the job, which shall be got approved by him. The installation procedure as prescribed in I.S. specification shall be followed. Rain water pipes shall have lead jointing.

#### 7.18.2.3 **Testing and commissioning**

All pipes and their fittings installed shall be tested as per relevant IS specifications in the presence of Purchaser or his representative and the test results submitted to him for approval.

### 7.19 **TECHNICAL SPECIFICATION FOR SANITARY FITTINGS**

#### 7.19.1 **General Requirements**

7.19.1.1 All the materials and fittings used shall be sourced from vendors approved by the Purchaser

7.19.1.2 Any damage caused to the building or to electric, sanitary, water supply or other installations etc. either due to negligence on the part of the contractor or due to actual requirements of the work, shall be made good and the building or the installations shall be restored to its original condition by the Contractor without any extra cost to the Purchaser.

#### 7.19.2 **Testing Of Pipelines For Drainage And Sanitation**

##### 7.19.2.1 **General guidance for the tests are given below**

###### (a) **Smoke test**

All soil pipes, waste pipes and vent pipes and all other pipes when above ground shall be approved gas tight by a smoke test conducted under a pressure of 25 mm of water and maintained for 15 minutes after all trap seals have been filled with water. The smoke is produced by burning oily waste or tarpaper or similar material in the combustion chamber of a smoke machine. Chemical smokes are not satisfactory.

###### (b) **Water test (cast iron pipes)**

Cast iron pipes shall be subjected to a test pressure of at least 1.50 M head of water at the highest point of the section under test. The tolerance figure of two liters per centimeters of diameter per kilometer may be allowed during a period of 10 (ten) minutes. The test shall be carried out by suitably plugging the low end of the drain and the ends of connection, if any, and filling the system with water. A knuckle bend shall be temporarily jointed in at the top and at a sufficient length of the vertical pipe jointed to it so as to provide the required test head or the top end may be plugged with a



connection to a hose ending in a tunnel which could be raised or lowered till the required head is obtained and fixed suitably for observation.

Subsidence of test water may be due to one or more of the following causes:

- i) absorption by pipes and joints/
- ii) Seating of pipes or joints.
- iii) Leakage at Joints or from defective pipes.
- iv) Trapped air.

Allowance shall be made for by adding water until absorption has ceased and after which the test proper should commence. Any leakage and the detective part of the work shall be cut out and made good.

## **7.20 TECHNICAL SPECIFICATIONS FOR OPEN SURFACE DRAIN**

The size of the drain as specified shall be the width of the drain at the top, measured between the masonry walls. The drains shall be given, as far as possible, uniform slope from the starting point to discharge point

## **7.21 TECHNICAL SPECIFICATION FOR PAINTING AND FINISHING OF STRUCTURAL STEEL WORKS**

### **7.21.1 General**

This covers the cleaning, preparation and painting of all surface requiring field painting and finishing in accordance with the schedule drawings.

### **7.21.2 Materials**

All painting materials shall be of ACMI – Aluminall or ACMI-Code or equivalent (IS:289) indigenously available, formulated and prepared by an approved manufacturer.

### **7.21.3 Preparation of Surfaces**

7.21.3.1 Surfaces shall be clean and dry and free from grease, dust, rust, loose particles, scale and efflorescence prior to application of paint.

7.21.3.2 Abraded portions of structural steel and miscellaneous steel shall be cleaned with solvents and wire brushed where required and spot primed with a material equivalent to and compatible with the material used for the shop prime coat.

7.21.3.3 Hollow steel doors and frames shall have abraded shop prime touched up with equivalent material.

7.21.3.4 Hand rails, toe plates, hangers and stair stringers shall be spot primed.

7.21.3.5 Masonry surfaces to be painted shall be broom-cleaned, wire brushed where required and crevices and voids shall be filled with an approved filler material. All efflorescence shall be removed in an approved manner.



7.21.3.6 Plaster surfaces to be painted shall be smooth and dry, free of dusting and crevices shall be filled with patching plaster.

7.21.3.7 Concrete surfaces to be painted shall be thoroughly cured, and shall be dry and free of dust, loose particles and foreign material. The surface shall be brushed with stiff fibre brush before painting.

#### 7.21.4 **Application**

7.21.4.1 Painting operations shall not be proceed until the Purchaser has the opportunity to inspect the condition of the prepared surface to be painted.

7.21.4.2 Prime coat, Intermediate and finish coats of paint shall be applied in strict conformance with the manufacturer's printed directions. Paint shall be thoroughly mixed and not more than ½ Kg of recommended thinner per 4.5 litres of paint shall be added if thinning is necessary.

7.21.4.3 Brushes and paint containers shall be kept clean. Exterior painting shall not be performed during periods of inclement weather. Interior painting may proceed during such periods only with the approval of the Purchaser.

7.21.4.4 All painting shall be done as per Manufacturer's Specifications.

7.21.4.5 The contractor shall prepare and submit samples step-by-step representative of the quality of the work that he is to perform, for approval of the Purchaser. Each sample shall be divided into equal parts of size large enough to be used for comparison with the actual work performed.

#### 7.21.5 **Clean-Up**

The contractor shall remove all equipment, un-used material and debris resulting from painting operations and shall leave the site in a condition acceptable to the Purchaser.

### 7.22 **TECHNICAL SPECIFICATION FOR DEMOLITION & DISMANTLING WORK**

#### 7.22.1 **General**

All materials obtained from the demolition shall be the property of the owner unless otherwise specified.

#### 7.22.2 **Terminology**

##### 7.22.2.1 **Dismantling**

The term dismantling implies carefully separating the parts without damage & removing.

##### 7.22.2.2 **Demolition**

The term Demolition implies breaking up. This shall consist of demolishing whole or part of work including all relevant items as specified or shown on the drawings.

##### 7.22.3 **Precautions**





All demolition/dismantling work shall be carried out in conformance with the local safety regulations as per IS – 4130 and extreme caution being exercised to avoid damage to the work and the equipment, which is to be left intact. Necessary precautions shall be taken to keep the dust nuisance down.

## **7.23 TECHNICAL SPECIFICATIONS FOR VIBRATION ISOLATION SYSTEM FOR MACHINE FOUNDATIONS (IF REQUIRED)**

### **7.23.1 General**

7.23.1.1 Block Foundation/ Frame Foundation with Vibration isolation system may be provided for HT voltage drives viz. booster fans, limestone crushers, mills, slurry recirculation pumps etc.

7.23.1.2 The vibration isolation system supplied should be of proven make. The bidder should have designed spring supported machine foundations, manufactured, supplied and installed vibration isolation system consisting of steel helical spring units (conforming to DIN 2096 & DIN 2089) and viscous dampers (providing damping resistance in all three planes) for not less than 25 (twenty five) machine foundations of heavy rotating machine systems. All the foundation systems should be in successful operation (without replacement) for at least three years as on the date of bid opening.

7.23.1.3 Individual spring units supplied should have load carrying capacities ranging from 100 KN to at least 1000 KN. The largest spring units supplied should have a load carrying capacity of not less than 1000 KN. The spring units have stiffness in both vertical and horizontal directions with the horizontal stiffness not less than 50% of vertical stiffness. The stiffness should be such that the vertical natural frequency of any spring unit at its rated load carrying capacity is not more than 3 Hz.

7.23.1.4 The damper units or spring-cum-damper units should be of viscous type offering velocity proportional damping. The damper units should be suitable for temperatures ranging from 0 to 50° C. The damping resistance of individual damper units should be such that the designed damping can be provided using reasonable number of units. The bidder should be able to supply damper units with damping resistance ranging from 40 kN Sec/m to 750 kN Sec/m.

7.23.1.5 In case of elevated foundations such as pedestals/walls, the sizes of the spring units, damper units and spring-cum-damper units should be such that groups of such units can be accommodated on the top of these pedestals/walls.

7.23.1.6 The bidder shall furnish information about the entire range of spring units, damper units and spring-cum-damper units manufactured by him to enable the owner to do the engineering. The information to be furnished should include the load carrying capacity, stiffness (vertical & horizontal), damping resistance, and dimensions of spring and damper units.

### **7.23.2 Codes of Practice Standards**



Latest revisions of the following codes shall be used for the design of the spring supported foundations:-

- IS : 456 Code of practice for plain & reinforced concrete.
- IS : 2974 Code of practice for design & construction of machine foundations.
- IS : 1893 Criteria for earth quake resistant design of structures.
- DIN : 4024 Machine foundations: Flexible supporting structures for machine with rotating masses.
- DIN : 2089 Helical compression springs out of round wire and rod: Calculation & design.
- DIN : 2096 Helical compression springs out of round wire and rod: Quality requirements for hot formed compression springs.
- VDI : 2056 Criteria for assessing Mechanical vibrations of machine.
- VDI : 2060 Criteria for assessing the state of balance of rotating rigid bodies.

### 7.23.3 Supporting Arrangement

The supporting arrangement for equipment shall consist of an RCC deck supported on vibration isolation system consisting of steel helical spring units and viscous dampers, which in turn shall be supported on RCC sub structure.

### 7.23.4 Equipment Supply

The equipment to be furnished for vibration isolation system shall comprise of the following:

- a) Steel helical spring units and viscous damper alongwith viscous liquid including associated auxiliaries for installation of the spring units and dampers like steel shims, adhesive pads, etc.
- b) Frames for prestressing of spring elements.
- c) Suitable hydraulic jack system including electric pumps, high pressure tubes etc. required for the installation, alignment etc. of the spring . One set of extra hydraulic jacks, and hand operated pumps shall also provided.
- d) Any other items which may be required for the complete installation for satisfactory commissioning of the spring system.

### 7.23.5 Documentation

The bidder shall furnish the following:

- i) A comprehensive write-up for each foundation indicating manner and details of providing staging and shuttering for RCC deck including tolerances, clearances required etc. The manner of dismantling the staging the shuttering shall also be stipulated.
- ii) Special requirements, if any, regarding concreting of the top
- iii) Complete step-by-step procedure covering the installation and commissioning of the spring system.
- iv) Manuals for installation, commissioning, testing and maintenance of the spring support system.



- v) A check list for conforming the readiness of the civil fronts for installation of vibration isolation system and equipments required at each stage of installation.
- vi) Bill of materials of various elements such as ash spring units, viscous dampers, with their rating, stiffness etc. included in the supply
- vii) Any other details which Owner/Consultant may consider necessary to facilitate design and construction of the foundations/structures.

#### **7.23.6 Packaging & Transportation**

All the equipments shall be suitably protected, coated, covered or boxed and crated to prevent damage or deterioration during transit, handling and storage at site till the time of erection. While packing all the materials, the limitations from the point of view of availability of railway wagon sizes, in India should be taken into account. The contractor shall be responsible for any loss or damage during transportation, handling and storage due to improper packing.

#### **7.23.7 Realignment of Spring System**

If any realignment of the spring system is required to be done for aligning the shaft or for any other reasons during the first one year of operation from the date of commissioning the same shall be done by the contractor without any cost to the Purchaser.

#### **7.23.8 Performance Guarantee**

The contractor shall guarantee the performance of the vibration isolation system for 24 months from the date of commissioning of each machine which shall be termed as "Guarantee Period".

#### **7.23.9 Design Life Of Foundation**

The spring supported foundation shall be designed for a minimum operating life of 30 years.

### **7.24 TECHNICAL SPECIFICATION FOR PRE-CAST RCC SLABS**

#### **7.24.1 General**

7.24.1.1 The precast ribbed slabs shall be manufactured at the project site for which adequate area will be given free of charge. The contractor shall arrange at his own cost necessary sheds etc. for casting, arrange for necessary facilities during and after manufacture, provide the sufficient handling equipment for curing in curing tanks the cast pieces and for stacking.

7.24.2 Materials used shall conform to those for cement concrete described elsewhere in this Section.

#### **7.24.3 Concrete Mix**



- 7.24.3.1 The concrete mix. shall conform to IS 456 (latest edition) for concrete. The compressive strength as measured by strength test at 28 days shall be as indicated on the drawings for different pieces of construction.
- 7.24.3.2 Aggregates shall be mixed by weight and the water cement ratio shall be controlled so as to obtain the densest concrete and the strength required.
- 7.24.3.3 The forms for the pre cast elements shall be made up of steel of sufficient thickness so as to be rigid and obtain a smooth surface after the forms are struck. The contractor shall submit detailed drawings of form work for the approval of the Purchaser. Finishing with the cement mortar shall not be allowed. Vibration shall be carried out with form vibrators mounted on to form work. In addition, rodding shall be done to ensure that the concrete material is evenly spread and fills all inaccessible regions. Nothing extra shall be paid for form work.
- 7.24.3.4 Curing shall be carried out for a period of seven days from the day of casting.
- 7.24.4 Bending and placing of reinforcement shall be as described for cement concrete elsewhere in this Section.

#### **7.24.5 Fixing In Position Of Structural Steel Embedments**

Structural steel in the form of angles, flats etc. which shall be supplied, fabricated by the Purchaser within the project area shall be transported and embedded in position in various pre cast members to correct lines and levels by means of welding or otherwise as indicated in the detailed working drawings.

#### **7.24.6 Sampling And Testing In Field**

Refer specifications for concrete.

#### **7.24.7 The Erection of Pre-Cast Slabs**

- 7.24.7.1 The pre-cast slabs shall rest on the steel structure.
- 7.24.7.2 The pre-cast elements shall be welded in position to the structural steel by means of matching pieces embedded already in the pre cast element.
- 7.24.7.3 The space between adjacent pre cast slabs shall be filled with cement concrete of suitable grade (a grade higher than that of the pre cast elements). The W/c ratio shall be kept to the minimum. It shall be as directed by the Purchaser.
- 7.24.7.4 After the erection of the pre cast pieces at site, the hooks provided for lifting purposes shall be cut flush to the surface of the slab.



## **7.25 TECHNICAL SPECIFICATION FOR METAL SHEET ROOFING, SIDE SHEETING AND ACCESSORIES**

### **7.25.1 General**

The work described herein shall cover providing and installing metal sheet roofing and cladding including translucent sheets and all accessories such as flashings, cappings, gutters, trims, supporting straps, brackets, foam fillers, sealants and the work shall be carried out strictly in accordance with this specification and applicable drawings.

### **7.25.2 Materials**

Material for sheets and accessories shall strictly conform to BIS/BS/ASTM/AS specifications as mentioned. Supplier shall furnish test certificates for verification of the same and shall make arrangements for inspection and marking of the materials at his works. Erection shall not be started before approval of materials including all accessories.

Length shall be such that numbers of joints are minimum. Wherever specified, to avoid longitudinal overlaps for larger span, sheets shall be of single length and shall be site formed.

### **7.25.3 Steel Roofing/Cladding Sheet**

High tensile Galvalume (AZ 150 gsm) SMP colour coated (in approved colour) or equivalent profile shall be used. Total coat thickness (TCT) of sheets shall be minimum 0.55 mm with base metal thickness without any coating shall be minimum 0.50 mm with minimum yield stress 550MPa.

Galvalume sheets shall conform to AZ 150 gsm of AS 1397 or ASTM 792 with hot-dip metallic coating of 55% Al and 45% Zn alloy having total coating mass of min. 150 gms/m<sup>2</sup> inclusive of both sides.  
The colour to be used for coating shall be intimated.

### **7.25.4 Translucent Sheets**

Skylights and Wall lights shall be made of translucent white acrylic modified, ultraviolet stabilised, fibreglass with minimum thickness of 2 mm and tensile strength of 10.3 kN/cm<sup>2</sup>. Translucent panels shall provide the same coverage as the panel width with length of 3600 mm. The translucent panels shall meet the light transmission value of 80%(+5%) according to ASTM D 1494.

### **7.25.5 Roof Extractors**

Roof extractors shall be fixed in position as per approved drawings. The work shall include making required opening in the sheeting, fixing the extractors as per the manufacturer's instructions with necessary fasteners. Lead fillers, felts or any other specified flashing shall be tucked into the sheeting. The lead flashings used shall be weighing not less than 30 Kg/sq. meter.



### 7.25.6 Accessories

Materials and coatings for ridge capping, barge capping, apron flashing, cover flashing, monitors and expansion joints shall be manufactured out of the same material as roofing / cladding sheets material and shall be shaped to match sheet profile.

## 7.26 TECHNICAL SPECIFICATION FOR G.I. ROOF & SIDE SHEETING AND ACCESSORIES

### 7.26.1 General

This covers the general requirements for G.I. sheeting for roofing and side cladding including all accessories and fixtures.

### 7.26.2 Materials

7.26.2.1 Galvanised steel corrugated sheets shall be hot dipped galvanized conforming in all respects to IS : 277 with a coating of grade 750.

7.26.2.2 The galvanized sheets shall be of the thickness, as specified and shall be of approved quality and manufacture as approved by Purchaser.

7.26.2.3 The sheets shall be free from cracks, pitting, blisters, split edges, twists, laminations, scales and other surface defects. Sheets shall be clearly sheared and be free from twist or buckle and shall have uniform corrugations, true in depth and pitch parallel to the sides of the sheet. The galvanized coating shall be clean, bright, smooth and free from ungalvanised spots and other defects. The sheets supplied shall show no sign of rust or white powdery deposits on the surface.

### 7.26.3 Storage of Materials

7.26.3.1 **Sheets shall be stacked to a height of not more than one metre on firm and level ground, with timber or other packing beneath them.**

7.26.3.2 Galvanised steel materials of same variety and size shall be stacked together.

7.25.3.3 All galvanized materials shall be protected from damage while stored on site preferably in sheltered store. If they are to be placed in an exposed position, they shall be protected from damage by wind and rain by providing a suitable cover.

7.26.3.4 Contractor shall exercise great care in handling the sheets and accessories. Damaged material shall not be stacked with sound materials. All damaged or rejected materials shall be removed from site immediately.

### 7.26.4 Laying

7.26.4.1 The sheets shall be laid on the purlins/other roof members and side girts as indicated on the drawings or as instructed by Purchaser



- 7.26.4.2 The maximum spacing of purlins shall be 2 m, 1.8 m and 1.6 m for sheets of 1.0mm, 0.8 mm and 0.63 mm thickness respectively.
- 7.26.4.3 Before the actual laying of sheets is started, the purlin spacing and the length of the sheets shall be checked to ensure proper laps and the specified overhang at the eaves. The end lap of the sheets shall always fall over a purlin/side girt.
- 7.26.4.4 The bearing surface of all purlins/other roof members and side girts shall be in one plane so that the sheets being fixed shall not be required to be forced down to rest on the purlins/side girts. The finished roof shall present a uniform slope and lines of corrugations shall be straight and true and the completed work shall present a neat and uniform appearance and be leak proof. For side sheeting, corrugation shall be vertical and in one plane.
- 7.26.4.5 The sheets shall be laid with a minimum lap of 150 mm at the ends and 2 ridges of corrugations at each side. In the case of roofs with a pitch flatter than 22 degrees or in the case of very exposed situations, minimum end laps shall be 200 mm. The side laps shall be laid on the side facing away from the prevailing monsoon winds. The minimum lap of sheets with ridges, hips and valleys shall be 200 mm measured at right angles to the line of ridge, hip or valley respectively. The free overhang of the sheets at the eaves shall not exceed 300 mm.
- 7.26.4.6 The sheets shall be cut to suit the dimensions or shape of the roof, either along their length or their width or in a slant across their lines of corrugations at hips and valleys. They shall be cut carefully with a straight edge and chiseled to give a smooth and straight finish. The corrugated galvanized sheets shall not generally be built into gables and parapets. They shall be bent up along their side edges close to the wall and the junction shall be protected by suitable flashing or by a projecting drip course covering the junction by at least 75 mm.
- 7.26.4.7 Where slopes of roofs are less than 22 degrees, sheets shall be joined together at the side laps by galvanized iron seam bolts and nuts of size 25 mm x 6 mm, each bolt with a bitumen and G.I. limpet washer or with a G.I. limpet washer filled with white lead. The seam bolts shall be placed zigzag over the two overlapping corrugations at a spacing not exceeding 600 mm along each of the staggered rows.
- 7.26.4.8 All laps in G.I. sheets shall be painted with one coat of zinc rich primer and two coats of approved paint before fixing in place.

#### 7.26.5 Fixing

- 7.26.5.1 Sheets shall be secured to the purlins and other roof members by means of 8 mm diameter galvanized iron J or L hook bolts and nuts with bitumen and G.I. limpet washer or with a G.I. limpet washer filled with white lead, as directed by Purchaser. The grip of the hook bolt on the side of the purlin shall not be less than 25 mm. Each hook bolt shall have a bitumen washer and a galvanized iron washer placed over the sheet before the nut is screwed down from above. There shall be a minimum of three hook bolts placed at the ridges of corrugations in



each sheet on every purlin and spacing shall not exceed 300 mm. Bitumen washer 35 mm in dia. and 1.5 mm thick shall be of approved manufacture. Each nut shall be screwed lightly at first. After 10 or more sheets are laid, the nuts shall be tightened to ensure a leak proof roof. The bolts shall be sufficiently long so that after fixing they project at least 12 mm above the top of their nuts.

7.26.5.2 Where sheets are laid on tubular purlins, the fixing bolt shall be designed to encompass at least half the tube circumference and precautions should be taken to prevent its rotation.

7.26.5.3 Holes for hook bolts etc. shall be drilled and not punched in the ridges of the corrugations in the exact positions to suit the purlins while the sheets are on the ground. The diameter of holes shall be 1.5 mm more than the diameter of the fixing bolts, while the holes in the washers shall be of the exact diameter of the hole bolts or the seam bolts. No hole shall be nearer than 40 mm to any edge of a sheet or an accessory. Sheets with holes drilled wrongly shall be rejected.

7.26.5.4 Direct fixing of sheets to drilled steel frame work or by stud welding or fixing by coach screws shall not be permitted.

## 7.26.6 Galvanised Iron Accessories

### 7.26.6.1 Ridges and hips

7.26.6.1.1 Ridges and hips of corrugated galvanised roofs shall be covered with ridge and hip sections of plain G.I. sheets with a minimum 200 mm lap on either side over the C.G.I. sheets. The end laps at the ridges and hips and between ridges and hips shall also be not less than 200 mm. The ridges and hips shall be of 600 mm overall width made from plain G.I. sheets, 0.6 mm or 0.8 mm thick, bent to shape and fixed as shown on the drawings.

7.26.6.1.2 Ridges and hips shall be fixed to the purlins below with the same 8 mm dia. G.I. hook bolts and nuts and bitumen and G.I. limpet washers, which fix the sheets to the purlins. At least one of the fixing bolts shall pass through the end laps of ridges and hips, on either side. If this is not possible extra hook bolts shall be provided.

7.26.6.1.3 The end laps of ridges and hips shall be joined together by G.I. seam bolts 25 x 6 mm size each with a bitumen and G.I. limpet washer. There shall be at least two such bolts in each end lap.

7.26.6.1.4 The edges of the ridges and hips shall be straight from end to end and their surfaces shall be plane and parallel to the general plane of the roof. The ridges and hips shall fit in squarely on the sheets and shall be leak proof.

### 7.26.6.2 Valleys and flashings

7.26.6.2.1 Valleys shall be 900 mm wide overall made from plain G.I. sheet 1.6 mm thick bent to shape and fixed as shown on the drawings or as directed by Purchaser.





Laps with C.G.I. sheets shall not be less than 250 mm on either side. The end laps of valleys shall also not be less than 250 mm.

7.26.6.2.2 Flashing shall be of 1.25 mm thick or 1.00 mm thick plain G.I. sheet having 400 mm overall width, bent to shape and fixed as shown on the drawings. They shall lap not less than 150 mm over the roofing sheets. The end laps between flashing pieces shall not be less than 250 mm.

7.26.6.2.3 Laying and fixing shall be as for Ridges and Hips.

## **7.27 TECHNICAL SPECIFICATION FOR ALUMINIUM DOORS, WINDOWS, VENTILATORS & PARTITIONS**

### **7.27.2 Materials**

7.27.2.1 Aluminium alloy used in the manufacture of extruded sections for the fabrication of doors, windows, ventilators shall conform to designation HE9-WP of IS:733.

7.27.2.2 Transparent sheet glass shall conform to the requirements of IS:2835. Wired and figured glass shall be as per IS:5437.

7.27.2.3 Builder's hardware of fittings & fixtures shall be from vendors approved by the Purchaser.

### **7.27.3 Workmanship**

7.27.3.1 The doors, windows, ventilators shall conform to the requirements of IS:1948. Aluminium windows, shall conform to IS: 1949, if so specified.

7.27.3.2 All aluminium units shall be supplied with anodized finish. The minimum anodic film thickness shall be 0.015 mm.

7.27.3.3 Doors, windows and ventilators shall be of an approved manufacture. Fabrication of the units shall be with the extruded sections, cut to correct lengths, mitred and welded at the corners to a true right angle conforming to the requirements of IS:1948. Tolerance in overall dimensions shall be within  $\pm 1.5$  mm. The frames and shutters shall be free from warp or buckle and shall be square and truly plane. Punching of holes, slots and other provisions to install fittings or fixtures later shall be made at the correct locations, as per the requirements.

7.27.3.4 Aluminium swing type doors, aluminium sliding windows, partitions shall be as described in the item of work and/or bid drawings which indicates generally the arrangement along with the overall size of the various components and weight per running metre of the extruded sections to be adopted.

7.27.3.5 IS:1948 and IS:1949 referred to incorporate the sizes, shapes, thickness and weight per running metre of extruded sections for the various components of the units. However, new sizes, shapes, thickness with modifications to suit snapfit glazing clips etc. are continuously being added by various leading manufacturers



of extruded sections, which are available in the market. As such, the sections of the various components of the unit proposed by the Contractor will be reviewed by the Purchaser and will be accepted only if they are equal to or marginally more than that specified in the codes.

7.27.3.6 The framework of the partitions with mullions and transoms shall be with anodized aluminium box sections of dimensions as per the item of work. Anodised Aluminium box sections shall be in-filled with timber of class 3 (silver oak or any other equivalent) as per IS: 4021. Panels of double/single glazing/plywood shall be fixed as per details indicated in the drawing. Partitions shall be fixed rigidly between the floor and the structural columns/beams including provision of necessary shims for wedging etc. Finished work shall be of rigid construction, erected truly plumb to the lines and levels at locations as per the construction drawings.

## **7.28 WET FLUE CHIMNEY**

### **i) Design Criteria**

The chimney shall be RCC Construction comprising of nos. of steel flues, one for each unit supported from floor at 45 m intervals starting from topmost floor at 6m below the top of chimney. The support bracket and bearing assembly shall be bolted to the locally thickened portion of flue on the support platform with arrangement to cater for thermal movement of flue element and enclosed by windshield of reinforced concrete shell. Internal and external platforms shall be provided not more than 45 m intervals and shall satisfy the requirements of high intensity aviation obstruction lights as per IS 4998/I.C.A.O. regulations, aviation lights are provided at three levels at 1/3, 2/3 and at top of Wind Shield.

Lightning protection, down conductors shall be provided as per Clause no.12.2.3 of IS:2309.

For chimney with brick lined flue, the thickness of brick wall is generally 230 mm & internal platforms shall be provided at 10m interval.

The chimney flues shall be made of mild steel/ corrosion resistant steel, with mineral wool insulation secured by G.I .Chicken wire mesh to insulate whole exterior of the flues.

The design & construction of steel chimney liners shall be based on the guidelines of EPRI Revised Wet Stack Design guide.

The steel flues shall be supported from floor at elevation 6M below chimney top and restrained laterally and also at several levels by access/ restrained platforms. Corrosion allowance shall be considered over structural considerations. The chimney roof shall be of reinforced concrete & with



provision for water/acid proofing by laying acid resistant tiles in acid resistant mortar.

Provision of chimney ventilation and rack & pinion elevator in the chimney is to be made. The rack & pinion elevator of load carrying capacity of 400kg, cabin floor size of approximately 1100mm x 1000mm and an operating speed of 40m/min, shall be provided.

Arrangements shall be provided for flue gas analysis/ measuring instruments with necessary arrangement of earthing.

Opening in the Chimney shell shall be provided for duct work, access door etc. The total plan area of openings at a particular section shall not be more than 15% of plan area of concrete shell at that location. The maximum width of opening shall be limited to an angle of not more than 30 degree subtended at center of concrete shell. The extra reinforcement around opening shall be calculated as per the following criteria and maximum reinforcement obtained out of the three criteria shall be provided:

- a) IS – 4998
- b) ACI – 307
- c) Reinforced concrete chimney and tower by Geoffrey M. Pinfeld.

The value of k shall be taken as 0.11 as per data on page No. 186 of reference at (c) above.

Minimum half the number of extra horizontal bars in shell around the opening to continue for circle round both faces and both sides.

ii) Materials

All material shall conform to IS Codes. However, the following shall apply:

The flue duct shall be lined with Borosilicate glass block or 2 mm thick Titanium (Grade 2 as per ASME SB265) or C-276 alloy. Cladding shall be done to achieve the required quality as per ASTM B 898-11. External surface of chimney flue liner projecting over the chimney roof shall be wrapped with 2 mm thick Titanium / C-276 sheet over insulation.

iii) Platform supporting Structure

The floor supporting beams shall take support on shell by making a pocket in the shell and Elastomeric bearings shall be provided below supporting beams. The platforms shall be designed for the following loads:

- a) Dead Load
- b) Live load on platforms during operation and maintenance (750 kg/m<sup>2</sup>) for chequered plate & 500 kg/m<sup>2</sup> for platform supporting beams.



- c) Construction Loads of  $750 \text{ kg/m}^2$
- d) Maximum deflection of platform beams shall be  $L/325$ . The Beams will be epoxy painted and as such no corrosion is taken into account.
- iv) Foundation

Foundation system shall be either bored cast in situ piles with pile cap or raft foundation. Circular cap or Raft shall be provided. Reference shall be made to CICIND Chimney book 2005. Design shall be based on working stress/limit state method. Foundation will be designed for resultant forces calculated as per SRSS method of across wind and concurrent along wind response.
- v) Platforms

The spacing of external platform shall satisfy the requirement of aviation warning lights as per IS: 4988, I.C.A.O regulations & instructions issued by Director General of Civil Aviation. The minimum clear width shall be 1000 mm & minimum live load shall be  $500 \text{ Kg/m}^2$ .

At roof level and all platform levels on upper surface 35 mm thick acid resistant tiles conforming to IS: 4457 over water proofing shall be provided.
- vi) Roll up Door

A rolling steel chain operated door of 4.0 m x 5.0 m shall be installed at base of shell for trucks access inside as per detail conforming to IS: 6248 "Metal Rolling Shutters & rolling grids ".
- vii) Personnel/ Access Doors

A Steel door of size 1000 mm x 2100 mm shall provide access at grade level.
- viii) Hatch

A mild steel hatch shall be provided as an access to the roof of the chimney. It shall be constructed of two outer sheets not less than 3mm thick mild steel with Steel stiffeners and to withstand Live load of  $300 \text{ Kg/m}^2$  . Hatch shall be painted with acid and heat resistant epoxy paint on both sides.
- ix) Elevator

Chimney Elevator within R.C.C shell with staircase shall be provided for transportation of personnel and equipment.
- x) Liner Hood /Cap

The Liner hood shall be fabricated from Cast iron or 10 mm thick stainless steel plate. The liner hood is the first element exposed to plume downwash.
- xi) Acid Collection Tank



Due to condensation within flue, Acid collection tank of adequate capacity shall be provided at base of Wet Flue Chimney with provision for draining the acid diluted by flushing system into the wastewater treatment system.

xii) Chimney Roof & Roof Drainage

The roof is of R.C.C. slab supported on MS beams. Roof is sloped towards rainwater down take pipes for drainage within interior of the shell.

xiii) Flue Support Arrangement

Flue shall be supported at platform levels. Alternatively, the flue shall be of "Top Hung" type & supported from top. Support bracket and bearing assembly shall be bolted to the locally thickened portion of the flue & in turn support the flue on the support platform. The arrangement shall cater to thermal movement of flue elements.

xiv) Chimney Painting

The entire inside surface of shell for full height with acid & heat resistant black bitumen paint as per IS: 158 to give a point DFT not less than 150 micron. For outside surface, the shell shall be painted top 50 m, with acid and heat resistant paint in alternate bands of signal red and white colour. The remaining portion on the outside surface with synthetic enamel paint in alternative bands of signal red and white colour. The spacing and width of bands shall be as per I.C.A.O. Guidelines.

xv) Platform Supporting Structure

The floor supporting beams shall take support on shell by making a pocket in the shell and elastomeric bearings shall be provided below supporting beams.

xvi) Flue Ducts

Flue ducts shall be designed to protect the chimney shell from high temperature, corrosive abrasive properties of the gases & from weathering elements by means of aluminum cladding.

Resin bonded mineral wool insulation of density not less than 96 kg/cum shall be laid in two layers composed of 40 mm & 25 mm thickness on external surface of steel flue. The insulation shall be tightly secured to the exterior surface of the liner by impaling them on studs welded to the surface at 450 mm c/c both horizontally & vertically. The studs shall extend minimum 25 mm beyond insulation and provided with circular or square speed washers. 20 gauge galvanized wire mesh with 25 mm hexagonal pattern conforming to IS : 3150 shall be wrapped around with minimum 150 mm overlap. The mesh is tied in place with 16 gauge GI wire at 300 mm centers.

Insulation for exposed portion of flue at top shall be 150 mm & in 2 to 3 layers with minimum density of 200 kg/cu.m.



xvii) Permissible Stresses for Chimney Shell

The stresses in steel reinforcement & concrete shall not exceed limits as per IS 4998: 2015. For Dead load+Wind, the permissible stress in concrete shall not exceed  $0.3f_{ck}$  where  $f_{ck}$  is the characteristic compressive strength of concrete.

xviii) General Design Criteria

- 1) The chimney flues shall be made of mild steel/ corrosion resistant steel with mineral wool insulation outside. The design of chimney flues is dependent upon
  - a. The flues shall be so sized to ensure that the flue gas exit velocity is of the order of 20-25m/s at normal continuous operating load. It should be also be ensured that the flue gas exit velocity at the lowest continuous unit load is high enough(of the order of 15m/s) to enable adequate dispersion of the flue gases.
  - b. Sulphur dioxide content of the flue gas calculated from sulphur content of fuel
  - c. Maximum burning rate of fuel
  - d. Topography of surrounding area
  - e. Height of adjacent buildings
  - f. Size of adjacent buildings.
  - g. The natural draught produced by chimney is dependent upon height of chimney, temperature difference between flue gas & external air.
  - h. Provision to be made for flue ducts to expand both circumferentially and vertically without producing stress in concrete chimney shell.
  - i. Thickness of flue duct shall be minimum 6 mm.
- 2) The concrete shell shall support platforms, the beam supporting the platform shall be made to rest on shell by making a pocket in shell, elastomeric bearing pads are provided below main girders & steel-lead bearing for other beam.
- 3) Minimum shell thickness is 200 mm at top & 450 mm at junction of shell with foundation junction.
- 4) The maximum deflection at top is limited to  $H/500$  where H is the height of chimney above grade level.
- 5) The lower values in the range of values specified in IS-4998 for dynamic modulus of elasticity shall be taken.
- 6) The static modulus of elasticity of concrete shall be  $5000 \sqrt{f_{ck}}$ .
- 7) The values specified in IS-4998 for dynamic modulus of elasticity shall be taken.
- 8) The minimum vertical reinforcement shall be 0.3% of the concrete area. Maximum spacing of vertical reinforcement in shell shall not be more than 250 mm on each face. Vertical bars shall be uniformly spaced and overlapping of bars shall be staggered vertically.
- 9) The minimum circumferential reinforcement shall be 0.2% of the concrete area. The circumferential reinforcement in the top 3m of the windshield shall be twice that required from design forces. Maximum



spacing of circumferential reinforcement bars in shell shall not be more than 200 mm on each face.

- 10) The clear cover to reinforcement shall be 50mm.

The final design shall be checked & verified by 'Wind Tunnel Test'. Dynamic interference effects due to additional chimney(s) located in the area or in future expansion shall be determined along with the other topographical features of the local area through model test.

Internal and external platforms is generally provided at 45 m intervals. Internal platforms will be of structural steel supported over RCC shell. A Structural steel staircase is provided to access platforms.

An opening in windshield at ground level shall be provided for installation of flue with suitable door for access of personnel & trucks. Aviation obstruction lighting for warning aircraft of chimney obstruction shall be provided.

xix) **Basis of design**

The reinforced concrete twin flue chimney is designed in accordance with IS 4998:2015 and "Criteria for design of Reinforced concrete chimney for reference ACI-307-1979" "specification for design & construction of reinforced concrete chimney" for items not covered in Indian /CICIND Code (International Committee for Industrial Chimneys).

The chimney shell is modeled as Beam elements made of annular conical sections of appropriate diameter and thickness. Chimney foundation shall be in concrete grade M-25 with minimum cement content of 400 kg/cu.m & wind shield shall be grade M-30 with minimum cement content 425 kg/cum. 43 Grade OPC for concrete foundation & shell be used.

xx) **Loading and their combinations**

Dead load:- All permanent loads due to weight of chimney shell, internal platforms and lining supported on them, ladders, flue ducts, staircase etc.

Imposed load:-

- i) Imposed load on service platform around chimney shall be 500 kg/sqm & design live load shall be 750 kg/sq.m during construction / erection.
- ii) Imposed load from ducts joining the chimney shall also be considered.

xxi) **Analysis**

Calculation of natural frequencies and mode shape shall be carried out. For this purpose chimney shaft is idealized as vertical cantilever with limited masses at different nodes. These nodes shall be provided at each platform. Minimum five modes shall be considered for calculation of natural frequency and amplitude.

Wind Loads :-



**General:**

Wind load shall be calculated as per clause 5.5 of IS 4998:2015 and IS 875 (Part3). Dynamic analysis shall be carried out and stability ensured under such conditions.

a) Along Wind loads

The along wind response of chimney shall be calculated as per Gust Factor method as per clause 5.5.5 of IS 4998:2015.

b) Across Wind loads

The across wind loads and response of chimney shall be evaluated as per clause 5.5.7 of IS 4998:2015.

c) Circumferential Ring Moments due to Wind

The circumferential ring moments due to wind and wind effect on chimneys shall be calculated as per clause 5.5.11 of IS 4998:2015.

xxii) Component Design Criteria

The concrete shell shall be designed as per working stress method/limit state method as per load combinations. The modular ratio shall be calculated for the following load combinations as per Annex-B of IS:456.

(a) Dead loads

(b) Dead Load + Wind Load + loads due to temperature effects;

(c) Dead load +Earth Quake loads+ loads due to temperature effects; and

(d) Circumferential ring moments due to wind + due to temperature effects.

Notes:-

1. Across wind loads shall be combined with co-existing along wind loads. The combined bending moment at any section shall be taken as resultant of across wind bending moments due to across wind loads and co-existing mean along-wind bending moment using SRSS method.
2. Design should also consider effects due to local loads, if any, on the shell.
3. Secondary effects due to deflection shall be considered for one cycle.





## SECTION 8.0

### MANDATORY SPARES

#### 8.0 MANDATORY SPARES

##### 8.1 Mechanical

Sl. No.	Description	Quantity
1.	<b>Gates/ Dampers in Flue Gas System</b>	
	i) Seals	1 Set of each type (Set means complete replacement for one gate)
	ii) Actuator	1 no. of each type
	iii) Expansion joints	1 no. of each type and size
2.	<b>Booster Fans</b>	
	i) Fan rotating element including impeller & shaft	1 Set
	Fan bearings	2 Sets
	ii) Motor bearings	2 Sets
	iii) Oil rings/seal/gaskets/packings/ bushes, metallic rings	4 Sets
	iv) Nuts and bolts	2 Sets
	v) Couplings between fan and motor	1 no.
	vi) Fan Blades (in case of axial fans)	1 Sets
	vii) Inlet guide vanes (IGV) (in case of radial fans)	1 Set
	viii) Casing and impeller wearing elements) (in case of radial fans)	1 Set
	ix) Lube oil system	
	a) Pump assembly	1 nos. of each type
	b) Pressure regulator	2 nos.
	c) Filters	4 Sets
	d) Coupling for oil pump & motor	1 no.
	e) Oil coolers	1 Set
	<i>Wet limestone absorber system</i>	
4.	<b>Nozzle, Piping, Lining etc.</b>	
	i) Nozzles for limestone slurry spray	10% of total requirement for both the absorber
	ii) Mist eliminator	10% of total requirement for both the absorber
	iii) Mist eliminator wash nozzles	10% of total requirement for both the absorber
	iv) Water distribution piping & other internals	10% as required for both the absorber



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	v)	Lining	5 % as required for both the absorber
<b>5.</b>	<b>Limestone slurry valves</b>		
	i)	Complete valves assembly	Two (2) Nos. for each type and size
	ii)	Seat, disc, spindle with nuts & bolts	Two (2) Nos. for each type and size
	iii)	Diaphragms for valves	Five (5) Nos. for each type and size
	iv)	Flaps for non-return valves	Two (2) Nos. for each type and size
	v)	Actuator for control/isolation	Two (2) Nos. for each type and size
<b>6.</b>	<b>Absorber System Agitators</b>		
	i)	Impeller assembly	1 Nos. for each type and size
	ii)	Bearings	2 Sets for each type and size
	iii)	Shaft assembly	1 Sets for each type and size
	iv)	Shaft seal	1 Sets for each type and size
	v)	Gear box, if applicable	1 no. of each type and size
	vi)	Complete agitator assembly	1 no. of each type and size
<b>7.</b>	<b>Oxidation Air Blowers (for each type and size)</b>		
	i)	Casing	2 Nos.
	ii)	Impeller/Vane/Lubes	2 Sets
	iii)	Shaft bearings driving end	2 Sets.
	iv)	Shaft bearings Non-driving end	2 Sets.
<b>8.</b>	<b>Oxidation Air Distributor</b>		
	i)	Distributor header	2 Nos.
	ii)	Nozzles for complete air distribution	2 Sets
	<i>Limestone conveying system</i>		
<b>9.</b>	<b>Conveyor Belt</b>		
	i)	Carrying idler rollers	15% of total requirements of rollers
	ii)	Impact idler rollers	10% of total requirements of rollers
	iii)	Return idler rollers	10% of total requirements of rollers
	iv)	Troughing training idler complete	4 Nos.
	v)	Return training idler complete	2 Nos.
	vi)	Transient idler complete	2 Nos.
	vii)	Conveyor belting	20% of each type & rating of the belt and thickness.
	viii)	Brake	2 Sets for each conveyor
	ix)	Brake shoes	2 Sets for each conveyor



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<b>10.</b>	<b>Pulleys</b>		
	i)	Drive pulley without bearings and plummer blocks	2 Nos.
	ii)	Non drive pulley without bearings & plummer blocks	4 Nos.
	iii)	Spherical roller bearings for pulleys of different sizes without plummer blocks	3 Nos. for each size
	iv)	Plummer blocks complete with bearings & sleeves	2 Nos. of each type & size
<b>11.</b>	<b>Carriage wheel assembly</b>		
	i)	Bearings	2 Nos. of each size and type
	ii)	Plummer block	2 Nos. of each size and type
	iii)	Oil seals	2 Nos. of each size and type
	iv)	Carriage wheel with shaft (without plummer blocks)	1 Set
	v)	Transverse drive assembly including motor, gear box, coupling etc.	1 Set
<b>12.</b>	<b>Gear Couplings</b>		
	i)	Complete gear couplings	2 Nos. of each size and type
	ii)	Bolts & nuts	2 Sets
	iii)	Seal kit	2 Sets
<b>13.</b>	<b>Fluid Couplings</b>		
	i)	Complete fluid coupling	1 Nos. of each size and type
	ii)	Multi disc assembly	4 Nos. of each size and type
	iii)	Bearings	1 Set for each size and type
	iv)	Seal kit	2 Sets for each size and type
	v)	Resilient drive plate assembly	2 Nos. of each size and type
	vi)	Fusible plugs	10 Nos. of each size and type
	vii)	Complete actuator assembly including motor, gear box etc.	1 Nos. of each size and type
	viii)	Oil filters	5 Nos. of each size and type
<b>14.</b>	<b>Gear Boxes</b>		
	i)	Bearings	1 Set for each type and size
	ii)	Oil seal for gear box	2 Sets
	iii)	Worm/Pinion for gear box	1 No. of each size
	iv)	Bolts for gear coupling	1 Set for each size
	v)	Complete gear box assembly	1 No. of each type & rating
<b>15.</b>	<b>Belt Cleaner &amp; Skirt Board</b>		
	i)	Modular segments for belt cleaner	10% of total population for each type & size
	ii)	Modular segments for skirt board	10% of total population for each type & size
	iii)	Skirt rubber	10% of total population for each type & size
	iv)	Complete belt cleaner (internal/external)	5% of total population for each type & size



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<b>16.</b>	<b>Magnetic Separators</b>		
	i)	Cleated conveyor belt	1 Set
	ii)	Drive assembly including motor & gear box	1 Set
	iii)	Pulleys with plummer block & bearings	1 Set of each type & size
	iv)	Sheaves	1 Set of each type & size
	v)	V- belts	2 Set of each type & size
<b>17.</b>	<b>Rack and Pinion Gates</b>		
	i)	Plate	10 Nos.
	ii)	Gland and Packing	10 Sets
<b>18.</b>	<b>Vibrating Feeders</b>		
	i)	Unbalanced motor	2 Nos.
	ii)	Base mounting springs	2 Sets.
<b>19.</b>	<b>Unloading &amp; Telescopic Chute</b>		
	i)	Gear Box	
		a) Bearing	2 Set
		b) Winch drum roller bearing	2 Set
	ii)	Limit switches	2 Nos.
	iii)	U clamps	4 Nos.
	iv)	Set of drive & driven sprocket	2 Sets
<b>20.</b>	<b>Lime Sampler</b>		
	i)	Plummer block	1 No. of each type and size
	ii)	Hammers	1 Set of each type and size
	iii)	Liner plate	1 Set
	iv)	Cutter lip	1 No.
	v)	Cutter seal	1 No.
	vi)	V-belts (for crusher)	1 Set
	vii)	Hammer pins	1 Sets of each type and size
	viii)	Pulley	1 No. of each type and size
	ix)	Conveyor belt	1.2 times length of each type and rating
	x)	Gear Box assembly for conveyor	1 No. of each type and rating
	xi)	Gear box drive assy, for primary and secondary samplers	1 Set of each type and rating
	xii)	Hydraulic pump with motor and coupling	1 Set of each type
	xiii)	Hydraulic motor	1 Set of each type
	xiv)	Hydraulic cylinder	1 Set of each type
	xv)	Cylinder sealing kit	2 Sets of each type
	xvi)	Set of hoses	2 Sets of each type
	xvii)	Coupling with grid for primary sampler	2 Sets
	xviii)	Screw conveyor gear box assembly	1 Set
<b>21.</b>	<b>Limestone Crusher</b>		
	i)	Plummer Block assembly complete including bearing, lock nut, lock washer etc. (DE+NDE)	2 Sets
	ii)	Shaft seal	4 Sets



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	iii)	Hammer Sets	10 Sets (1 set means hammers required for one crusher)
	iv)	Rotor assembly complete consisting of rotor shaft & keys, End discs, Centre discs, distance rings, suspension bars, disc clamping nuts and shaft extension etc. but without hammers, bearings and pillow blocks	1 Set
	v)	Cage bars/Perforated screen plates as applicable	4 Sets
	vi)	Breaker plate	4 Sets
	vii)	Liners	2 Sets
	viii)	Suspension bars	4 Sets
	ix)	Kick-off plate	4 Sets
	x)	Screen plate upper & lower	4 Nos. each
	xi)	Tramp iron pick up plate	2 Nos. each
	xii)	Fluid coupling	
	a)	Fluid coupling complete	1 Set
	b)	Bearings	2 Sets
	c)	Seal kit (sealing rings)	2 Sets
	d)	Fusible plugs	8 Nos.
	e)	Oil pump motor Set (if applicable)	1 Set of each type
	f)	Oil filter	3 Sets
	g)	Complete actuator and engaging assembly (including motor, gear box etc.)	1 Set
	h)	Cooler assembly (if applicable)	1 No.
	i)	Oil/Water valves	2 nos. of each type
	j)	Gear coupling/other flexible coupling of crusher drive along with bolts and sealing kit, as applicable	2 Sets
	k)	Multi Disc assembly (for fluid coupling)	2 Sets of each type and rating
	l)	Resilient Drive plate assy.	2 Sets of each type and rating
<b>22.</b>	<b>Dust Extraction System</b>		
	i)	Filter bags	10% of total Qty.
	ii)	V-belt	1 Sets of each type and size
	iii)	Bearing	1 No of each type & size
	iv)	Flexible connection between fan & duct	1 Set of each size
<b>23.</b>	<b>Bucket Elevator</b>		
	i)	Buckets	20% of total quantity (complete bucket assembly)
	ii)	Belt	20% of total length
	iii)	Linkages	20% of total quantity



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<b>24.</b>	<b>Limestone Feeders</b>		
	i)	Belt	2 Sets
	ii)	Belt drive motor	1 No.
	iii)	Belt drive reducer	1 no.
	iv)	Speed reducer assembly	1 no.
	v)	Weighing Instruments	1 Set
	vi)	Feeder weighing roll	1 no.
	vii)	Gravimetric feeder gate actuator assembly	1 no.
	viii)	Counter assembly of feeder complete	1 no.
	ix)	Feeder head pulley assembly	1 no.
<b>25.</b>	<b>Wet Ball Mills</b>		
	i)	Mill Wear Parts (Liners) & Grinding element	1 Sets
		Note : One Set of Mill Wear Parts (Liners) above is defined as under	
		1 Set = (Grinding elements needed for complete replacement of one mill) X (8000 x 1) / GWL, rounded off to nearest higher whole number.	
		Where	
		GWL- =Guaranteed wear life of Mill Wear Parts as offered by the bidder.	
	ii)	Mill Motor	1 no.
	iii)	Auxiliary Motor	1 no.
	iv)	Gear box internals (including Bearings and Seals)	2 Sets
	v)	Complete Gear Box	1 Sets
	vi)	Mill motor Bearings	1 Sets
	vii)	Lube Oil / Grease System	
		Pump assembly	1 nos. of each type
		Motor	1 nos. of each type
		Pressure regulator	1 nos. of each type
		Filters	2 nos. of each type
		Pump & Motor coupling	1 nos. of each type
	vii)	Speed reducer	
		a) Complete assembly	2 Nos.
		b) Bearings	1 Set.
		c) Oil seal for gear box	1 Set.
		d) Gear Set	2 Nos.
<b>26.</b>	<b>Limestone Slurry Handling Horizontal Centrifugal Pumps (for each type &amp; size)</b>		
	i)	Impeller	4 Nos.
	ii)	Casings	2 Nos.
	iii)	Shaft	2 Nos.
	iv)	Shaft sleeves	2 Sets.
	v)	Impeller/ casing liner	2 Sets
	vi)	Seals	2 Sets.



	vii)	Pump & motor bearing	2 Sets.
	viii)	Gear box	1 No.
	ix)	Pump- motor coupling	1 No.
<b>27.</b>	<b>Other Horizontal Centrifugal Pumps (for each type &amp; size)</b>		
	i)	Impeller	1 No.
	ii)	Casing	1 No.
	iii)	Shaft	1 No.
	iv)	Shaft sleeves	1 Set
	v)	Impeller/ casing liner	1 No.
	vi)	Seals	1 Set
	vii)	Pump & motor bearing	2 Set
	viii)	Gear box	1 No.
	ix)	Pump- motor coupling	1 No.
<b>28.</b>	<b>Vertical Centrifugal Pumps ( for each type &amp; size), if applicable</b>		
	i)	Suction bell with strainer	1 No.
	ii)	Bowl Assembly	1 Set
	iii)	Cutless rubber bearing	1 Set
	iv)	Pump shaft/ line shaft	1 Set
	v)	Bearings	2 Sets
	vi)	Motor bearing (one at each end)	2 Sets
	vii)	Thrust bearing	2 Nos
<b>29.</b>	<b>Sump Pumps (for each type &amp; size)</b>		
	i)	Impeller, with key and nut	1 No
	ii)	Suction bell with strainer	1 No.
	iii)	Bowl assembly	1 Set
	iv)	Pump shaft	1 Set
	v)	Pump & motor bearings	1 No of each size
	vi)	Oil seal	1 No of each size
<b>30.</b>	<b>Limestone Slurry Pipes and Fittings</b>		
	i)	Limestone slurry pipe	20% of total length requirement for the system
	ii)	Limestone slurry pipe bends & fittings	4 Nos. for each type & size
	<i>Gypsum dewatering &amp; handling system and waste water system</i>		
<b>31.</b>	<b>Hydro Cyclones (for each type &amp; size)</b>		
	i)	Hydrocyclones	1 Set
	ii)	Feed vessel	1Set
	iii)	Lining for vessel	1 Set
	iv)	Complete vessel assembly	1 No.
	v)	Valves	1 Nos. of each type & size
	vi)	Pressure gauge	1 Nos.
	vii)	Measuring nozzle	1 Set
	viii)	Flanges for cycles	1 Se
	ix)	Over flow & underflow pipes and fittings	1 Set
	x)	Filters	1 Set
		Vortex finder and apex inserts	1 Set
<b>32.</b>	<b>Vacuum Belt Filters</b>		
	i)	Filter Cloth	1Nos.
	ii)	Belt (if applicable)	1 Sets.



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	iii)	Vacuum Box Seals	1 Nos.
	iv)	Drive Motor (if applicable)	2 Sets.
<b>33.</b>	<b>Vacuum Pumps</b>		
		Pump Impeller Assembly	1 no.
		Pump Bearings	1 Set
		Motor Bearings	1 Set
		Seals	1 Set
<b>34.</b>	<b>Vacuum Breaker Valves</b>		
		Valve Assembly	1 no.
		Actuator	1 no.
<b>35.</b>	<b>Miscellaneous Agitators</b>		
	i)	Impler assembly	1 Nos. for each type and size
	ii)	Bearings	2 Sets for each type and size
	iii)	Shaft assembly	1 Sets for each type and size
	iv)	Shaft seal	1 Sets for each type and size
	v)	Gear box, if applicable	1 no. of each type and size
	vi)	Complete agitator assembly	1 no. of each type and size
<b>36.</b>	<b>Knife Gate Valve</b>		
	i)	Slide	1 Nos.
	ii)	Complete assembly	
		a) Cylinder operated	1Nos.
		b) Manual operated	1 Nos.
	iii)	Solenoid Valves	1 Nos. each type
<b>37.</b>	<b>Other Valves</b>		
	i)	Complete valves for each type and size	2 Sets
	ii)	Seat, disc, spindle with nut for each type and size	2 Sets
	iii)	Diaphragms for each type and size of diaphragm type valves	5 Sets
	iv)	Flats of each type and size of non-return valves	1 Set
<b>38.</b>	<b>Hoists &amp; Cranes</b>		
	i)	Long travel wheel	1 No.
	ii)	Cross travel wheel	1 No.
	iii)	Bearings for each gear box	1 Set
	iv)	Bearings for long travel wheels	1 Set
	v)	Bearings for cross travel wheels	1 Set
	vi)	Oil seals for each gear box	1 Set
	vii)	Pins & rubber bushes for the flexible coupling for each motor	1 Set
	viii)	Wire rope for hoist	1 length
	ix)	Brake linings for all brakes	1 Set





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	x)	Brake spring for all brakes	1 Set
	xi)	Trustors with cups and seals for electro-hydraulic thruster brakes	1 Set
	xii)	Limit switches for all motions	1 Set
	xiii)	Contact for main and reversing contractors	1 Set
	xiv)	Carbon brushes and brush holders for all slip ring type motors	1 Set
	xv)	Solenoid coils for all the electro-mechanical brakes	1 Set
	xvi)	Make and trip coils	1 Set
	xvii)	Fuse links for each motor	1 Set
	xviii)	Overload relays	1 Set for each crane
	xix)	Push buttons	1 Set for each crane
	xx)	Indicating lamps	1 Set for each crane
	<i>Air compressor system</i>		
39.	<b>Air Compressor</b>		
	i)	H.P. Stage – complete HP Stage assembly	1 Set of each type/rating
	ii)	L.P. Stage – Complete LP Stage assembly	1 Set of each type/rating
	iii)	Motor Bearings	2 Sets
	iv)	LP stage Gear and Pinion	1 Set
	v)	HP stage gear and Pinion	1 Set
	vi)	Air Intake Filter Element with Gaskets	4 Sets
	vii)	Oil Filter Element with Gaskets & Seals	4 Sets
	viii)	Safety Valve Springs and Gaskets for HP stage	1 Set
	ix)	Safety Valve Springs and Gaskets for LP stage	1 Set
	x)	Valves (within the compressor house with actuators)	2 nos. of each type/ratings/size
	xi)	Oil Pump/Motor	
	xii)	Oil Pump and Motor complete assembly	1 Set
	xiii)	Pump impeller/rotor with shaft	1 Set
	xiv)	Set of bearings	2 Sets
	xv)	Set of Seals	2 Sets
	xvi)	Drain/Moisture Trap	2 Sets of each type/size
	xvii)	Oil Cooler Gaskets & Seals	2 Sets
40.	<b>Air Drying Plant (Twin tower type ) for IA System (as applicable)</b>		
	i)	Pre filter element (ceramic candle or as applicable)	2 Sets
	ii)	After filter element (ceramic candle or as applicable)	2 Sets
	iii)	Heater element (if applicable)	1 Set
	iv)	Blower bearing (if applicable)	1 Set
	v)	Blower motor bearing (if applicable)	2 Sets



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	vi)	Valves & valve actuators (pneumatic/hydraulic)	2 Sets
	vii)	Heater coil for temperature stabilization (for HOC type) (as applicable)	2 Sets
41.		<b>Rotary Drum type Air Drying Plant for Instrument Air System (as applicable)</b>	
	i)	Drive assembly consisting of motor, gear boxes, drive shaft & coupling	1 Set
	ii)	Motor for air compressor	1 no.
42.		<b>Air Handling Unit</b>	
	i)	V-belts for AHU Blower	2 Sets
	ii)	AHU Blower bearing	1 Set
	iii)	Blower motor bearing	1 Set
	iv)	Filters at suction and discharge of all AHUs	25% of installed population
43.		<b>Unitary Air Filtration Unit</b>	
	i)	Supply Air fans	
	ii)	V-belts for supply air fans	2 Sets
	iii)	Supply air fan bearings	1 Set
	iv)	UAF Pump	
	v)	Pump bearings	1 Set
	vi)	Impeller for Pump	1 no.
	vii)	Pump Shaft	1 no.
	viii)	Shaft sleeves	1 Set
	ix)	Gland Packings for pumps	1 Set
	x)	Nylon Filter	1 Set
	xi)	Spray nozzles	5% of total population or 50 numbers whichever is higher
	xii)	Water strainer	1 no.
	xiii)	Brass suction screen/strainer for unitary air filtration tank.	1 Set
	xiv)	Motor for Centrifugal fan for UAF	1 no.
44.		<b>Goods Cum Passenger Elevator</b>	
	i)	Friction block	2 nos.
	ii)	Guide roller of each type	20% of total population or 3 nos. whichever is higher
	iii)	Contactors of each type	2 nos.
	iv)	Control transformer	1 no. of each type
	v)	Time device	2 nos. of each type
	vi)	Rectifiers	2 nos. of each type
	vii)	Overcurrent relay	2 nos. of each type
	viii)	Auxiliary relay	2 nos. of each type
	ix)	Resistor	20% of the total population or 3 nos. whichever is maximum



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	x)	Fuses of each rating	20% of the total population or 3 nos. whichever is maximum
	xi)	Limit switches of each type	3 nos. of each type
	xii)	Push button	2 nos. of each type
	xiii)	Contact device (if applicable)	2 nos. of each type
	xiv)	Brake motor	2 nos.
	xv)	Transmitters	2 nos. of each type
	xvi)	Switches of each type	2 nos.
	xvii)	Receiver	3 nos.
	xviii)	Bearings of each type & size	2 Nos.
	xix)	Roller of each type	3 nos.
	xx)	Bushings (for front door)	2 Sets
	xxi)	Brake	
		Fans	2 Nos.
		Brake pads	2 Sets
		Brake discs	2 Sets
		Magnetic coils	2 Sets
	xxii)	Worm gear 'O' ring, sealing rings	3 Sets
	xxiii)	Pinion	2 nos. of each type
	xxiv)	Elevator motor with VVVF drive	1 No.
<b>45.</b>	<b>Chimney Elevator</b>		
	i)	Brake Assembly complete	1 No.
	ii)	Gear Assembly complete	1 No.
	iii)	Limit Cams	
	a)	Sensor	3 Nos.
	b)	Switch arm	3 Nos.
	iv)	Cab	
	a)	Guide roller	100% of the total ones installed each type or min. 1 whichever is higher
	b)	Switch	3 Nos.
	v)	Sliding Door Rollers (if applicable)	4 Nos. each type
	vi)	Machinery	
	a)	Guide roller	2 Nos.
	b)	Pinion	2 Nos.
	c)	Rubber inserts (if applicable)	12 Nos.
	d)	Groove ring (if applicable)	6 Nos.
	e)	Brake motor	1 No.
	vii)	Cable Trolley bearing (if applicable)	3 Nos. of each type
	viii)	Electrical & C&I Equipment	
	a)	Contractors	1 No. of each type
	b)	Auxiliary transformer	1 No.
	c)	Relays	1 No. of each type & rating
	d)	Switch	2 Nos. each type
	e)	Rectifier	3 Nos.
	f)	Limit Switch	3 Nos. each type
	g)	Transmitter (if applicable)	1 No. if applicable



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	h)	Receiver (if applicable)	1 No. (if applicable)
	i)	Battery Charger	1 No.
	j)	Push Buttons	3 Nos. of each type
	k)	Timers	2 Nos. of each type & rating
	l)	Main drive motor	1 Set with control system
<i>Fire protection and detection system spares</i>			
46.	<b>Deluge Valve Assemblies</b>		
	i)	Complete deluge valve assembly along with internals and accessories	10% or 1 No. of each type, class, size and model whichever is more
	ii)	Clapper assembly complete (consisting of clapper seat rubber, screws etc.)	10% or 1 No. of each type, class, size and model whichever is more
	iii)	Butterfly	10% or 1 No. of each type, class, size and model whichever is more
	iv)	Disc. (Butterfly)	10% or 1 No. of each type, class, size and model whichever is more
	v)	Stem for Butterfly Valve	10% or 1 No. of each type, class, size and model whichever is more
	vi)	Gasket for Butterfly Valve	10% or 1 No. of each type, class, size and model whichever is more
	vii)	Bushing/Bearing (butterfly valve)	10% or 1 No. of each type, class, size and model whichever is more
	viii)	Strainer elements with O-rings and stiffeners	10% or 1 No. of each type, class, size and model whichever is more
	ix)	Y-Type strainer	10% or 1 No. of each type, class, size and model whichever is more
47.	<b>MVW Spray System</b>		
	i)	Spray Nozzles	10% or 10 No. of each type, class, size and model whichever is more
	ii)	QB Detectors	10% or 20 No. of each type, class, size and model whichever is more
48.	<b>HVW Spray System</b>		
	i)	Spray Nozzles	10% or 10 No. of each type, class, size and model whichever is more
	ii)	QB Detectors	10% or 20 No. of each type, class, size and model whichever is more



<b>49.</b>	<b>Fire Detectors</b>		
	i)	Multisensor detectors (Addressable)	10% or 10 No. of each type, class, size and model whichever is more
	ii)	Indicators assembly for smoke detectors provided in false ceiling (Response indicator)	10% or 10 No. of each type, class, size and model whichever is more
	iii)	LHS cable for conveyors	10% or 10 No. of each type, class, size and model whichever is more
<i>Air conditioning and ventilation system</i>			
<b>50.</b>	<b>Air Handling Unit</b>		
	i)	V-belts for AHU Blower	2 Sets
	ii)	AHU Blower bearing	1 Set
	iii)	Blower motor bearing	1 Set
	iv)	Filters at suction and discharge of all AHUs	25% of installed population
<b>51.</b>	<b>Unitary Air Filtration Unit</b>		
	i)	Supply Air fans	
	a)	V-belts for supply air fans	2 Sets
	b)	Supply air fan bearings	1 Set
	ii)	UAF Pump	
	a)	Pump bearings	1 Set
	b)	Impeller for pump	1 no.
	c)	Pump shaft	1 no.
	d)	Shaft sleeves	1 Set
	e)	Gland Packings for pumps	1 Set
	f)	Nylon Filter	1 Set
	g)	Spray nozzles	5% of total population or 50 numbers whichever is higher
	h)	Water strainer	1 no.
	i)	Brass suction screen/strainer for unitary air filtration tank.	1 Set
	j)	Motor for Centrifugal fan for UAF	1 no.

**Note:**

- i) Wherever quantity of spares have been defined in percentage, the quantity shall be rounded off to next higher integer in case of fractions.
- ii) Wherever quantity of spares has been defined in 'Set', it shall mean the quantity of spares to be supplied for one complete replacement for one equipment.
- iii) In the case of spares offered in 'Sets', the details of each Set giving the number of parts in the Set shall be clearly mentioned.
- iv) In case of any equipment being supplied is of different type/ design, the list of its spares and their quantities to be supplied shall be as mutually agreed and approved by purchaser during detailed engineering.



## 8.2 Electrical

<b>Sl. No.</b>	<b>Description</b>	<b>Quantity</b>
<b>1</b>	<b>11/6.6/3.3 kV Switchgears</b>	
a)	Breaker pole of each rating	1 Set
b)	Spring charging motor complete of each type	1 No.
c)	Shunt trip coil of each type	1 No.
d)	Closing coil of each type	1 No.
e)	Current transformer of each type	1 No.
f)	Potential transformer of each type	1 No.
g)	Protective relay of each type	1 No.
h)	Anti-pumping relay of each type and rating	1 No.
i)	Auxiliary relays of each type	1 No.
j)	Lock out relays of each type	1 No.
k)	Timers of each type	1 No.
l)	Moving contact assembly of each installed rating	1 Set
m)	Stationary (fixed) contact	1 Set
n)	Bus seal-off bushings of each type	1 No.
o)	Busbar support insulators	5% of total population
s)	Control switches of each type	1 No.
t)	Selector switches of each type	1 No.
u)	Isolation switch for the control supply of each type	1 No.
v)	Operating mechanism rod for each rating	1 No.
w)	Set of gaskets of each rating	2 Sets
x)	Ammeter of each type and range	1 No.
y)	Voltmeter of each type and range	1 No.
z)	Indicating lamps	10 Nos.
aa)	Indicating lamp covers of all colours, lamp resistors and holders	10% of installed quantity
ab)	Fuse base and holder of each type and rating of each type	1 Nos.
ac)	Fuse of each rating of each type of each type	2 Nos.
ad)	Maintenance tools and accessories for maintenance	1 Set
ae)	Isolating contact (Fixed and moving) of each rating	1 Set
af)	Terminal blocks	2 Nos.
ag)	Contactors with HRC fuses of each type and rating	10%
ah)	Auxiliary contactors of each type and rating	10%
ai)	Control supply transformers of each type	1 No.
aj)	Breaker Trolley with each panel	1 No.
<b>2</b>	<b>11/ 6.6/ 3.3kV Segregated Phase Busducts</b>	
a)	Bus insulators of each type and rating	2 Nos.
b)	Set of seal-off bushings of each type and rating	1 Sets
c)	Set of 3 phase, Aluminium flexibles	1 Sets
d)	Set of 3 phase, copper flexibles	1 Sets



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e)	Drain plug with cap	1 Nos.
f)	Silica Gel Breathers	2 Nos.
g)	Gaskets of each type (20 mtrs. Set)	1 Sets
h)	Rubber bellows	1 Sets
i)	Space heaters complete Set	1 Sets
<b>3</b>	<b>415V Switchgear and non-segregated phase busduct, DC boards</b>	
<b>3.1</b>	<b>415V Switchgear, DC boards</b>	
a)	Breaker pole of each rating	1 Set
b)	Spring charging motor complete of each type	1 No.
c)	Shunt trip coil of each type	1 No.
d)	Closing coil of each type	1 No.
e)	Current transformer of each type & ratio of each type	1 No.
f)	Potential transformer of each type & ratio of each type	1 No.
g)	Protective relay of each type	1 No.
h)	Anti-pumping relay of each type and rating	1 No.
i)	Auxiliary relays of each type	1 No.
j)	Lock out relays of each type	1 No.
k)	Timers of each type	1 No.
l)	Moving contact assembly of each installed rating	1 Set
m)	Stationary (fixed) contact	1 Set
n)	Bus seal-off bushings of each type	1 Nos.
o)	Busbar support insulators	5% of total population
s)	Control switches of each type	1 No.
t)	Selector switches of each type	1 No.
u)	Isolation switch for the control supply of each type	1 No.
v)	Operating mechanism rod for each rating	1 No.
w)	Set of gaskets of each rating	2 Sets
x)	Ammeter of each type and range	1 No.
y)	Voltmeter of each type and range	1 No.
z)	Indicating lamps	10 Nos.
aa)	Indicating lamp covers of all colours, lamp resistors and holders	10% of installed quantity
ab)	Fuse base & holder of each type & rating of each type	1 No.
ac)	Fuse of each rating of each type of each type	2 Nos.
ad)	Maintenance tools and accessories for maintenance	1 Set
ae)	Isolating contact (Fixed and moving) of each rating	1 Set
af)	Terminal blocks	2 Nos.
ag)	Contactors with HRC fuses of each type and rating	10%
ah)	Auxiliary contactors of each type and rating	10%
ai)	Control supply transformers of each type	2 Nos.



<b>3.2</b>	<b>415V Non-segregated phase busduct</b>	
a)	Bus insulators of each type and rating	2 Nos.
b)	Set of seal-off bushings of each type and rating	1 Set
c)	Set of 3 phase, Aluminium flexibles	1 Set
d)	Set of 3 phase, copper flexibles	1 Set
e)	Silica Gel Breathers	2 Nos.
f)	Gaskets of each type (20 mtrs. Set)	1 Set
h)	Space heaters complete Set	2 Sets
<b>3.4</b>	<b>Auxiliary Service Transformers</b>	
<b>3.4.1</b>	<b>Oil filled type Transformer</b>	
a)	HV, LV and Neutral bushing of each type and rating	1 Set
b)	Winding temperature indicator for each rating of transformer	1 No.
c)	Tap changer contacts for each rating of transformer	1 Set
d)	Magnetic oil gauge/ oil level indicator with contacts for each rating of transformer	1 No.
e)	Oil temperature indicator with contacts for each rating of transformer	1 No.
f)	Buchholz Relay for each rating of transformer	1 No.
g)	Float with contact for Buchholz Relay for each rating of transformer	1 No.
h)	Set of gaskets (other than that with bushing) for each rating of transformer	1 No.
i)	Set of valves for each rating of transformer	1 Set
j)	Pressure relief device for each rating of transformer	1 No.
k)	Neutral grounding resistor of each type and rating	1 No.
<b>3.4.2</b>	<b>Dry Type Transformer</b>	
a)	Limb of complete LT and HT of temperature sensing devices	1 Set
b)	Bushing (in case of separate item on transformers offered) HV, LV and LV neutral	1 No.
<b>3.5</b>	<b>Motors</b>	
<b>3.5.1</b>	<b>11/ 6.6/ 3.3 kV Motors</b>	
a)	Termination kits (if elastimold type) of each type	1 No.
b)	Termination kits (end connection)	1 No.
c)	Temperature indicators	1 No.
d)	Vibration indicators	1 No.
e)	Terminal box Teflon glands	1 No.
f)	Phase segregated terminal boxes	1 No.
g)	Heaters	1 Set
h)	Couplings	1 No.
i)	Bearings (DE & NDE) for each type & rating of motors (if not specified under equipment spares)	1 Set
j)	Motor of each type and rating	1 no. of each type and rating





<b>3.5.2</b>	<b>415V Motors</b>	
a)	Terminal plates for motors for each rating	1 No.
b)	Heaters	2 Sets
c)	Greasing arrangements for each type of motor	4 Sets
d)	Motor of each type and rating	1 no. of each type and rating
e)	Bearings (DE & NDE) for each type & rating of motor (if not specified under equipment spares)	5 Sets
<b>3.6</b>	<b>Power and Control Cables</b>	
	11/ 6.6/ 3.3kV grade power cables for each type and size	10% of installed quantity
	1.1kV grade power and control cables for each type and size	10% of installed quantity
<b>3.7</b>	<b>Battery</b>	
a)	Battery cell	2 Nos.
b)	Cell container of each type	2 Nos.
c)	Level indicator	2 Nos.
d)	Vent plugs	5 Nos.
e)	Intercell connector	5 Nos.
f)	Set of nuts, bolts and washer	5 Nos.
<b>3.8</b>	<b>Battery Chargers : For float cum boost charger of batteries</b>	
a)	Electronic Cards of each type and rating (with all components mounted)	1 Set
b)	fuses of each type and rating	4 Nos.
c)	SCR of each type and rating	2 Nos.
d)	Blocking Diode of each type and rating	2 Sets
e)	Potentiometer of each type and rating	2 Sets

**Note:**

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- ii) Wherever quantity of spares has been defined in 'Set', it shall mean the quantity of spares to be supplied for one complete replacement for one equipment.
- iii) In the case of spares offered in 'Sets', the details of each Set giving the number of parts in the Set shall be clearly mentioned.



### 8.3 CONTROL AND INSTRUMENTATION

1	<b>Measuring Instruments</b>		
	i)	Electronic transmitters	
	a)	Transmitters of all types, ranges and model no. (for the measurement of Pressure, differential pressure flow, level, etc.)	10% or 2 no. of each type and model, whichever is more
	b)	Electronic cards / PCB's for each type and model and model of transmitters	10% or 5 nos. of each type, whichever is more
	ii)	Temperature elements	
	a)	RTDs* of each type & length	10% or 2 nos. whichever is more
	b)	Thermocouples of each type like K-type, R-type, metal etc. and length *	10% or 2 nos. whichever is more
	c)	Cold junction compensation boxes of each model	10% or 2 nos. whichever is more
	d)	Thermostatic units for each model of CJC box	10% or 2 nos. whichever is more
		* (With head assembly, terminal block and nipple)	
	iii)	Local Indicators like temperature, pressure, differential pressure, flow gauges and flow meters etc.,	5% or 1 no. of each make, model and type whichever is more (to be divided to various ranges in proportion to main of all make, model, type population)
	iv)	Process actuated switch devices Including all types of pressure, differential pressure, flow, temperature, differential temperature, level switch devices	5% or 1 no. of each type and model whichever is more
	v)	Level transmitters (displacer type)	
		Electronic cards / PCB's of level transmitters	5% or 1 no. whichever is more for each type and model.
		Level transmitters	5% or 1 no. of each type, displacer length and model whichever is more
	vi)	PD type flow transmitters	5% or 1 Set of each type and model whichever is more
2	<b>Process Connection Piping (for impulse piping/tubing, sampling piping/tubing and air supply piping as applicable)</b>		
	i)	Valves of all types and models	10% or 2 no. of each type, class, size and model whichever is more



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	ii)	2 way, 3way, 5way valve manifolds	10% or 2 no. of each type, class, size and model whichever is more
	iii)	Fittings	10% or 2 packet of each type, class, size and model whichever is more.
	iv)	Purge meters	10 % of each model or 2 Nos. whichever i
	v)	Filter regulators	10 % of each model or 2 Nos. whichever is more
<b>3</b>	<b>Instrumentation Cable, Internal Wiring and Cable Connectors</b>		
	i)	Pre fabricated cable of each type	10% of installed quantity
	ii)	Pre fabricated cable connector	10% or 1 no. of each type and model, whichever is more
	iii)	Other cables	10 % of each type, pair and size of actual installed quantity
<b>4</b>	<b>Electrical Actuators</b>		
	i)	Actuators	10% or 2 no. of each type, model and rating, whichever is more
	ii)	Power unit for modulating actuator	10% or 2 nos. of each type, whichever is more
	iii)	DC-DC unit/power pack units	10% or 2 nos. of each type, whichever is more
	iv)	Electronic cards	10% or 5 nos. of each type, whichever is more
	v)	Brake assembly	10% or 2 nos. of each type, whichever is more
	vi)	Brake coils	10% or 2 nos. of each type, whichever is more
	vii)	Position feedback transmitters	10% or 2 nos. of each type, whichever is more
	viii)	Control unit	10% or 2 nos. of each type, whichever is more
	ix)	Torque and limit switch assembly	10% or 2 nos. of each type, whichever is more
<b>5</b>	<b>PLC Control System</b>		
	i)	Power supply unit	10 % or 2 nos. of each type and model, whichever is more
	ii)	Input/ output modules	10 % or 2 nos. of each type and model, whichever is more
	iii)	Central processor unit	10 % or 2 nos. of each type and model, whichever is more
	iv)	Interface units	10 % or 2 nos. of each type and model, whichever is more



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	v)	Interconnecting cables	2 run length of each type and size
	vi)	Push button & control switches	10% or 2 nos. of each type and model, whichever is more
	vii)	Connectors for pre-fab cable	5 nos. of each type and model
	viii)	Cooling fan in PLC system/cabinet	10% or 2 nos. whichever is more
	ix)	Indication lamps of all types	100%
	x)	Audible devices	10% or 5 nos. of each type whichever is more
	xi)	Batteries including battery for RAM battery back-up	10% or 2 nos. of each type whichever is more
	xii)	Keyboard	10% or 2 nos. of each type whichever is more.

**Note:**

- i) Wherever quantity of spares have been defined in percentage, the quantity shall be rounded off to next higher integer in case of fractions.
- ii) Wherever quantity of spares has been defined in 'Set', it shall mean the quantity of spares to be supplied for one complete replacement for one equipment.
- iii) In the case of spares offered in 'Sets', the details of each Set giving the number of parts in the Set shall be clearly mentioned.

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## SECTION 9.0

### QUALITY ASSURANCE PLAN

The testing and inspection requirements of major equipment of FGD system to be followed by the bidder over and above the respective code/ standard requirements are given hereunder:

#### 9.1 MECHANICAL SYSTEMS

##### 9.1.1 Flue Gas System

###### 9.1.1.1 Booster fans

- i) Rotor components shall be subjected to ultrasonic test at mill and magnetic particle examination/dye penetration examination after rough machining.
- ii) Butt welds in rotor components shall be subjected to 100% UT and all welds shall be subjected to MPE or DPT after stress relieving.
- iii) All rotating components of fans shall be dynamically balanced to quality grade 2.5 of ISO 1940.
- iv) Test for natural frequency of all fan components, including fan blades shall be carried out for the fans.
- v) Full range performance test shall be carried out on one fan as per BS 848, Part-1.
- vi) Hydraulic coupling of booster fan shall be checked for string test i.e., operational check of one fan assembly using hydraulic coupling to check temperature rise, smooth operation, vibration and noise level. Dry run test shall preferably be carried out during string test.

###### 9.1.1.2 Thermal insulation

- i) Thermal insulation
  - a) Pre-formed fibrous pipe insulation and LRB mattresses/ sections of rock wool/ mineral wool from approved manufacturing sources conforming to and tested as per relevant standards shall be used.
  - b) For resin bonded mineral wool insulation, testing shall be carried out as per IS: 8183.
  - c) For resin bonded rock wool insulation, testing shall be carried out as per IS: 9842.
  - d) Type tests except thermal conductivity shall be regularly carried out once in three months.



- e) Type test for thermal conductivity shall be carried out by the manufacturer minimum once in six months. Thermal conductivity (K value) shall be measured in line with IS: 3346.

#### 9.1.1.3 Dampers

- i) All the dampers shall be subjected to operational test/checks.
- ii) Gas tight dampers shall be subjected to shop leakage test to demonstrate the guaranteed tightness (minimum one damper of each type and size offered). In case such type test is already done, the reports of the same shall be submitted for review.
- iii) All dampers shall be checked for sealing dimensions to establish guaranteed tightness.

#### 9.1.1.4 Structure, Ducts, Hoppers

- i) All materials shall be tested for chemical and mechanical properties as per relevant standard. All plates above 40mm shall be 100% Ultrasonically tested.
- ii) Visual inspection of all welds shall be performed in accordance with AWS DI .1.
- iii) NDT requirements of structural steel welds shall be as under:
  - a) 100% RT/UT on butt-welds of plate thickness  $\geq 32$ mm.
  - b) For plates of  $25\text{mm} \leq \text{thickness} < 32\text{mm}$ : 10% RT and 100% MPI.
  - c) For plates of thickness  $< 25\text{mm}$ : 10% MPI/LPI.
- iv) Edge for shop and field weld shall be examined by MPI for plate thickness  $\geq 32$ mm.

#### 9.1.2 Absorber

##### 9.1.2.1 Metal Structures

- i) Only material which has been identified against mill sheet or test certificates shall be used for construction. Check testing shall be carried out in the absence of MTC. All plates above 40mm shall be 100% Ultrasonically tested.
- ii) Visual inspection of all welds shall be performed in accordance with AWS DI .1.
- iii) NDT requirements of structural steel welds shall be as under:
  - a) 100% RT/UT on butt-welds of plate thickness  $\geq 32$ mm.



- b) For plates of 25mm≤thickness<32mm-10%RT and 100% MPI.
- c) For plates of thickness <25mm-10% MPI/LPI.
- iv) Edge for shop and field weld shall be examined by MPI for plate thickness ≥ 32mm.

#### 9.1.2.2 Spray Nozzles

- i) Spray nozzles shall be tested for physical properties.
- ii) Spray nozzles also shall be subjected to performance test.

#### 9.1.2.3 Agitators

- i) Rubber lining shall be tested for hardness and spark test.
- ii) Impellers shall be tested for dimensional and balancing check.
- iii) Gear Boxes shall be tested for run test as per standard practice.

#### 9.1.2.4 Other Critical Equipment

Checks/ NDTs shall be done as per relevant Indian Standards or equivalent International Standards.

### 9.1.3 Limestone & Gypsum Handling System

#### 9.1.3.1 Crushers

The details of the checks to be carried out for various components are to be submitted by the Contractor for Owner's approval. However, some indicative checks on different items are given below which should necessarily form part of the Quality Assurance Plan to be agreed with the Owner.

- i) All plates equal to or above 25mm thickness shall be ultrasonically tested.
- ii) Shaft forgings and suspension bars to be checked for ultrasonic testing in addition to check for chemical, mechanical, hardness, microstructure etc. as per applicable material specification.
- iii) Following minimum NDT requirements to be ensured for welds:
  - a) Butt welds - UT/RT and 100% MPI/DPT.
  - b) Fillet Welds - 10% MPI/DPT.
- iv) Crusher rotor to be dynamically balanced. Procedure to be submitted for approval.



- v) No-load trial run test to be carried out at shop to check for speed(RPM), temperature rise, noise level and vibration.

#### 9.1.3.2 Metal Detectors

- i) Functional test including sensitivity, Burn in test, operation of liquid spray marker, detection of smallest piece of different materials as specified.
- ii) Test report for Degree of protection test to be furnished.

#### 9.1.3.3 Belt Conveyor System

The details of the checks to be carried out in the various equipment are to be submitted by the Contractor for Owner's approval. However, some indicative checks on different items are given below which should necessarily form a part of the Quality Assurance Plan to be agreed with the Owner.

##### 9.1.3.3.1 Idlers

- i) Check for run out and free movement shall be carried out on idlers. Run out shall be restricted as per IS:8598
- ii) Test for dust proofness, water proofness and dynamic friction factor of the Idlers shall be conducted at shop. The detailed procedures for the same shall be submitted for review and approval.

##### 9.1.3.3.2 Belting

- i) Rubber cover of finished belt shall be checked for tensile strength and elongation at break before and after ageing. Rubber cover shall also be checked for abrasion, tear strength and hardness.
- ii) For finished belts, checks for elongation at 10% nominal tensile strength tensile and elongation at break in longitudinal (warp) direction and tensile in transverse (weft) direction shall be carried out.
- iii) Adhesion test between ply to ply and cover to ply shall be carried out.
- iv) Troughability test and Test for fire resistance shall be carried out.
- v) Test for procedure qualification for belt vulcanizing joint (at site) shall be done. Procedure for belt vulcanizing joint shall be discussed and finalized during FQP finalization.
- vi) There will be a limitation on the no. of repairs allowed on the belts. Following will be the acceptance norm for the cover repairs.
  - a) The maximum size of a repair shall be limited to a size equivalent to one fifth the belt width. No single dimension shall exceed one fifth (1/5) of belt width.





- b) Small local repair by dough filling of size 25mm x 25mm to a limited extent shall not be counted of repairs. However, in case of cluster of repairs, same shall be counted as a patch repair.
- c) The maximum number of patch repair shall not exceed 5 per 100 meter. However, the total number of patch and dough filling repairs shall not exceed 10 per 100 meters.
- vii) In addition to above, Steel Cord belt shall be tested for following also:
  - a) Cord dia and breaking strength
  - b) Finished belt shall be tested for cord pull-out strength before and after ageing, peeling resistance.
  - c) Dynamic cord pull out test
  - d) Cord dia, pitch and number of cords
- viii) In no case shall the cover thickness or the width of belt be less than that given in specification.
- ix) For testing purpose, belt sample shall be taken from anywhere of the belt roll length offered

#### 9.1.3.3.3 Belt vulcanizing machine

- i) Check for tensile strength shall be carried out on a sample vulcanized belt joint for each type of belt in shop. However, if such test has been done earlier, the report for same shall be submitted for verification.
- ii) Complete assembly shall be tested at shop for temp. and pressure developed.

#### 9.1.3.3.4 Pulleys

- i) In addition to chemical, mechanical, hardness, microstructure as per applicable material specification, pulleys shaft forgings shall be subjected to ultrasonic testing.
- ii) 100% MPI/DPT on all welds shall be conducted and RT/UT on butt welds shall be conducted.
- iii) Static balancing of pulleys shall be carried out after rubber lagging.
- iv) Checks on rubber lagging to include abrasion loss, shore hardness test, peel-off strength test and physical properties. Peel-off strength shall be 10 kg/cm, Abrasion loss shall be less than 250 cubic mm when tested as per DIN 53516.



#### 9.1.3.3.5 Pull chord & belt sway switches

The following tests shall be carried out:

- i) Over all dimension and functional test.
- ii) HV & IR test
- iii) Degree of protection test report.

#### 9.1.3.3.6 Zero speed switch, under belt switch and chute blockage switch

The following tests shall be carried out:

- i) Burn in test at 50 deg C for 48 hours shall be done for electronic switches.
- ii) Over all dimension and functional tests.
- iii) HV & IR
- iv) Degree of protection test

#### 9.1.3.3.7 Drive Equipment

- i) Gear Boxes
  - (a) In addition to checks for physical, chemical, hardness, microstructure as per relevant standard, the shaft and gear/pinion forgings shall be subjected to ultrasonic testing
  - (b) MPI to be carried out on Gears/Pinions after machining. Case depth, hardness and MPI after hard facing shall be checked to ensure freedom from defects.
  - (c) Gear reducer shall be checked for reduction ratio, backlash and contact pattern. No load shop trial run to be conducted on gear boxes to check for oil leakage, temperature rise, noise level and vibration.
- ii) Flexible Coupling
  - (a) Ultrasonic testing shall be conducted on forgings for gear sleeve and gear hub, if gear coupling is provided.
  - (b) MPI shall be carried out after machining to ensure freedom from cracks.
- iii) Fluid Coupling
  - (a) Dynamic balancing shall be carried out for the rotating parts.
  - (b) Check for leak tightness of the coupling shall be carried out.



- (c) Functional test on fusible plug for each type of coupling shall be conducted at shop.
- (d) All couplings to be run tested at shop on no load.
- (e) Check for temperature rise, torque-speed, torque-slip characteristics and over speed test shall be included during performance test of one coupling of each type preferably at full load.

#### 9.1.3.3.8 Belt Scales

The details of the checks to be carried out in the various equipment are to be submitted by the Contractor for Employer's approval. However, some indicative checks are given below which should necessarily form a part of the quality assurance plan to be agreed with the Employer.

- i) Mounting arrangement/Overall dimensional check shall be carried out on the Belt Scales.
- ii) Belt scale shall be calibrated with test weight/test chain in static at works and with test weight for dynamic condition at site.
- iii) All electronic modules shall be subjected to burn in test at 50 Deg C for 48 hours.
- iv) General check for load cell shall be carried out.
- v) Test report for degree of protection on enclosure shall be furnished.
- vi) Accuracy/performance check shall be demonstrated at site.

#### 9.1.4 Dust Control System

The tests etc. shall be carried out various components of dust extraction system offered by the bidder in line with standard industry practice. The details of the checks to be carried out on the various equipment are to be submitted by the Contractor for Purchaser's approval.

#### 9.1.5 Bucket Elevator

- i) All plates equal to or above 25 mm thickness shall be ultrasonically tested.
- ii) Castings and forgings, forged/rolled bar/section shall be subjected to ultrasonically test in addition to check for chemical, mechanical, hardness, microstructure etc. as per applicable material specification.
- iii) Machined and hard faced surface of casting/forging and other hardened, stellite parts shall be subjected to DPT/MPI in addition to check for case



depth, hardness as applicable for chain/sprocket/gear reducer/ rollers/  
wheel/ pan etc.

- iv) Following minimum NDT requirements shall be followed for welds:
  - a) Butt Welds in Tension - 100% UT/RT and 100% MPI/DPT.
  - b) Butt Welds in Compression - UT/RT and MPI/DPT.
  - c) Fillet Welds - MPI/DPT.
- v) For other items like drive system, motor, pulley, belt etc. relevant portion of specification shall be applicable.
- vi) No load trial run test shall be carried out at shop on completely assembled Bucket Elevator to check for trouble free operation, temperature rise, Noise & vibration. The procedure for the No load trial run shall be submitted for approval.

#### 9.1.6 Silos/ Bunkers

- i) All material shall be tested for Chemical & Mechanical properties as per relevant standard. MPI/DP test on welding shall be carried out. Fit up assembly checks shall be carried out at shop for all despatchable segments.
- ii) Bag Filters: Bag Leakage test shall be carried out for pressure parts. Pulsing and sequential test on bag filter shall be done.

#### 9.1.7 Ball Mills

- i) Raw material for shaft, coupling, gears and pinions, top and bottom races and other rotating components shall be subjected to UT. MPI/LPI shall be carried out to check surface soundness.
- ii) Wear-resistant parts shall be UT/RT tested to check soundness after suitable heat treatment. Check for chemical composition, hardness and microstructure shall be carried out.
- iii) Butt welds in the tube/separator/body casing of the mill shall be tested by RT and MP'. All other welds in main tube/separator shall be tested by MPI/LPI for acceptance. The tube shall be statically balanced.
- iv) All gearboxes shall be run tested for adequate duration to check rise in oil temperature, noise level and vibration. Check for leak tightness of gear case also shall be performed.

##### 9.1.7.1 Gravimetric Feeders

- i) Any welds in the casing/pulley fabrication shall be checked with MPI.
- ii) Routine tests shall be done as per relevant Indian Standards or equivalent International Standards.



- iii) All major items like plates for casing, head pulley, tail pulley, pulley shaft and major castings shall be procured with respective material test certificates.
- iv) Calibration check shall be carried out on all feeders.

#### 9.1.3.7.2 Lubricating oil systems

Complete lub oil system shall be checked suitably as per standard practice.

#### 9.1.8 Vacuum Belt Filter System

- i) Impeller, casing and shaft of vacuum pumps shall be tested for chemical and mechanical properties as per relevant standard. All plates above 40mm shall be 100% Ultrasonically tested.
- ii) UT on shaft (if greater or equal to 40mm) and impeller shall be carried out.
- iii) All vacuum pumps shall be tested at shop for capacity, power, pressure, efficiency, noise and vibration etc.
- iv) Filter cloths and belts shall be tested for physical properties as per relevant standard
- v) Hydro cyclones shall be checked by visual, dimensional etc.

#### 9.1.9 Monorail and Hoists

##### 9.1.9.1 Hooks

- i) All tests including proof load test as per relevant IS shall be carried out.
- ii) MPE or DPT shall be done after proof load test.

##### 9.1.9.2 Steels castings

Steel castings shall be subjected to DPT on machined surface.

##### 9.1.9.3 Forgings

- i) All forgings (wheel, gears, pinions, axles, hooks and hook trunion) greater than or equal to 50mm diameter or thickness shall be subjected to ultrasonic testing.
- ii) DPT or MPE shall be done after hard facing and machining.

##### 9.1.9.4 Wire rope

Wire rope shall be tested as per relevant standard.

##### 9.1.9.5 Electric hoists

All electric hoists shall be tested as per IS-3938 and chain pulley blocks shall be tested as per IS-3832.



### 9.1.10 Ventilation System

- i) Fans
  - a) 20% DPT of welding on fan hub, blades, casing and impeller as applicable shall be carried out.
  - b) DPT of fan shafts shall be carried out after machining.
  - c) UT of fan shafts (diameter greater than or equal to 50mm) shall be carried out.
  - d) Rotating components of all fans shall be statically and dynamically balanced to ISO-1940 Gr. 6.3.
  - e) All centrifugal fans shall be subjected to run test for 4 hour or till temperature stabilization is reached. Vibration, noise level, temperature rise and current drawn shall be measured during the run test.
  - f) One fan of each type and size will be performance tested as per corresponding IS code for airflow, static pressure, total pressure, speed, efficiency, power consumption, noise, vibration and temperature rise.

Piping Valves and fillings- Refer clause 9.10.3

### 9.1.11 Packaged, split and window air conditioners

- i) Compressor of packaged air conditioner (PAC) shall be tested as per relevant code/standard.
- ii) PAC shall be subjected to production routine test in accordance with IS: 8148 for the following.
  - a) General running test.
  - b) Pressure or leakage test of refrigerant.
  - c) Insulation resistance test.
  - d) High voltage test.
  - e) Performance test on one PAC of each type/size at ambient condition to check for following:
    - DBT and WBT of supply and return air.
    - Air flow
    - Current, voltage measurement and power consumption
    - Noise and vibration measurement
- iii) Manufacturer's standard test certificate or guarantee certificate shall be submitted for split and window air conditioners.



### 9.1.12 Elevators

- i) The details of the checks to be carried out in the various equipment are to be submitted by the contractor for owner's approval. However, some indicative checks on different items are given below which should necessarily form part of the quality assurance plan to be agreed with the owner.
- ii) All forgings shall be subjected to ultrasonic test to ensure free from internal defects in addition to check for chemical and mechanical properties.
- iii) 10% of the welds selected at random shall be subject to DP test.
- iv) All forged components shall be subjected to DPI/MPI after machining.
- v) Gear Reducer shall be checked for gear ratio, backlash, contact pattern. No load shop trial run shall be conducted on gear boxes to check for oil leakage, temperature rise, noise and vibration.
- vi) Buffer springs shall be subjected to load test as per relevant specifications. Material certificates for springs shall also be furnished
- vii) All components prior to assembly shall be checked for dimensions.
- viii) Car sling and car body in assembled condition shall be checked for position of all major components i.e. car sling, inside depth, width, height, positions of push box, indicator box lights, fans etc.
- ix) Function test of Elevator assembly shall be carried out.
- x) All electrical equipment shall be of proven quality.
- xi) Galvanized components/parts shall be checked for weight of Zn coating, thickness of coating, uniformity of coating and adhesion test and visual examination as per IS 2633 and IS 2629.

### 9.1.13 Fire Detection & Protection System

- i) **Hydrant System: Shop Tests**
  - a) Hydrant Valve:
    - All valves shall be hydro tested for body and seat.
    - Capacity test / flow test shall be done as per relevant standard.
  - b) Water Monitor, Hoses, Branch Pipes, Couplings and Nozzles:
    - All tests including hydraulic test shall be done as per relevant Indian/ International standard.



**ii) High/ medium velocity water spray: shop tests**

- a) For Pipes, Fittings, Valves and specialties, requirements are indicated separately.
- b) Deluge Valves and Spray Nozzles
  - All valves shall be hydro tested for body and seat.
  - Performance test / functional test of 'Deluge Valves' and 'Spray Nozzles' shall be carried out.

**iii) Detectors**

All 'Detectors' shall be tested as per relevant Indian / International Standards. Detectors shall also meet the requirements of UL / FM / LPC/VDS etc.

**iv) Piping, valve and specialties**

Refer clause 9.1.14.

**v) Portable & mobile fire extinguishers**

- a. All fire extinguishers shall be tested as per relevant standard.
- b. Performance / function test shall be carried out on sampling basis as per relevant code / standard.

**vi) Site tests.**

- a) Fire Extinguishers: A performance demonstration test at site of five (5) percent or one (1) number, whichever is higher, of each type and capacity of the extinguisher shall be carried out by the contractor. All consumables and replaceable items require for the contractor without any extra cost to employer would supply this test would be supplied by the Contractor without any extra cost to employer.
- b) Piping Protection:
  - Thickness, Holiday by spark test, Adhesion test shall be carried out as per relevant standard.
  - Complete piping shall be Hydro pressure tested, at 1.5 X DP or 2 X MWP whichever is higher, before protection.
- c) Welding of Pipes:
  - ERW Black / rolled welded:
    - 100% DPT on root of butt and finish weld of butt and fillet.
    - RT on 10% randomly selected joints shall be carried out (for underground piping).





- **GI Pipes**

Welding on GI Pipes in general shall not be done. Welding of GI Pipes, if permitted by design, (butt / socket / fillet weld) shall be done strictly as per approved drawing and procedure approved by NTPC Engineering. For all such welds 100% DP test and random 1% RT shall be done.

#### **9.1.14 Miscellaneous Equipment**

##### **9.1.14.1 Pressure Vessels**

- i) NDT on weld joint shall be as per respective code requirements or the minimum as specified as below:
  - a) 100% DPT on root run of butt weld, nozzle welds and finished fillet welds.
  - b) 10% DPT on all finished butt welds.
  - c) 10% RT (covering all 'T'/cross joints) of butt welds.
- ii) Butt welds of dished ends shall be stress relieved and subjected to 100% RT.
- iii) Each finished vessels shall be hydraulically tested to 150% of the design pressure for a duration of 30 minutes.

##### **9.1.14.2 Tanks**

- i) Tests shall be carried out on the materials of the tanks to establish their mechanical properties, and chemical compositions
- ii) Plates shall be subject to 100% ultrasonic testing.
- iii) Welding
  - a) Root run of butt welds shall be examined by 100% DPT or MPE.
  - b) Butt welds, full penetration joints and nozzle welds shall be checked by 100% RT and 100% MPE or DPT.
  - c) Fillet welds shall be checked by 100% MPE or DPT.
- iv) Rubber lining shall be subject to hardness and spark test, as applicable.
- v) Visual check and dimensional measurement shall be carried out on the completed equipment.
- vi) The fabricated tank shall be subject to water fill test to check for the leakage.



### 9.1.15 Low Pressure Piping, Valves and Fittings etc.

#### 9.1.15.1 Pipes, fittings

- i) Tests shall be carried out on the materials on various components to establish their mechanical properties and chemical composition. Further, heat treatment shall be carried out for materials as required.
- ii) Dye penetration test of welds of pipes and fittings (including welds of rolled and welded pipes) shall be carried out.
- iii) All pipes and fittings shall be tested as per applicable codes/ standards at manufacturer's works.

#### 9.1.15.2 Valves

- i) Tests shall be carried out on the materials on various components to establish their mechanical properties and chemical composition. Further, heat treatment shall be carried out for materials as required.
- ii) Shaft/ spindle of size  $\geq 50$  mm diameter shall be subjected to ultrasonic test.
- iii) Machined surfaces of casing, disc and shaft shall be subjected to 100% MPI or DPT as applicable.
- iv) All valves shall be hydraulically tested for body, seat and back seat (wherever provided) at 1.5 times the maximum pressure to which respective valves can be subjected during plant operation. Check valves shall also be tested for leak tightness test at 25% of the specified seat test pressure. For rubber lined valves, hydraulic test shall be carried out before rubber lining.
- v) For butterfly valves, hydraulic test, seat and disc string test and proof of design test (if not carried out earlier) shall be carried out in accordance with latest edition of AWWA-C-504 standard.
- vi) Visual and dimensional check shall be carried out for all valves as per relevant code/ approved drawing.
- vii) Functional/ operational checks for and check for smooth opening and closing of the valves shall be carried out.
- viii) Gate, globe and swing check valves
  - a) Machined surfaces of castings and butt welds shall be subjected to MPE or DPT.



- b) Blue matching, wear travel for gates, valves, pneumatic seat leakage, reduced pressure test for check valves shall be done as per relevant standard.
- vii) Diaphragm valves
- a) Seat leakage test for actuator operated valves, shall be done with by closing the valves with actuator.
  - b) Tests on rubber parts per batch of rubber mix such as hardness, adhesion, spark test, bleed test and flex test on diaphragm, type test for diaphragm for 50,000 cycles.
- viii) Cast butterfly valves
- a) Machined surfaces of casing, disc and shaft shall be subjected to MPE or DPT.
  - b) Actuator operated valves shall be checked for seat leakage by closing the valves with actuator. Seat leakage test shall be carried out in both directions.
- ix) Fabricated butterfly valves:
- a. UT shall be carried out on plate material for body and disc.
  - b. Machined surfaces of casing, disc and shaft shall be subjected to MPE or DPT.
  - c. Butt welds of thickness above 30mm on body and disc shall be subject to 100% RT along with and post weld heat treatment for stress relieving.
  - d. Actuator operated valves shall be checked for seat leakage by closing the valves with actuator. Seat leakage test shall be carried out in both directions.
- x) Dual plate check valves:
- a. Dry cycle test (spring cycle test) for one lakh cycles shall be carried out as a type test.
  - b. Machined surfaces of casing, disc and shaft shall be subjected to MPE or DPT.



### 9.1.15.3 Rubber lining of pipes and valves

- i) For rubber lining, the following tests shall be carried out as per IS-4682 part-I or acceptable equivalent standard:
  - a) Adhesion test
  - b) Measurement of thickness
  - c) Shore hardness test
  - d) Visual examination and spark test at 5 kV/mm of thickness
  - e) Bleeding resistance test (as applicable) with keeping the sample in 33% HCl, 48% NaOH and DM water for 72 hours.
  - f) Bleeding test and ozone resistance test shall be done on rubber material.
- ii) Dimensional check shall be carried out as per relevant code/ approved drawing.

### 9.1.15.4 Coating and wrapping of pipes

Spark test, adhesion test and material test for primer and enameled and coal tar tapes, as applicable, shall be carried out as per AWWA-C-203-91.

### 9.1.15.5 Rubber expansion joints

- i) Rubber compound test slab after vulcanising shall be tested for tensile strength, elongation and shore hardness. Tests on rubber compound shall also include hydro stability test as per ASTM D-3137 and ozone resistance test as per ASTM D- 380.
- ii) Fabric strength of synthetic fibre for reinforcement shall be checked, and test for rubber to fabric adhesion as per IS: 3400 or ASTM D- 413, rubber to metal adhesion as per IS 3100 or ASTM D-429 shall be carried out.
- iii) All expansion joints in assembled condition shall be subjected to vacuum test at 730 mm Hg under conditions to ensure its suitability to withstand deflection in each axial transverse and longitudinal direction. Duration of test shall be of minimum 10 minutes.
- iv) All bare bellows shall be subjected to hydraulic pressure test in normal condition at twice the design pressure for a duration of 30 minutes. Additionally, all bare bellows shall be subjected to deflection tests under pressure, pressure being raised from zero to the design value in regular steps and deflection measured at each step.
- v) All expansion joints in assembled condition along with control rod assembly shall be subjected to deflection test under design pressure.



- vi) Either during the hydraulic test or during the vacuum test, change in circumference at the top position of the arch shall not exceed 1.5% of measured circumference at normal position.
- vii) Twenty four (24) hours after the above tests, the permanent set (variation in dimensions with respect to its original dimension) shall be measured and recorded. The permanent set shall not be more than 0.5%.
- viii) Life cycle test and burst test shall be carried out on bellows of each type, design and size.

#### 9.1.15.6 Dosing pumps/ metering pumps

- i) Tests shall be carried out on the materials of the pumps to establish their properties, and chemical compositions
- ii) Pump casings shall be subject to hydraulic test at 1.5 times the shut off pressure or 2 times the working pressure whichever is higher.
- iii) Pumps shall be performance tested as per HIS, USA.

#### 9.1.15.7 Horizontal centrifugal pumps

- i) Tests shall be carried out on the materials of the pumps to establish their properties, and chemical compositions.
- ii) 100% DPT or MPE shall be carried out for the rotor and machined surfaces of casing and impellers.
- iii) UT on pump shaft (diameter greater than or equal to 50mm), MPI or DPT on pump shaft and impeller after machining shall be carried out.
- iv) All rotating components of the pumps shall be statically and dynamically balanced to ISO-1940 Gr. 6.3.
- v) Assembly fit up check, and dimensional check shall be carried out for the completed pump assembly.
- vii) Pump casings shall be subject to hydraulic test at 1.5 times the shut off pressure or 2 times the working pressure whichever is higher for a minimum duration of 30 minutes.
- viii) All pumps shall be tested at manufacturer's works for head, capacity, power and efficiency as per requirements of HIS, USA or equivalent standard. Pump shall be given running test over the entire operating range covering from the shut-off head to the maximum flow. Acceptance shall be as per approved datasheet and HIS only.
- ix) Pumps shall be subjected to strip down examination visually to check for mechanical damages after testing at shop in case abnormal noise level and/or excessive vibration are observed during the shop test.

#### 9.1.15.8 Vertical sump pumps

- i) All materials should be of tested quality and test certificates to be provided.



- ii) Shaft forgings to be subjected to ultrasonic testing.
- iii) DPT to be done on machined shaft and impeller.
- iv) Impellers to be dynamically balanced to ISO 1940 Gr.6.3.
- v) All pressure parts shall be hydraulically tested at 150% of the shut-off head or 200% of rated head, whichever is higher for 30 minutes. No leakage is allowed.
- vi) All pumps to be performance tested as per Hydraulic Institute Standard/ Indian Standard. Performance test to include check for noise, vibration level and bearing temperature rise.

#### 9.1.15.9 Blowers

- i) Tests shall be carried out on the materials of the rotary blowers/ compressors to establish their properties, and chemical compositions.
- ii) 100% DPT or MPE shall be carried out for the rotor and machined surfaces of casing and impellers.
- iii) The shaft and impellers shall be dynamically balanced.
- iv) Assembly fit up check, and dimensional check shall be carried out for the completed blower assembly.
- v) The blower/ compressor casing shall be subject to hydraulic test at 1.5 times the shut off pressure or 2 times the working pressure whichever is higher.
- vi) The blowers/ compressor shall be performance tested as per relevant code/ standard.

#### 9.1.15.10 Air Compressors

- i) All pressure parts shall be hydraulically tested at not less than 150% of design pressure for a duration of 30 minutes prior to painting.
- ii) All other parts including inter-connecting piping shall be hydraulically tested wherever possible, as per relevant codes.
- iii) Ultrasonic testing shall be carried out on all forgings and rotor for dia 50mm and above. MPI/DPT shall be done on machined area of the components.
- iv) During assembly all clearances and alignments shall also be checked and recorded
- v) Rotor shall be statically and dynamically balanced.
- vi) Performance test on the compressor shall be carried out in accordance with ISO: 1217/Eq. The test shall also include demonstration of loading



and unloading mechanism (Capacity control) and operation of safety valve.

vii) Vibration and Noise level measurement shall be done during shop performance test.

viii) Air Receiver

a) Each finished vessel shall be hydraulically tested at 150% of the design pressure for a duration of 30 minutes

b) NDT on weld joints shall be as per respective code requirements or the minimum as specified below:

- 100% DPT on root run of butt welds
- 100% DPT on all finished butt welds and fillet welds
- 10% RT on butt welds which shall include all T-Joints

#### 9.1.16 Hangers and Supports

i) All raw materials used shall have co-related mill test certificate meeting mandatory checks of material specification.

ii) Completed springs shall be tested for sagging test and load versus deflection test. For diameter more than 25mm, MPE shall also be carried out.

iii) Butt welds of thickness 32mm and above shall be tested for UT, and for butt welds of thickness less than 32mm MPE shall be done. Fillet welds shall be tested for MPE.

iii) Dampers with viscous fluids shall be checked for viscosity of liquid used, damping resistance of the damper, stiffness of the damper etc.

iv) Turn-buckle, pipe clamps and hangers of thickness greater than 25mm shall be checked by MPE or DPT on bent portions.

v) One hanger of each type and size shall be checked for variation in deflection and travel versus load test.



## 9.2 ELECTRICAL SYSTEMS

9.2.1 HT Bus duct										
11kV, 6.6kV & 3.3kV Segregated Phase Bus ducts										
Items/ Components/ Sub-systems	Tests/ Checks									
	Visual and Dimensional Checks	Electrical, Mechanical, Chemical properties	WPS and PQR	NDT, DP or MPI, RT	Paint shade and Adhesion test	Galvanizing Test as per IS: 2629/ 2633/ 6745	Electrical clearance and creepage	Functional/ Operational check	Make, Type, Rating, Model, TC, General physical inspection	Routine tests on complete busduct
Enclosure/ cubicle	Y	Y		Y	Y		Y			Y
Busbar flexible connector and disconnect or link	Y	Y		Y						
Steel structure and plate IS:2062	Y					Y				
Bushing, post and support insulator (IS:9431 and 2544)	Y	Y					Y		Y	Y
Welding of enclosure and conductor	Y		Y	Y						
Gasket, silicagel breather								Y	Y	
Complete busduct IS:8084	Y				Y		Y			Y

Y =Test applicable

### Site tests :

The following minimum tests/ checks shall be conducted at site. Any other tests/ checks as per the manufacturer's recommendation shall also be carried out

- Power frequency voltage withstand test
- Air leakage test
- Water tightness test on outdoor portion of bus-duct
- Insulation resistant measurement of equipment and all wiring
- Milli-volt drop





**9.2.2 Auxiliary Service Transformers**

**9.2.2.1 Oil-filled Outdoor Transformers**

Items/ Components/ Sub-systems	Tests/ Checks													
	Visual and Dimensional	Mechanical properties	Electrical strength	Thermal properties	Chemical Composition	Compatibility with oil	Core Loss (on first Job) Hot	NDT, DP or MPI, UT	Ageing Test	Voltage Ratio, Vector Group and	Make, Type, Rating, Model, TC,	WPS and PQR	Vacuum and Pressure Test	Routine Tests
Tank, HV and LV Cable Box/ Flange throat	Y	Y						Y					Y	
Conservator/ Radiator/ Cooler/ Pipes	Y	Y						Y						
Copper Conductor (IS:191)	Y	Y	Y		Y									
Insulating Material	Y	Y	Y	Y	Y	Y								
CRGO Lamination and Built Core	Y	Y	Y		Y	Y	Y							
Bushing / Insulator ( IS:2544/ 5621)	Y	Y									Y			Y
Gasket	Y				Y	Y		Y						
Transformer oil ( IS:335)														Y
Off-circuit tap changer	Y										Y			
Core coil assembly and pre-tanking	Y									Y				
Marshalling box	Y	Y						Y						
WTI, OTI, MOG, PRD, Breather, Terminal Connector, Bucholz Relay, Globe and Gate Valve,	Y										Y			
Welding (ASME Sect-IX)	Y											Y		
Complete Transformer (IS:2026)	Y													Y

Y =Test applicable



9.2.2.2 Dry Type Indoor Transformers												
Items/ Components/ Sub-systems	Tests/ Checks											
	Visual and dimensional check	Mechanical properties	Electrical strength	Thermal properties	Chemical properties	Core loss (on first job), Hot Spot	NDT DP or MPI	Voltage ratio, vector group and polarity	Make, Type, Rating, Model, TC, General physical inspection	WPS and PQR	Measurement of capacitance and tan delta between winding	Routine tests
Enclosure door, HV and LV Cable box/ Flange throat	Y	Y							Y			
Copper conductor	Y	Y	Y	Y								
Insulating material	Y			Y	Y							
CRGO lamination and built core	Y					Y						
Bushing/ Insulator ( IS:2544/ 5621)	Y								Y			Y
Gasket	Y								Y			Y
Off-circuit tap changer	Y								Y			
Core coil assembly	Y						Y					
Marshalling box	Y											
WTI, Thermister, Terminal connector	Y								Y			
Welding										Y		
Complete transformer (IS:11171)	Y										Y	Y

Y =Test applicable

**Site tests :**

The following minimum tests/ checks shall be conducted at site. Any other tests/ checks as per the manufacturer's recommendation shall also be carried out

- a) Dry out test
- b) Resistance measurement of windings
- c) Ratio test
- d) Vector group test
- e) Tap changer test
- f) Buchholz relay test
- g) Low oil level alarm.
- h) Temperature indicators
- i) Marshalling kiosk
- j) Protective relays
- k) Magnetizing current



9.2.3 Motors		Tests/ Checks																
Item/ Components/ Sub-system	Visual	Dimensional	Make, Type, Rating, TC, General physical	Mechanical, Chemical properties	NDT, DP or MPI, UT	Metallography	Electrical characteristics	Welding/ Brazing (WPS/ PQR)	Heat treatment	Magnetic characteristics	Hydraulic, Leak, Pressure test	Thermal characteristics	Run out	Dynamic balancing	All tests as per IS:325/ IS:4722/ IS:9283	Vibration	Over speed	Tan delta, shaft voltage and polarisation
Plates for stator frame, end shield, spider etc.	Y	Y	Y	Y					Y									
Shaft	Y	Y	Y	Y	Y	Y			Y									
Magnetic material	Y	Y	Y	Y	Y		Y			Y		Y						
Rotor copper/ Aluminium	Y	Y	Y	Y		Y	Y		Y									
Stator copper	Y	Y	Y	Y			Y		Y			Y						
SC ring	Y	Y	Y	Y	Y	Y	Y	Y	Y									
Insulating material	Y		Y	Y			Y					Y						
Tubes for cooler	Y	Y	Y	Y	Y				Y		Y							
Sleeve bearing	Y	Y	Y	Y	Y				Y		Y							
Stator, Rotor coils	Y	Y	Y				Y	Y										
Castings, stator frame, terminal box and bearing housing etc.	Y	Y	Y	Y	Y			Y										
Fabrication and machining of stator, rotor, terminal box	Y	Y			Y				Y									
Wound stator	Y	Y					Y	Y										
Rotor complete	Y	Y					Y						Y	Y				



Standard Technical Specification for Retrofit of Wet Limestone Based Flue Gas Desulphurisation  
(FGD) System in a Typical 2x500 MW Thermal Power Plant  
Section- 9 (Quality Assurance Plan)

Stator, Rotor, Terminal Box assembly	Y	Y					Y												
Accessories, RTD, BTD, CT, Brushes, Diodes, space heater, antifriction bearing, cable glands, lugs, gaskets etc.	Y	Y	Y																
Complete motor (IS: 325/ IS:4722/ IS:9283)	Y	Y	Y												Y	Y	Y	Y	1
Y =Test applicable, Y1 = for 11kV and 3.3kV motors only																			
<b>Note</b>																			
This is an indicative list of tests/ checks. The manufacture is to furnish the detailed Quality Plan indicating the practices and procedure followed along with relevant supporting documents during QP finalization. However QP approval is not envisaged for 415V motors upto 50 KW.																			

**Site Tests :**

The following minimum tests/ checks shall be conducted at site. Any other tests/ checks as per the manufacturer's recommendation shall also be carried out

- i) Measurement of vibration.
- ii) Measurement of insulation resistance and polarization index
- iii) Measurement of full load current.
- iv) Test running of the motors, checking the temperature rise and identifying the hot spot etc.



**9.2.4 11kV, 6.6kV and 3.3kV Switchgear (Table 1/2)**

Items/ Components/ Sub-systems	Tests/ Checks													
	Make, Type, Model, Rating and TC	Electrical Properties	Mechanical properties	Chemical properties	Dimensions and Finish	Functional and operational features	Item to conform to relevant Standards	Pretreatment as per IS 6005	Paint shade, thickness, adhesion and finish	Functional Checks	HV and IR Test	Degree of Protection - Routine test	CB Operation timing check	All Routine Tests as per relevant standards
Aluminum busbar material (IS: 5082)	Y	Y	Y	Y	Y		Y							
Copper busbar material (IS :613 )	Y	Y	Y	Y	Y		Y							
Bus bar support insulation (IS:9431)	Y	Y	Y		Y		Y			Y				
HT Circuit Breaker (IEC:56 )	Y				Y	Y	Y			Y			Y	Y
HT Contactors ( IS:9046 )	Y				Y	Y	Y			Y				Y
Protection and auxiliary relays (IS:3231/ 8686 )	Y				Y	Y	Y			Y				Y
HT CT's and PT's (IS:2705/ 3156)	Y				Y		Y							Y
HT Fuses ( IS:9385 )	Y				Y	Y	Y							
Surge arrester ( IEC:99-4 )	Y				Y		Y							Y
LT Contactors ( IS:13947)	Y				Y	Y	Y			Y				
Control and selector switches (IS:6875)	Y				Y	Y	Y			Y				
Indicating meters (IS:1248)	Y				Y	Y	Y			Y				Y
Indicating lamps (IS:13947)	Y				Y	Y	Y			Y				
Push buttons (IS: 4794)	Y				Y	Y	Y			Y				
Control transformer ( IS:12021 )	Y				Y	Y	Y							Y
LT fuses (IS:13703)	Y				Y	Y	Y							
Energy meters (IS:722 )	Y				Y	Y	Y							Y
Transducers (IEC:60688)	Y				Y	Y	Y							Y

Y =Test applicable



9.2.4 11kV, 6.6kV and 3.3kV Switchgear		(Table 2/2)												
Items/ Components,/ Sub-system	Tests/ Checks													
	Make, Type, Model, Rating and TC	Electrical properties	Mechanical properties	Chemical properties	Dimensions and Finish	Functional and Operational features	Item to conform to relevant standards	Pretreatment as per IS: 6005	Paint shade, thickness, adhesion and	Functional checks	HV and IR Test	Degree of Protection - Routine test	CB Operation timing check	All Routine Tests as per relevant standard
Diodes	Y	Y				Y	Y			Y				
Terminal Blocks	Y	Y				Y	Y							
Synthetic Rubber Gasket ( IS:11149/ 3400 )	Y	Y			Y		Y							
Breaker Handling Trolley	Y				Y	Y		Y	Y					
HT Switchgear Panel (IS:3427)	Y				Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Y =Test applicable														

**Site tests:** The following minimum tests/ checks shall be conducted at site. Any other tests/ checks as per the manufacturer's recommendation shall also be carried out.

- a) General
  - i) HV test on complete switchboard with CT and breaker/ contactor in position
  - ii) Check continuity and IR value of space heater
  - iii) Check earth continuity for the complete switchgear board
- b) Circuit Breaker/ Contactors
  - i) Check control wiring for correctness of connections, continuity & IR values
  - ii) IR values, resistance and minimum pick up voltage of coils
  - iii) All functional checks and electrical & mechanical interlocks provided
  - iv) Checks on spring charging motor, correct operation of limit switches and time of charging
- c) Current and Voltage Transformers
  - i) Insulation resistance test
  - ii) Ratio test on all cores
  - iii) Polarity test
- d) Relays
  - i) Insulation resistance between AC to DC terminals and between all terminals and body
  - ii) Check minimum pick up voltage of DC coils
  - iii) Relay settings



9.2.5 415V Switchgear and Busduct														
9.2.5.1 415V Switchgear (Table 1/2)														
(MCC, PCC, ACDB, DCDB, Local push button station, Local motor starters)														
Items/ Components/ Sub-system	Tests/ Checks													
	Make, Model, Type, Rating and TC	Dimensions and Finish	Electrical properties	Mechanical properties	Chemical properties	Functional and Operational features	Item to conform to relevant standards	Pretreatment as per IS 6005	Paint shade, adhesion, thickness and finish	Functional checks	Milli-volt drop Test	IR – HV – IR Test	Degree of protection Routine test	All Routine tests as per relevant standards
Sheet steel (IS:513)	Y	Y		Y	Y		Y							
Aluminum bus bar material (IS:5082)	Y	Y	Y	Y	Y		Y							
Copper bus bar material (IS:613)	Y	Y	Y	Y	Y		Y							
Support insulator (IS:943, IS:10912, IEC: 660 )	Y	Y	Y	Y			Y							
Air circuit breaker (IS:13947)	Y	Y				Y	Y		Y	Y				Y
Energy meters ( IS:722 )	Y	Y				Y	Y		Y					Y
Power and auxiliary contactor (IS:13947)	Y	Y				Y	Y		Y					
Protection and auxiliary relays (IS:3231)	Y	Y				Y	Y		Y					Y
Control and selector switches (IS:6875)	Y	Y				Y	Y		Y					
CT and VT (IS 2705/ 3156)	Y	Y					Y							Y
MCCB ( IS:13947 )	Y	Y					Y		Y					
Indicating meters (IS:1248)	Y	Y				Y	Y		Y					Y
Indicating lamps (IS:13947)	Y	Y				Y	Y		Y					
Air break switches ( IS:13947 )	Y	Y				Y	Y		Y					
Control terminal blocks	Y	Y				Y	Y							
Y =Test applicable														



**9.2.5.1 415V Switchgear (Table 2/2)**  
**(MCC, PCC, ACDB, DCDB, Local push button station, Local motor starters)**

Items/ Components/ Sub-system	Tests/ Checks													
	Make, Model, Type, Rating and TC	Dimensions and Finish	Electrical properties	Mechanical properties	Chemical properties	Functional and Operational Features	Item to conform to relevant standards	Pretreatment as per IS: 6005	Paint Shade, Adhesion, Thickness and	Functional checks	Milli-volt drop Test	IR – HV – IR Test	Degree of Protection - Routine test	All Routine tests as per relevant
Fuse (IS:13703)	Y	Y				Y	Y			Y				
Control transformer (IS:12021)	Y	Y				Y	Y			Y				Y
Push Buttons (IS:4794)	Y	Y				Y	Y			Y				
Transducer (IEC:60688)	Y	Y				Y	Y			Y				Y
MCB (IS:8828)	Y	Y				Y	Y			Y				
Breaker handling trolley	Y	Y				Y			Y	Y				Y
Synthetic rubber gasket (IS:11149)	Y	Y		Y	Y		Y							
415V Switchgear (IS:8623 )	Y	Y				Y	Y	Y	Y	Y	Y	Y	Y	Y

Y =Test applicable





9.2.5.2 415V Busduct															
Items/ Components	Tests/ Checks														
	Dimension and surface finish	Make, Type, Rating and Test certificate	Electrical properties	Mechanical properties	Chemical properties	Item to conform to relevant IS	WPS approval, Welder qualification	Weld quality check ( DP test and X-ray)	Paint shade, Thickness, Adhesion and	Tightness by torque measurement	Electrical clearances	Galvanizing test as per IS 2629/ 2633	IR – HV – IR test	Phase sequence check	Degree of protection routine test
Aluminum sheets/ plates/ strips / flexibles/ tubes (IS:5082/ 737)	Y	Y		Y	Y	Y	Y	Y							
CRCA flats/ ISMC (IS:2062)	Y	Y		Y	Y	Y									
Neoprene/ synthetic rubber gaskets (IS:11149/ 3400)	Y	Y		Y	Y										
Rubber bellows (IS:3400)	Y	Y		Y	Y										
Support insulator (BS:2782, IEC:660, IS:10912 )	Y	Y	Y	Y											
Galvanized structure and GI earthing flat (IS:2629/ 2633/ 4749)	Y	Y				Y					Y				
Space heater and Thermostat		Y	Y												
LT busduct (IS:8623 Part 2)	Y	Y				Y	Y	Y	Y	Y		Y	Y	Y	
Y = Test applicable															



### Site tests :

The following minimum tests/ checks shall be conducted at site. Any other tests/ checks as per the manufacturer's recommendation shall also be carried out.

- a) General
  - i) HV test on complete switchboard with CT and breaker/ contactor in position
  - ii) Check continuity and IR value of space heater
  - iii) Check earth continuity for the complete switchgear board
- b) Circuit Breaker/ Contactors
  - i) Check control wiring for correctness of connections, continuity and IR values
  - ii) IR values, resistance and minimum pick up voltage of coils
  - iii) All functional checks and electrical & mechanical interlocks provided
  - iv) Checks on spring charging motor, correct operation of limit switches and time of charging
- c) Current and Voltage Transformers
  - i) Insulation resistance test
  - ii) Ratio test on all cores
  - iii) Polarity test
- d) Relays
  - i) Insulation resistance between AC to DC terminals and between all terminals and body
  - ii) Check minimum pick up voltage of DC coils
  - iii) Relay settings
- e) Bus duct
  - i) Power frequency voltage withstand test
  - ii) Insulation resistant measurement of equipment and all wiring
  - iii) Milli-volt drop test



9.2.6 Power and Control Cables														
9.2.6.1 11kV, 6.6kV and 3.3kV Power Cables													(Table 1/2)	
Item/ Components/ Sub-system	Tests/ Checks													
	Make, Type, Rating and TC	Dimension/ surface finish	Mechanical properties	Chemical composition	Spark test	Curing properties	Electrical properties	Hot set test, Eccentricity and Ovality	Lay length and sequence	Armour coverage, cross over, looseness, gap between two wire	Sequential marking/ surface finish/ cable length	Tensile strength and elongation before and after ageing on outer sheath and insulation	Thermal stability on outer sheath	Metallic screening ( if applicable)
Aluminium (IS-8130)	Y	Y	Y	Y			Y							
Semi conducting compound	Y		Y			Y	Y							
XLPE compound (IS-7098- Part-II)	Y		Y			Y	Y					Y		
FRLS PVC compound (IS-5831, ASTM-D2843, ASTM-2863, IEC-754 Part-1)	Y		Y									Y	Y	
Triple extrusion and curing/ Manufacturing of core		Y			Y			Y	Y					
Copper tape	Y	Y	Y				Y							
Polyster tape	Y	Y												
Armour wire/strip	Y	Y	Y											
Copper tapping	Y	Y						Y						
Inner sheath	Y	Y												
Armouring										Y				Y
Outer sheathing		Y									Y	Y	Y	
Power cable (Finished) (IS : 7098 Part-II) IEC:332, IS-5831, ASTM-D2843, ASTM-2863,IEC-754 Part-1)	Y								Y	Y	Y	Y	Y	
Wooden drum(IS:10418)/ Steel drum		Y												
Y =Test applicable														



**9.2.6.1 11kV, 6.6kV and 3.3kV Power cables (Table 2/2)**

Item/ Components/ Sub-system	Tests/ Checks			
	Anti termite coating on wooden	Constructional requirements feature	Routine and acceptance test as per	FRLS tests
Aluminium (IS-8130)				
Semi conducting compound				
XLPE compound (IS-7098- Part-II)				
FRLS PVC compound (IS-5831, ASTM-D2843, ASTM-2863, IEC-754 Part-1)				Y
Triple extrusion and curing/ Manufacturing of core				
Copper tape				
Polyster tape				
Armour wire/strip				
Copper tapping				
Inner sheath				
Armouring				
Outer sheathing		Y		Y
Power cable (Finished) (IS : 7098 Part-II) IEC: 332, IS-5831, ASTM-D2843, ASTM-2863, IEC-754 Part-1)		Y	Y	Y
Wooden drum (IS-10418) /Steel Drum	Y			
Y =Test applicable				
<b>Notes</b>				
1)	Additional acceptance tests like FRLS, thermal stability, tensile strength and elongation after ageing shall be done on one sample/ lot			
2)	Length measurement/ surface finish/ eccentricity/ ovality shall be checked on one length/ size/ lot			
3)	Routine test shall be carried out on each drum length as per specifications.			



**9.2.6.2 1.1 kV PVC and XLPE cables (Table 1/2)**

Item/ Components/ Sub-system	Tests/ Checks											
	Make, Rating, Type and TC	Dimension/surface finish	Mechanical properties	Chemical composition	Electrical properties	Spark test	Hot set test (XLPE)	Lay length/ sequence	Armour coverage, cross over, looseness, Gap between two armour wire/ strip	Sequential marking/ surface finish/ cable	Tensile strength, elongation before and after ageing of insulation and outer	Thermal stability of insulation and outer
Aluminum (IS-8130)	Y	Y	Y	Y	Y							
PVC compound (IS-5831)	Y		Y		Y						Y	
XLPE compound (IS-7098 Pt-I)	Y		Y		Y		Y				Y	
FRLS PVC compound (IS-5831 ) ASTM-D-2843/ ASTM-D-2863 IEC-754 Part-I	Y		Y								Y	
Armour wire/strip (IS-3975)	Y	Y	Y									
Insulated core		Y				Y	Y					Y
Laid up core		Y						Y				
PVC Inner sheath		Y										
Armouring		Y							Y			
Outer sheath		Y								Y	Y	Y
Finish cable (IS-1554 and 7098 – Part-1) ASTM-D-2843/ ASTM- D-2863 IEC-754 Part-I Swedish Chimney SS 4241475 for (F3 category) Flammability test IEC-332 Part –3 Cat-B	Y	Y							Y	Y	Y	Y
Wooden drum (IS-10418) / Steel drum		Y										

Y =Test applicable



9.2.6.2 1.1 kV PVC and XLPE Cables		(Table 2/2)			
Item/ Components/ Sub-system	Tests/ Checks				
	Anti termite treatment on wooden	Constructional/ requirement as per specification	Routine and acceptance test as per relevant standard and specification	FRLS Tests	
Aluminum (IS-8130)					
PVC Compound (IS-5831)					
XLPE Compound (IS-7098 Pt-I)					
FRLS PVC Compound (IS-5831 ) ASTM-D-2843/ ASTM-D-2863 IEC-754 Part-I				Y	
Armour wire/strip (IS-3975)					
Insulated Core					
Laid up core					
PVC Inner sheath					
Armouring					
Outer sheath				Y	
Finish cable (IS-1554 & 7098 – Part-1) ASTM-D-2843/ ASTM- D-2863 IEC-754 Part-I Swedish Chimney SS 4241475 for (F3 category) Flammability test IEC-332 Part –3 Cat-B		Y	Y	Y	
Wooden drum (IS-10418) / Steel drum	Y				
Y =Test applicable					
<b>Notes</b>					
1)	(*) Not applicable for XLPE insulation				
2)	Additional acceptance tests like FRLS, thermal stability, tensile strength and elongation after ageing shall be done on one sample / lot.				
3)	Length measurement / surface finish shall be checked on one length/ size/ lot				
4)	Routine test shall be carried out on each drum length as per specifications.				



9.2.6.3 1.1 kV PVC Control cables		(Table 1/2)									
Item/ Components/ Sub-system	Tests/ Checks										
	Make, Type, Rating, Test certificate (TC)	Dimension/ surface finish	Mechanical properties	Chemical composition	Electrical properties	Spark test	Lay length/ sequence	Armour coverage, cross over, looseness, gap between two armour wire	Sequential marking/ surface finish/ cable	Tensile strength, elongation before and after ageing of insulation and outer sheath	Thermal stability of insulation and outer
Copper conductor (IS-8130)	Y	Y	Y	Y	Y						
PVC compound (IS-5831)	Y		Y		Y				Y		
FRLS PVC compound IS-5831 ASTM-D-2843/ ASTM-D-2863 IEC-754 Part-1	Y		Y						Y		
Armour wire/strip (IS-3975)	Y	Y	Y								
Insulated core		Y				Y	Y				
Laid up core		Y					Y				
PVC Inner sheath		Y									
Armouring		Y					Y				
Outer sheath		Y						Y	Y	Y	
Finished cable (IS-1554) ASTM-D-2843/ ASTM-D-2863 IEC-754 Part-1 Swedish Chimney: SEN SS 424-1475( F3 category) Flammability test IEC-332 Part-3 Cat-B	Y	Y						Y	Y	Y	
Wooden drum( IS:10418)/ Steel drum		Y									
Y =Test applicable											



9.2.6.3 1.1 kV PVC Control cables		(Table 2/2)			
Item/ Components/ Sub-system	Tests/ Checks				
	Anti termite treatment on wooden	Constructional feature as per	Routine and Acceptance test as per relevant standard and	FRLS test	
Copper conductor (IS-8130)					
PVC compound (IS-5831)					
FRLS PVC compound IS-5831 ASTM-D-2843/ ASTM-D-2863 IEC-754 Part-1				Y	
Armour wire/strip (IS-3975)					
Insulated core					
Laid up core					
PVC Inner sheath					
Armouring					
Outer sheath				Y	
Finished cable (IS-1554) ASTM-D-2843/ ASTM-D-2863 IEC-754 Part-1 Swedish Chimney: SEN SS 424-1475 ( F3 category) Flammability test IEC-332 Part-3 Cat-B		Y	Y	Y	
Wooden drum( IS : 10418) / Steel drum	Y				
Y =Test applicable					
<b>Notes</b>					
1)	Additional acceptance tests like FRLS, thermal stability, tensile strength and elongation after ageing shall be done on one sample/ lot				
2)	Length measurement / surface finish shall be checked on one length/ size/ lot				
3)	Routine test shall be carried out on each drum length as per specifications.				





**9.2.7 Installation of Cables, Earthing system and Lightning Protection system**

Items/ Components/ Sub-systems	Tests/ Checks													
	Make, Type, Model, Rating and TC	Dimension	Pre-treatment of sheet	Paint shade, paint thickness, adhesion	IP protection	Bought out items/ Bill of material	HV and IR	Galvanize test	Functional test as per specification	Proof load	Deflection test	Constructional feature as per	All Routine and acceptance tests	Item conform to relevant standard
Switch box/ Junction box/ Receptacles (IS-513, IS:5, IS:2629, IS:2633, IS:6745)	Y	Y	Y	Y	Y	Y	Y	Y	Y			Y	Y	
Cable glands (BS:6121)	Y	Y												Y
Cable lug (IS:8309)	Y	Y												Y
Lighting wire (IS:694)	Y	Y										Y		Y
Flexible conduits	Y	Y										Y		Y
Conduits (Galvanize and Epoxy) IS:9537, IS:2629, IS:2633 and IS:6745	Y	Y	Y					Y					Y	
RCC hume pipe (IS:458)	Y	Y												Y
Cable termination and Straight through joint (VDE-0278)	Y	Y			Y	Y						Y	Y	
Cable Trays, Flexible supports system and accessories IS:513, IS:2629, IS:2633 and IS:6745	Y	Y	Y			Y		Y		Y	Y	Y	Y	
Trefoil clamp	Y	Y												Y
GI flats for earthing and lightning protection (IS:2062, IS:2629, IS:6745 and IS:2633)	Y	Y	Y					Y						Y
GI wire (IS-280)	Y	Y	Y					Y						Y

Y =Test applicable



### Site tests :

The following minimum tests/ checks shall be conducted at site. Any other tests/ checks as per the manufacturer's recommendation shall also be carried out

- i) Cables
  - a) Check for physical damage
  - b) Check for insulation resistance before and after termination/ jointing.
  - c) HT cables shall be pressure tested (test voltage as per IS:7098) before commissioning
  - d) Check of continuity of all cores of the cables.
  - e) Check for correctness of all connections as per relevant wiring diagrams. Any minor modification to the panel wiring like removing/ inserting, shorting, change in terminal connections, etc. shall be carried out
  - f) Check for correct polarity and phasing of cable connections
  - g) Check for proper earth connections for cable glands, cable boxes, cable armour, screens, etc.
  - h) Check for provision of correct cable tags, core ferrules, tightness of connections
  
- ii) Cable trays/ supports and accessories
  - a) Check for proper galvanizing/ painting and identification number of the cable trays/ supports and accessories.
  - b) Check for continuity of cable trays over the entire route.
  - c) Check that all sharp corners, burrs, and waste materials have been removed from the trays supports.
  - d) Check for earth continuity and earth connection of cable trays
  
- iii) Earthing and Lightning protection system
  - a) Earth continuity checks
  - b) Earth resistance of the complete system as well as sub-system.



9.2.8 DC Storage Battery											
9.2.8.1 Lead-Acid type battery											
Item/ Components/ Sub-system	Tests/ Checks										
	Dimensions and finish	Conformance to relevant drawing	Chemical composition	Lead coating thickness (minimum 25 microns, IS:6848 and Adhesion check	Conformance to CPWD Specification for teak wood	Paint process checks, paint shade, thickness, adhesion	Constructional requirements as per specification	Insulation Resistance	Marking ( Routine and Acceptance test)	Checking of polarity and absence of short circuit (Routine and Acceptance test)	Test for capacities for 10 hours discharge rate along with the test for voltage during discharge (Acceptance test)
Container and Lids ( IS:1146)	Y	Y									
Vent plugs	Y	Y									
Sealing compound (IS:3116)		Y	Y								
Positive and Negative plates		Y	Y								
Separators ( IS:6071 )	Y	Y									
Electrolyte (water/ sulphuric acid ) (IS:1069/ 266)		Y	Y								
Inter-cell connectors and fasteners	Y	Y		Y							
Battery stand	Y	Y			Y	Y					
Cell insulators	Y	Y					Y				
Stack assembly	Y	Y									
Lead-Acid battery (IS:1652 )	Y						Y		Y	Y	Y
Y =Test applicable											



9.2.8.2 Ni - Cd type battery		(Table 1/2)									
Items/ Components/ Sub-system assembly	Tests/ Checks										
	Dimensions and finish	Impact strength	Conformance to relevant part drawing and Manufacturer's standards	Resistance to alkali	Chemical composition	Nickle plating thickness	Paint shade, thickness, adhesion and finish	Air pressure test after heat sealing	Marking and mass (Routine and Acceptance test)	Air pressure test (Acceptance test)	
Container and Lids ( IS:1146)	Y	Y	Y	Y							
Vent Plugs	Y		Y	Y							
Perforated steel strips	Y		Y	Y		Y					
Active material for positive and negative Plates			Y		Y						
Separators	Y		Y	Y							
Electrolyte			Y		Y						
Inter-cell connectors and fasteners	Y		Y	Y		Y					
Battery stand	Y			Y			Y				
Cell Insulators	Y		Y	Y							
Stack assembly	Y		Y					Y	Y		
Ni-Cd Battery (IS:10918 )	Y								Y	Y	
Y =Test applicable											



9.2.8.2 Ni- Cd type battery	(Table 2/2)			
Items/ Components/ Sub-system assembly	Tests/ Checks			
	Retention of charge test (Acceptance test)	AH test (Acceptance test)	Insulation Resistance (Acceptance test)	Polarity and absence of short circuit (Routine and Acceptance test)
Container and Lids ( IS:1146)				
Vent Plugs				
Perforated steel strips				
Active material for positive and negative Plates				
Separators				
Electrolyte				
Inter-cell connectors and fasteners				
Battery stand				
Cell Insulators				
Stack assembly		Y		Y
Ni-Cd Battery (IS:10918 )	Y	Y	Y	Y
Y =Test applicable				

**Site tests :**

The following minimum tests/ checks shall be conducted at site. Any other tests/ checks as per the manufacturer's recommendation shall also be carried out.

- i) Physical examination
- ii) Dimensions, mass and layout
- iii) Marking
- iv) Polarity and absence of short circuit.
- v) Insulation resistance
- vi) Ampere - hour capacity
- vii) Retention of charge
- viii) Air pressure test



9.2.9 Battery Charger													
Item/ Components/ Sub-system	Tests/ Checks												
	Make, Model, Type, Rating and Finish	Chemical and Mechanical tests	Sheet steel pretreatment and painting	Conform to relevant standard	Dimensional check and paint shade, thickness.	Complete physical examination for constructional	Temperature rise test	Dynamic response test	Ripple content test, load limiter and Annunciator and AVR operation test	Operational and functional checks	HV and IR test	Burn-in test at 50°C for 48 hrs	Degree of protection test .
Rectifier transformer (IS:2026)	Y			Y			Y				Y		
Electronic components including potentiometer ( vernier type)	Y			Y									
PCB and electronic cards	Y			Y									
19"standard racks for electronic card	Y					Y							
Control and selector switches (IS:6875)	Y			Y						Y			
Indicating meters (IS:1248 )	Y			Y						Y			
Indicating lamps (IS:13947)	Y			Y						Y			
Air break switches/ Fuses (IS:13947/13703)	Y			Y						Y			
Control terminal blocks (IS:13947)	Y			Y									
Control transformer ( IS:12021)	Y			Y						Y			
Push buttons ( IS:4794 )	Y			Y						Y			
MCB ( IS:8828)	Y			Y						Y			
PVC insulated copper control wires (IS:694)	Y			Y									
Sheet steel ( IS:513 )	Y	Y	Y	Y									
Synthetic rubber gaskets	Y	Y		Y									
Annunciator	Y									Y		Y	
Battery charger	Y				Y	Y	Y	Y	Y		Y	Y	Y
Y =Test applicable													



**Site tests :**

The following minimum tests/ checks shall be conducted at site. Any other tests/ checks as per the manufacturer's recommendation shall also be carried out

- i) Complete physical examination
- ii) Checking of proper operation of annunciation system
- ii) Temperature rise test at full load
- iv) Insulation resistance test
- v) Automatic voltage regulator operation
- vi) Load limiter operation
- vii) Dynamic response test

9.2.10 VFD Module				
Attributes/ Characteristics  Items/ Components/ Sub-system assembly	Visual & Dimensional checks	Make / Type/ Rating etc.	Final Inspection as per IS/ IEC	Remarks
HT Breaker (IEC-56)	Y	Y	Y	
DC Reactor	Y	Y		For details refer table for DC Reactor
Transformer	Y	Y		For details refer table for Transformer
Motor	Y	Y		For details refer separate table for Motor
VFD Panel	Y	Y		For details refer table for VFD Panel

Note: 1) This is an indicative list of tests/checks. The manufacture is to furnish a detailed Quality Plan indicating the practices & Procedure followed alongwith relevant supporting documents during QP finalization

2) Make of all major Bought-out Items will be subject to purchaser's approval



**9.2.10.1 DC Reactor**

ATTRIBUTES/ CHARACTERISTICS	Visual	Dimensional	Mechanical and Chemical Property	Electrical Characteristics	Pretreatment by seven tank	Painting by Stove Enamelling	Final inspection as per IS:2026	Welding/ NDT
ITEMS/ COMPONENTS, SUB_SYSTEM ASSEMBLY								
1. Winding Material (Aluminium)	Y	Y	Y	Y				
2. Insulation Material	Y	Y		Y				
3. Sheet Steel	Y	Y	Y					
4. Winding	Y	Y		Y				
5. Fabrication of Enclosures	Y	Y			Y	Y		Y
6. Assembly	Y	Y						
7. Routine Tests	Y	Y					Y	

(R) - Routine Test applicable

(A) - Acceptance Test

Y – Test

Note:

- 1) This is an indicative list of tests/checks. The manufacturer is to furnish a detailed quality plan indicating the Practices and Procedure adopted along with relevant supporting documents during QP finalization of all items.
- 2) All major Bought-out items shall be subject to purchaser's approval.





**9.2.10.2 Transformer (Oil Filled)**

Attributes / Characteristics  Items/Components Sub Systems	Visual & Dimensional Checks	Mechanical Properties	Electrical Strength	Thermal Properties	Chemical composition	Compatibility with oil	NDT/ DPT/ MPI/ UT	Ageing Test	Voltage Ratio, Vector Group & Polarity, Magnetic Balance Test	Make/ Type/ rating/ Model/ TC/ general Physical Inspection	WPS & PQR	Routine Test as per relevant test	Routine test
Tank, H.V. & L.V. Cable Box / Flange throat	Y	Y					Y						
Conservator / Radiator / Cooler / Pipes	Y	Y					Y						
Copper Conductor (IS:191)	Y	Y	Y		Y								
Insulating Material	Y	Y	Y	Y	Y	Y							
CRGO Lamination & Built Core	Y	Y	Y		Y	Y							
Bushing / Insulator (IS:2544 / 5621)	Y	Y								Y		Y	
Gasket	Y				Y	Y		Y				Y	
Transformer Oil ( IS:335 / IEC296)												Y	
Off-Circuit Tap Changer	Y									Y			
Core Coil Assembly & Pre-tanking	Y								Y				
Marshalling Box	Y	Y					Y					Y	
WTI, OTI, MOG, PRD, Breather, Terminal Connector, Bucholz Relay, Globe & Gate Valve,	Y									Y			
Welding (ASME Sect-IX)	Y										Y		
Complete Transformer (IS:2026/ IEC-60076)	Y												Y



Note: 1) This is an indicative list of tests / checks. The manufacturer is to furnish a detailed Quality Plan indicating the practice and procedure along with relevant supporting documents.

2) All major Bought Out Items will be subject to Purchaser's approval.



### 9.2.10.3 Dry Type Transformer

Attributes / Characteristics	Visual & Dimensional Checks	Mechanical Properties	Electrical Strength	Thermal Properties	Chemical Properties	NDT/ DPT/ MPI/ UT	Voltage Ratio, Vector Group & Polarity	Make/ Type/ rating/ Model/ TC/ general Physical Inspection	WPS & PQR	Routine Test as per relevant Standard	Measurement of Capacitance and tan delta between winding	Routine test
Items/Components Sub Systems												
Enclosure door, H.V. & L.V. Cable Box / Flange Throat	Y	Y						Y				
Copper Conductor	Y	Y	Y		Y							
Insulating Material	Y			Y	Y							
CRGO Lamination & Built Core	Y											
Bushing /Insulator ( IS:2544 / 5621)	Y							Y		Y		
Gasket	Y							Y		Y		
Off-Circuit Tap Changer	Y							Y				
Core Coil Assembly	Y						Y					
Marshalling Box	Y									Y		
WTI, Thermister, Terminal Connector	Y							Y				
Welding									Y			
Complete Transformer (IS:11171 / IEC 60076)	Y										Y	Y

Notes: 1) This is an indicative List of test/checks. The manufacturer is to furnish a detailed Quality Plan indicating his practice and procedure along with relevant supporting documents during QP finalization for all item.  
2) All major Bought out Items will be subject to Purchaser's approval.



Standard Technical Specification for Retrofit of Wet Limestone Based Flue Gas Desulphurisation  
(FGD) System in a Typical 2x500 MW Thermal Power Plant  
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9.2.10.4 VFD Panel														
Attributes Characteristics														
Item/ Components/ Sub-system/ Assembly	Electrical Properties	Mechanical Properties	Chemical properties	Dimension/ Finish	Type/ Rating/ Functional Check	HV/ IR	Routine Test as per relevant Standard	Constructional Features	IS : 6005, Seven tank process	Paint finish/ Shade/ Thickness	Mounting/ BOM/ Make, Completeness	Interlock functional & operation testing/ Simulation check	Degree of Protection Test	Final testing as per relevant standard
Sheet Steel (IS-513)		Y	Y	Y										
Aluminum / Copper Busbar (IS-5082/IS-613/IS-1987)	Y	Y	Y	Y										
Support Insulator (BS-2782/IEC-660/IS-10912)	Y	Y	Y	Y										
Control / Selector Switch (IS6875)					Y	Y	Y							
Contactors/ MCB (IS-13947)					Y	Y	Y							
O/L Protection relays (IS-3231)					Y		Y							
C.T /V.T/ Indicating Meter (IS2705/3156/1248)					Y	Y	Y							
Fuse/ Fuse carrier (IS-13703)					Y	Y	Y							
Terminals/lugs/PVC wires (IS13947//IS-694)	Y			Y	Y	Y	Y							
Timers (IS-3231)					Y	Y	Y							
Push Button/ Lamp/ (IS-6875)					Y	Y	Y							
Control Transformer (IS12021)					Y	Y	Y							
Mimic, Annunciator					Y		Y							
GASKET (IS-11149)		Y	Y	Y	Y		Y							
Fabrication								Y						
Pretreatment & Painting									Y	Y				
VFD panel										Y	Y	Y	Y	Y



**NOTE:**

1. This is an indicative list of Test/ Checks. The manufacturer to furnish a detailed Quality Plan indicating the practice and procedure along with relevant supporting documents.
2. All major Bought-out items will be subject to Purchaser's approval.



**9.2.11 Station Lighting**

Attributes / Characteristics  Items/Components Sub Systems	Make, Type, Rating/ TC	Dimension	Pre-treatment of sheet	Paint shade thickness Adhesion & Finish	Galvanization Tests	IP Test	Bought-out items/ Bill of Material	HV & IR	Functional check as per spec.	Constructional feature as per spec.	Routine tests as per relevant standard & spec..	Acceptance tests as per relevant standard & spec.	Item to conform to relevant standard
Luminaries (IS:10322 Pt.5 Sec.1 (Non-LED type)	Y					Y		Y			Y	Y	Y
Electronic Ballast	Y										Y	Y	Y
Lighting wire (IS:694)	Y										Y		
Fans (IS:374)	Y										Y		
Pole (IS:2713)	Y			Y						Y	Y	Y	
Lamps (IS:9800, IS:9974)	Y										Y	Y	
Lighting Mast (with raise & lower lantern type)	Y	Y			Y					Y	Y	Y	
Wall mounted Lighting Panel (IS:513, IS:5)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
Switch Box/ Junction Box/ Receptacles/ Local Push Button Station/ Lighting Panel (IS:513, 2629, 2633, 4759,6745)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
Cable Gland (BS:6121)	Y	Y									Y		
Cable lug (IS:8309)	Y	Y									Y		
Flexible Conduit	Y										Y		
Lighting Transformer (IS:11171)	Y									Y	Y		
Epoxy & Galvanised Conduit (IS:9537, 2629, 2633, 4759, 6745)	Y	Y									Y		Y



### 9.3 CONTROL AND INSTRUMENTATION (C& I) SYSTEM

#### 9.3.1 Measuring Instruments (Primary & Secondary)

ITEMS	TESTS	Dimensions (R)	Make, Model, Type and Rating (R)	Process/ Electrical Connection (R)	Calibration (R)	Test as per Standard (R)	Insulation Resistance (R)	IBR Certification (if applicable) (R)	Hydro Test (R)	Material Test Certificate (R)
1. PR Gauge (IS-3624)		Y	Y	Y	Y	Y				
2. Temp. Gauge (BS-5235)		Y	Y	Y	Y	Y				
3. Pr./ D.P.Switch (BS-6134)		Y	Y	Y	Y	Y	Y			
4. Electronic Transmitter(IEC- 60770)		Y	Y	Y	Y	Y	Y			
5. Temp. Switch		Y	Y	Y	Y	Y	Y			
6. Recorder(IS-9319/ANSI C-39.4)		Y	Y	Y	Y	Y	Y			
7. Vertical indicators		Y	Y	Y	Y		Y			
8. Digital Indicators		Y	Y	Y	Y		Y			
9. Integrators		Y	Y	Y	Y					
10. Electrical Metering Instrument (IS-1248)		Y	Y	Y	Y	Y	Y			
11. Transducer (IEC-688)		Y	Y	Y	Y	Y	Y			
12. Thermocouples (IEC-754/ ANSI-MC-96.1)		Y	Y	Y	Y	Y	Y			
13. RTD (IEC-751)		Y	Y	Y	Y	Y	Y			
14. Thermowell		Y		Y				Y	Y	Y
R-Routine Test    A- Acceptance Test                      Y – Test applicable										
<b>Note:</b> This is an indicative list of tests/checks. The manufacturer is to furnish a detailed quality plan indicating the Practices and Procedure adopted along with relevant supporting documents.										



Standard Technical Specification for Retrofit of Wet Limestone Based Flue Gas Desulphurisation  
(FGD) System in a Typical 2x500 MW Thermal Power Plant  
Section- 9 (Quality Assurance Plan)

ITEMS	Dimensions (R)	Make, Model, Type and Rating (R)	Process/ Electrical Connection (R)	Calibration (R)	Requirement as per Standard (R)	WPS approval (A)	Non-destructive testing (R)	Calculation for accuracy (R)	Insulation Resistance (R)	IBR Certification (as applicable) (R)	Hydro Test (R)	Material Test Certificate (R)
15. Cold junction compensation box	Y	Y	Y	Y					Y			
16. Orifice plate (BS-1042)	Y	Y	Y	Y*	Y	Y **	Y**			Y	Y**	Y
17. Flow nozzle (BS-1042)	Y	Y	Y	Y*	Y	Y	Y			Y	Y	Y
18. Impact head type element	Y	Y	Y					Y				Y
19. Level transmitter/ float type switch	Y	Y	Y	Y					Y	Y	Y	Y
20. Analysers	Y	Y	Y	Y								
21. Dust emission monitors	Y	Y	Y	Y								
* Calibration to be carried out on one flow element of each type and size if calibration carried out as type test same shall be repeated.												
** if applicable												
R-Routine Test    A- Acceptance Test            Y – Test applicable												
<b>Note:</b> This is an indicative list of tests/checks. The manufacturer is to furnish a detailed quality plan indicating the Practices and Procedure adopted along with relevant supporting documents.												





**9.3.2 Process, Connection & Piping for C&I Systems**

ITEMS	Visual (R)	GA, BoM, Layout of components & construction feature (R)	Dimension (R)	Paint Shades/ Thicknesses (R)	Flattening, Flaring, Hydro test, Hardness check as per ASTM Standard	Component Ratings (R)	Wiring (R)	Make, Model, Type, Rating (R)	IR & HV (R)	Review of TCs for instruments/ devices (R)	Accessibility of TBs/ Devices (R)	Illumination Grounding (R)	Tubing (R)	Leak/ Hydro Test (A)	Chemical/ Physical Properties of material (A)	Proof Pressure test Dismantling and reassembly test, Hydraulic impulse and vibration test (R)	Tests as per Standards and Specification
Local Instrument enclosure	Y	Y	Y	Y		Y	Y	Y	Y	Y	Y	Y	Y				
Local instruments racks	Y	Y	Y	Y		Y	Y	Y	Y	Y	Y	Y	Y				
Junction Box	Y	Y	Y	Y *		Y		Y	Y								
Gauge Board	Y	Y	Y	Y		Y		Y		Y		Y	Y				
Impulse pipes and tubes	Y		Y		Y			Y						Y			
Socket weld fittings ANSI B-16.11	Y		Y					Y						Y			Y
Compression fittings	Y		Y					Y					Y	Y	Y		
Instrument valves & Valve manifolds	Y		Y					Y					Y	Y			
Copper tubings ASTM B75	Y							Y									Y
* applicable for painted junction boxes.																	
R-Routine Test applicable	A- Acceptance Test										Y – Test						



Note: This is an indicative list of tests/checks. The manufacturer is to furnish a detailed quality plan indicating the Practices and Procedure adopted alongwith relevant supporting documents.

9.3.3 Instrumentation Cable																
ITEMS	TESTS															
	Conductor Resistance (R) & (A)	High Voltage (R) & (A)	Insulation Resistance (R) & (A)	Constructional detail, Dimensions (A)	Outer Sheath/ Core marking, end sealing (A)	Thermal Stability (A) +	Visual, Surface finish (A) +	Electrical Parameters ** (A) +	Persulphate Test (A) +	Overall/ Coverage/ Continuity (A)	Swedish chimney Test (SS 4241475) (A) ++	FRLS Test * (A) ++	Tensile & Elongation before & after ageing (A)	Vol. Resistivity at room & elevated temp. (A) ++	Spark Test report review (R)	
<b>Instrument cable twisted and shielded</b>																
Conductor(IS-8130)	Y			Y			Y									
Insulation(VDE-207)				Y	Y	Y	Y						Y		Y	
Pairing/Twisting				Y	Y		Y									
Shielding				Y			Y			Y						
Drain wire	Y			Y			Y		Y	Y						
Inner Sheath				Y	Y	Y	Y					Y	Y			
Outer Sheath				Y	Y	Y	Y					Y	Y			
Over all cable	Y	Y	Y	Y	Y		Y	Y			Y			Y		
Cable Drums(IS-10418)				Y			Y									
(R) - Routine Test													(A) - Acceptance Test		(Y) - Test Applicable	



**Note :**

1. High Temp. cables shall be subjected to tests as per VDE-207 (Part-6) Compensating cables shall be checked for Thermal EMF/ Endurance test as per IS 8784.
2. This is an indicative list of tests/checks. The manufacture is to furnish a detailed Quality Plan indicating his practice & Procedure along with relevant supporting documents during QP finalization for all items.
3. Sampling Plan for Acceptance test shall be as per IS 8784 (As applicable)

\* FRLS Tests: Oxygen/ Temp Index (ASTM D-2863), Smoke Density Rating (ASTM-D 2843), HCL Emission ( IEC-754-1)

\*\* Characteristic Impedance, Attenuation, Mutual Capacitance, Cross Talk (As applicable)

+ Sample size will be One No. of each size/ type per lot.

++ Sample size will be One No. sample for complete lot offered irrespective of size/ type

**9.3.4 Control Desk, PLC Panel, Smoke Detector, Fire Alarm & Control System**

ITEMS	TESTS	Visual (R)	GA, BoM, Layout of components (R)	Dimension (R)	Paint Shades/ Thicknesses (R)	Alignment of section (R)	Component Ratings/ Make/ Type (R)	Wiring (R)	IR & HV (R)	Review of TCs for instruments/ devices/ Recorders, indicators/ oaic items/ Transducers (R)	Accessability of TBs/ Devices (R)	Illumination (R)	Functional Check for control element	Mimic (R)	Test as per IEC 1131 (R) *	Tests as per Standards (R) & (A)
1. Control Desk		Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y		
2. Annunciation/ Control/ PLC Panel		Y	Y	Y	Y		Y	Y	Y	Y	Y			Y	Y	





**9.3.5 Power Supply For C&I Systems (UPS/ Voltage Stabilizer)**

ITEMS	TESTS	Visual/ Dimension/ Rating/ Paint adhesion/ thickness (R)	General arrangement/ BoM/ Make of components/ Mimic.(R)	Efficiency, regulation (R)	Input voltage variation (A)	Output voltage & frequency adj. range (A)	Preliminary light load test (R)	Load transfer retransfer test (R) *	AC input failure and return test (R)	Parallel operation and current division (R)	Relative harmonic content (R)	Restart with PRI A.C and battery (separately) (R)	System transfer and retransfer (R) *	Asynchronous transfer (R)	Ripple content (R)	Load limiter operation (R)	IR/ HV (R)	Tests as per Standards (R) & (A)
UPS/CONVERTER (IEC-146 PT-4)		Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
VOLTAGE STABILISER		Y	Y	Y	Y	Y				Y		Y					Y	
LEAD ACID BATTERY (TUBLER) IS:1651																		Y
LEAD ACID BATTERY (PLANTE) IS:1652																		Y
NICKEL-CADMIUM BATTERY (IEC-623)																		Y

\* Transfer time and Over shoot /under shoot during load & system transfer shall be recorded

(R)-Routine Test applicable

(A)- Acceptance Test

(Y) – Test

**Note:**

This is an indicative list of tests/checks. The manufacturer is to furnish a detailed quality plan indicating the Practices and Procedure adopted alongwith relevant supporting documents.





**9.3.7 Electrical Actuators with Integral Starters**

<b>Test/ Attributes Characteristics</b>  ITEMS/ COMPONE NT/ SUB- SYSTEM ASSEMBL Y/TESTIN	RPM (R)	No Load current (R)	IR & HV Test (R)	Mounting Dimension (R)	All routine test as per Standard & Specification (R)	Correct Phase Sequence (R)	Operation & setting of limit switch/ torque switch (R)	Stall torque/ current (R)	Hand wheel operation/ Auto de clutch function (A)	Function of Aux. like potentiometer, space heater (R)	EPT output (R)	Grease leakage (R)	Local/ Remote (open-stop-close) operation (R), Safety check (Single phasing, Phase correction, Tripping etc.) (A)
<b>ELECTRICAL ACTUATOR WITH INTEGRAL STARTERS (IS:9334)</b>													
Motor	Y	Y	Y	Y	Y								
Final Testing	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
(R) - ROUTINE TEST TEST APPLICABLE (A) - ACCEPTANCE TEST (Y) -													
<b>NOTE :</b> This is an indicative list of tests/checks. The manufacturer is to furnish a detailed quality plan indicating the practices & procedure along with relevant supporting documents.													



## **9.4 CIVIL WORKS**

### **9.4.1 Sampling, Testing and Quality Assurance for Civil Works**

#### **9.4.1.1 General**

- i) This part of the specification covers the sampling, testing and quality assurance requirement for all civil and structural works including excavation and filling, cast in situ concrete and allied works, fabrication and erection of structural steel works, masonry / sheeting and allied works, finishing items, etc.
- ii) The Contractor shall carry out all sampling and testing in accordance with the relevant Indian standards and / or international standards and this technical specification. Where no specific testing procedure is mentioned, the tests shall be carried out as per the best prevalent engineering practices and to the directions of the Purchaser. The Contractor shall establish the QA&QC laboratory at site. All sampling and all field tests shall be done in the presence of the Purchaser or his authorised representative. The tests which cannot be carried out in the field laboratory shall be done at a laboratory of repute such as CSMRS, NCBM, IITs, National Test House, Kolkata etc. as agreed by the Engineer. The cost of transportation and other associative cost including the test charges shall be borne by the contractor and be shall deem to be included in his contract price.
- iii) The recommendations and suitability of material for concreting and other building materials like brick, cement, aggregates etc., shall be ascertained by contractor prior to start of work. Preliminary evaluation of aggregate and its evaluation for potential alkali-aggregate reactivity as per following shall be done:-

#### **A. Evaluation of Aggregates:**

- To carry out different tests on coarse aggregate sample i.e. specific gravity, water absorption, sieve analysis, deleterious material; soundness, crushing value, impact value, abrasion value, elongation index and flakiness index, as per IS: 2386.
- To carry out different tests on fine aggregate sample i.e. specific gravity, water absorption, sieve analysis, soundness, deleterious material, silt content, clay content and organic impurities as per IS: 2386.

#### **B. Evaluation of Aggregates for Potential Alkali-Aggregate Reactivity:**

- To carry out petrographic analysis and accelerated Mortar bar Test





on aggregate samples (1N NaOH at 80 deg. Centigrade for 14 days as per ASTM 1260, or the method established/ developed by CSMRS for 22days test.

All records shall be submitted, unless specified otherwise, as per the format developed by the Contractor and approved by the Engineer.

- iv) The Contractor shall enclose a comprehensive list of bought out items (BOIs) envisaged in the contract for carrying out fabrication/ manufacturing/ erection/ construction/ commissioning activities, procurement of forged, cast, semi-finished and finished components/equipment etc. and shall indicate the names of reputed manufacturers for each of them in their bid proposal.
- v) The list of manufacturers / sub-vendors of each of the BOIs identified/ indicated by the Contractor shall be discussed/ reviewed by the Purchaser during post bid discussions and the list of proposed manufacturers / sub-vendors shall be agreed/ approved. The Contractor's proposal shall include vendor's site facilities, expertise, facilities established at the respective works, the process capability, process stabilization, QC systems followed, experience list, etc. along with his own technical evaluation for identified sub-Contractors proposed. The formats for furnishing above details shall be given to the Contractor at post bid discussion stage.
- vi) Structural steel supply if in the scope of the contractor shall be procured from Main Steel Producers like SAIL, TISCO, RINL, Essar Steel, Ispat Industries, JSW Steel, Lloyds Steel Industries, Jindal Steel & Power and Sunflag Steel & Iron Co., Bhandara [only for rounds (15-105 mm), flats (45-120 mm width & 4.75-28 mm thick), hex rods (15.5-42 mm) and wire rods (5.5-38 mm)].  
  
Reinforcement steel supply if in the scope of the contractor shall be procured from Main Steel Producers like SAIL, TISCO, RINL, Essar Steel, Ispat Industries, JSW Steel, Lloyds Steel Industries, Jindal Steel & Power and Jai Balaji Industries Ltd, Durgapur (for 8-40mm reinforcement steel).
- vii) The Field Quality Plans shall detail out all the equipment, the quality practices and procedures etc. to be followed by the Contractor's "Site Quality Control Organization", during various stages of site activities starting from receipt of materials/equipment at site.

The contractor shall furnish complete QA & QC programme (QAP) for the work envisaged which may include the following :-

- The organisation structure for the management and implementation of the proposed Quality Assurance Programme.



- Document Control system
- The procedure for procurement of materials and source inspection.
- System for site controls including process controls.
- Control of non-conforming items and systems for corrective action
- Inspection and test procedures for site activities
- System for indication and appraisal of inspection status
- System for maintenance of records
- System for handling, storage and delivery.
- Quality Plan detailing out quality practices and procedures, relevant standards and acceptance levels for all types of work under the scope of this contract.

Based on the schedule of work agreed with the Purchaser and the approved FQP, the Contractor shall prepare a schedule of tests and submit them to the Purchaser and organise to carry out the tests as scheduled/ agreed.

- viii) The contractor shall prepare and obtain approval of the Owner of the Field Quality Plan (FQP) well before the start of the work. This FQP shall cover for all the items / activities covered in the contract/schedule of items and required for completion of the work.
- ix) All materials / components and equipment covered under the scope of work which are to be manufactured at shop/ factory of the vendor/subvendor shall be covered under a comprehensive quality assurance programme. Manufacturing Quality Plan (MQP) shall detail out all the components and equipment, various test/inspection, to be carried out as per the requirements of this specification and standards mentioned therein.
- x) All the equipment shall be duly calibrated by NABL/ NPL accredited laboratories/accreditation agencies.
- xi) The Contractor shall submit to the Purchaser Field Welding Schedule for field welding activities, the format for Field Welding Schedule shall be furnished to the Contractor at pre-award stage. The field-welding schedule shall be submitted to the Purchaser along with all supporting documents, like welding procedures, heat treatment procedures, NDT procedures etc. at least ninety days before schedule start of erection work at site. The Contractor shall submit Welding Procedure Specification (WPS) for Purchaser approval/ acceptance, the format for the WPS shall be furnished to the Contractor during post bid discussion stage.



All welding and brazing shall be carried out as per procedure drawn and qualified in accordance with requirements of ASME Section IX/BS-4870 or other International equivalent standard acceptable to the Purchaser. All welding/brazing procedures shall be submitted to the Purchaser or its authorized representative for approval prior to carrying out the welding/brazing.

All brazers, welders and welding operators employed on any part of the contract either in the Contractor's/ sub-Contractor's works or at site or elsewhere shall be qualified as per AWS D1.1/ASME Section-IX or BS-4871 or other equivalent International Standards acceptable to the Purchaser.

Welding procedure qualification and Welder qualification test results shall be furnished to the Purchaser for approval. However, where required by the Purchaser, tests shall be conducted in presence of Purchaser /authorized representative.

No welding shall be carried out on cast iron components for repair.

All the heat treatment results shall be recorded on time temperature charts and verified with recommended regimes.

All Non-destructive examination shall be performed in accordance with written procedures as per International Standards and as mentioned elsewhere in the technical specification; The NDT operator shall be qualified as per SNT-TC-1A (of the American Society of non-destructive examination). NDT shall be recorded in a report, which includes details of methods and equipment used, result/evaluation, job data and identification of personnel employed and details of co-relation of the test report with the job. The records of RT (Films) and UT (inspection records or printed reports if possible) shall be documented and produced to Purchaser.

- xii) The Contractor shall associate themselves with the reputed specialized blasting agency such as CMRI, NIRM for trials blasts, design blasts, blasting pattern, monitoring of blast during the blasting operations at site. All blasting work shall be done as per approved blasting scheme/ design/ pattern in line with the technical specification requirements and all statutory laws, rules, regulations, relevant standards pertaining to the acquisition, transport, storage, handling along with use of explosives shall be strictly followed by the Contractor.
- xiii) The Contractor shall install and operate equipments (such as tri-axial seismograph) for continuous monitoring and control of blast induced vibrations, noise level/ air pressure, dust, silica and noxious gases during all blasting operations in line with the Technical Specification requirements in association with the specialized blasting agency.



## 9.4.2 General QA Requirements

### 9.4.2.1 Storage and handling of common building materials

All materials shall be stacked and stored by the Contractor as per IS-4082 and as per the requirements specified in Purchaser Technical Specification.

### 9.4.2.2 Excavation and filling works

- i) The contractor shall submit a work methodology covering various items of works for all stages of excavation and filling works. This methodology shall broadly include the quantity wise and classification wise identification of source of excavation and filling, suitability tests as per specification requirements, method of stockpiling, transportation, placement, spreading, compaction, equipment, list of protocols, in-situ tests, third party lab test if required, acceptance checks for final clearance.
- ii) Tolerance for finished surface level shall be within 20 mm of the level shown in the drawing. For an unimportant area, tolerance up to +75mm shall be acceptable at the discretion of the engineer. However, these tolerances shall be applicable for localized areas only.

#### Acceptance criteria shall be:

- a) When only one set of sample is tested, then all individual samples collected and tested should pass without any deviation
- b) For retest of any sample two additional samples shall be collected and tested, and both should pass without any deviation.
- c) Where a large number of samples are tested for a particular test then 9 samples out of every 10 consecutive samples tested shall meet the specification requirement.

### 9.4.2.3 Masonry and allied works

Unless specified otherwise the tolerances in construction of masonry works shall be as below:

Sl. No.	Type of Check	Tolerance
1	Deviation in verticality in total height of any wall of a building	Shall not exceed 12.5mm (more than one storey) 6mm per 3m height (within a storey)
2	Deviation from the position shown on the plan of any brickwork	Shall not exceed 12.5mm (more than one storey)



3	Relative displacement between load bearing walls in adjacent storeys intended to be in vertical alignment	Shall not exceed 6mm
4	Deviation of bed joint from horizontal in any length, and it	Shall not exceed 6mm (upto 12m) Shall not exceed 12.0 mm total (in any length over 12m)
5	Deviation from the specified thickness of bed-joints, cross-joints or perpend	Shall not exceed 1/5 <sup>th</sup> of the specified thickness
6	Finished plastered surface	Deviation not more than 4 mm when checked with a straight edge of 2 m length placed against the surface
7	The average thickness of plaster	Not be less than the specified thickness
8	The minimum thickness over any portion of the surface	Not less than the specified thickness by more than 3 mm for plaster thickness above 12mm and 1 mm for ceiling plaster

#### 9.4.2.4 Concrete works

For concreting works provisions of technical specifications and IS: 456 shall apply. A detailed methodology for concrete works shall be submitted by the contractor to Purchaser for approval.

The methodology for concrete works shall broadly contain the suitability of source of aggregates, cement, admixture, water and reinforcement steel, etc. the available concrete mix design, results of trial mix carried out at site, method / control of batching, mixing, transportation, layer wise placement, compaction, fixing / removal of form work, staging, fixing of water stops at appropriate locations along with specials, expansion joints, contraction joints and construction joints, cover blocks and method of curing, methodology of repair of newly placed hardened concrete, testing and sampling of concrete during production and placement and acceptance checks for final clearance.

Exposed surfaces of concrete shall be kept continuously in a damp or wet condition for at least seven days from the date of placing concrete in case of ordinary Portland cement, not be less than 10 days for concrete exposed to dry and hot weather conditions, at least 10 days or period may be extended to 14 days where mineral admixtures or blended cements are used.



Approved curing compounds may be used in lieu of moist curing with the permission of purchaser.

Reinforcement steel shall conform to relevant IS codes. Lapping / spacing of reinforcement shall be so staggered that under no circumstances more than 50% of bars at any cross section shall be lapped. Corrosion resistance Steel shall be used for the foundations wherever specified in the technical specification. Sample test for 3% of the number of mechanical bars grips subject to a minimum of three, shall be carried out up to the yield strength of reinforcement of bars.

Test shall be conducted for the water tightness of the liquid retaining structures as per technical specifications, IS 3370 and IS 6494.

All the materials, equipment, processes used in pre cast concrete work shall conform to the requirements for the cast-in-situ concrete.

If fly ash is used in concrete, source of supply shall be checked for suitability as per IS 3812 (Part-I). Routine tests for retention of particles on 45 $\mu$  sieve and loss on ignition shall be carried out on each lot of fly ash before its use. The storage of fly ash shall be similar to that of cement. Separate Silo for fly ash shall be provided in the batching plant. Validation of Mix design using fly ash shall be carried out by an approved specialist agency, before start of concrete production.

The acceptance criteria of concrete shall be in accordance with IS 456.

All records of concreting, reinforcement, testing of materials, as-built dimensions, the details of the rectification, etc. shall be maintained as given below. Four copies of such record in a bound form shall be submitted to owner for their record and future reference.

- i. Testing data / report of aggregates including petrographic examination & potential reactivity of aggregate and repeated temperature cycle tests wherever specified.
- ii. Testing records of admixture as per IS-9103 / ASTM C494 including third party test reports.
- iii. Approved scheme for concreting
- iv. Hourly records of concreting including pour card
- v. Protocol indicating the dimensional tolerance and details of inserts
- vi. Records giving the details of rectification giving the location of grouting, the quantity of grout used at each location, type of grout used
- vii. Bar bending schedule
- viii. Location and details of mechanical anchoring used for reinforcement



- ix. Protocol giving the details of checking of reinforcements before concreting and conformance to the reinforcement details as shown in the construction drawings
- x. Photographs showing the areas where rectification works have been carried out. Photographs should be taken before and after rectification
- xi. Temperature control record of concrete at the time of placement if applicable.
- xii. Details of curing, staging and fixing / removal of formwork, checklist for formwork as per IS 14687 including all machine foundations
- xiii. Batching Plant shall be calibrated regularly at least once in a 3 months. Computerized output shall be taken for each batch of production of concrete. Production and supply of concrete from batching plant shall conform to the provisions of IS 4926.
- xiv. Dimensions (length, cross sectional dimensions, straightness, squareness, and flatness) and tolerances for pre cast members as per Technical Specification. Load test on Pre cast members (except pre- cast tiles to be laid in the reservoir) shall be carried out @ 1% up to 1000 nos., @0.5% from more than 1000 nos. precast members of one type. The load test shall be carried out as per the provisions of IS-456 and relevant IS code.

#### 9.4.2.5 Structural steel work

For structural steel works provisions of technical specifications and IS: 800 shall apply. A detailed methodology for structural steel works shall be submitted by the contractor to Purchaser for approval.

The contractor shall submit the welding procedures specification (WPS), heat treatment procedures, NDT procedures etc. at least ninety days before scheduled start of erection work at site. All welding and brazing shall be submitted to the Purchaser and carried out as per procedure drawn and qualified in accordance with requirements of ASME Section IX/BS-4870 or other International equivalent standard acceptable to the Purchaser.

All brazers, welders and welding operators employed on any part of the contract either in the contractor's / sub-contractor's works or at site or elsewhere shall be qualified as per AWS D1.1/ASME Section-IX or BS-4871 or other equivalent International Standards acceptable to the Purchaser.



The records of welding procedure qualification and welder qualification test results shall be furnished to the Purchaser for approval. However, where required by the Purchaser, the tests shall be conducted in presence of Purchaser / authorized representative.

No welding shall be carried out on cast iron components for repair. All the heat treatment results shall be recorded on time temperature charts and verified with recommended regimes.

All Non-destructive examination shall be performed in accordance with written procedures as per International Standards and as mentioned elsewhere in the technical specification. The NDT operator shall be qualified as per SNT-TC-IA (of the American Society of non-destructive examination). NDT shall be recorded in a report, which includes details of methods and equipment used, result/evaluation, job data and identification of personnel employed and details of co-relation of the test report with the job. The records of RT (Films) and UT (inspection records or printed reports if possible) shall be documented and produced to Purchaser.

Low hydrogen electrode (AWS E-7018) for welding of High/Medium tensile steel, for M.S (IS 2062 Gr. A/Gr. B, IS 8500) sections thickness above 20mm shall be used. Preheating and Post weld heat treatment requirements shall be complied as specified in the technical specification / approved WPS.

The requirements of pre-heating shall be as per relevant IS.

The following tests/ checks shall be carried out for structural steel works:

SL. NO.	TESTS / CHECKS	QUANTUM / STANDARD
1	Physical and chemical properties of material if supply in the scope of contractor	As per relevant codes, review of correlated mill test certificates or check testing in absence of MTC
2	Ultrasonic test on plates above 40mm	As per ASTM A435
3	Welding procedure & welders qualification test	AWSD1.1/ASME Section-IX or BS-4871 or other equivalent International Standards
Fillet Weld		





Standard Technical Specification for Retrofit of Wet Limestone Based Flue Gas Desulphurisation  
(FGD) System in a Typical 2x500 MW Thermal Power Plant  
Section- 9 (Quality Assurance Plan)

4	Macro-etch examination on production test coupons for main fillet welds	Minimum one joint per built up beams, columns and crane girder etc.
5	Tension member of crane girder	Dye penetration test on 25% weld length
6	All other fillet welds	DPT on 5% of weld length with minimum 300mm at each location
<b>Butt Weld</b>		
7	DPT	100% after back gouging on all butt welds
8	Mechanical testing of production test coupons	Minimum one joint per built up beam, column and crane
9	Radiography test on butt welds  (In case of failure of any welds in SPOT/RT or UT the % of retesting shall be doubled at that particular location. Acceptance criteria of NDT on welds shall be as per AWS D1.1.	100% RT on butt welds of tension flange (bottom flange) of crane girders  10% RT weld length of each welder on butt welds,
10	Ultrasonic testing on full penetration welds (other than butt welds)	100% UT on the web to flange joint of crane girder  10% UT on other full penetration joints
11	Control assembly checkin shop before erection	1st and further every 10th set of identical structure
12	Dimensional tolerances during fabrication and erection	as per IS-7215 and IS-12843
13	Surface Preparation and Paint thickness	SA 2 1/2 , By elcometer random after each coat, each member



#### 9.4.2.6 **Painting works**

Painting works shall be carried out as per the provisions of technical specifications. A detailed methodology for painting works shall be submitted by the contractor to Purchaser for approval.

The methodology for painting works shall broadly contain the source of approved brand of paints, shot / sand blasting as specified, minimum acceptable size of shot used for blasting, application of primer, intermediate coat and final coat, experience of applicator, etc. testing of painting work and acceptance checks for final clearance.

#### 9.4.2.7 **Sheeting works**

All bought out items shall be procured from the manufacturer's approved by engineer and tested as per relevant IS Codes/ Specification. Raw material of colour coated sheets shall meet the chemical & physical properties as per relevant standards / codes referred in the approved data sheet. It shall be tested for colour match, bare metal thickness, weight of Z/AZ coating, thickness of painting system, reverse impact, T-Bend adhesion, scratch resistance, salt spray test for 1000 Hrs and any other test / properties as specified in the technical specifications. Colour coated sheets shall be marked with video jet printing at the interval not more than 2m bearing manufacturer's name, date and time of manufacturing. Fasteners shall also be tested for 1000 hrs salt spray test as per the requirement of technical specifications.

Bonded Mineral Wool Insulation shall meet the requirements of thickness, density, thermal Conductivity, all other tests as per the technical specifications and IS-8183.

For sheet installation no gas cut opening shall be allowed at the site, whenever opening is specified these shall be properly cut in the factory and shall be filled with lipping / flashing for true shape / dimension etc. The sheets/ packets shall be stacked neatly clear off the ground at an angle to the ground, over a base pallet to provide drainage. Water / moisture should not be allowed to stagnate on surface, or in between layers. This can damage the coating, and cause corrosion.

#### 9.4.2.7 **Tile works**

The contractor shall submit the work methodology which shall include the type, grade and make of materials along with their technical data sheets, details, etc., clearance from E-I-C regarding leak proofness and damp proofness of parent concrete surface, surface preparation, the procedure of application, curing, testing and acceptance.

The tests shall be carried out on acid resistant bricks / tile- water absorption,



compressive strength, resistance to acid, flexural strength, dimensions and all other tests as per IS 4860 and IS 4457, bitumastic ready mixed paint as per IS 158, bitumastic as per IS 9510, potassium silicate, resin type and sulphur type mortars as per IS 4832, part I, II and III, surface preparation for painting as per IS 2395, epoxy painting shall be carried for required coating thickness and dry film thickness.

#### 9.4.2.8 Fire proof doors

Fire Proof doors shall be tested for the requirements mentioned in the Technical Specification. The type test of the doors shall be carried out at CBRI Roorkee for minimum 2 hours fire rating and its Fabrication drawing shall also be approved by CBRI, Roorkee. DFT of paint of Fire Proof Doors and its fittings and fixtures as per BOQ shall be checked. The doors shall be finished with suitable fire retardant painting system

#### 9.4.2.9 Water proofing

Water proofing shall be tested for water tightness by creating a pond of water minimum 25 mm height on area of 6 m x 6 m, for the period of 48 hrs on fully dried elastomeric membrane surfaces. Minimum 5% area of the roof shall be subjected to water tightness test. Such test necessarily be conducted on vulnerable areas like drain channel / drain head. No dampness shall be visible on the underneath side of roof (i.e. ceiling), parapet and well junctions etc. which have been subjected for testing. The above testing shall be carried out prior to application of wearing course.

#### 9.4.3 Piling Work (If Applicable)

A detailed methodology for piling works shall be submitted by the contractor to Purchaser for approval. The methodology shall broadly contain the method of boring, stability of bore hole, termination criteria, tests / checks for termination level, fabrication of cage, cage lowering, concrete batching / mixing, transportation, placing, recording of the time of construction operations, method of conducting initial and routine load tests, testing and sampling of concrete during production and placement and acceptance checks on piles for final clearance.

The piling works shall be executed as per the technical specifications, approved drawings, relevant codes / standards, FQP and BOQ. In addition to the requirements of technical specifications, the following shall also be ensured while execution of piling works:

- a) Time gap between completion of pile boring and start of concreting should be kept to the minimum. However, the maximum time gap shall not be more than 6 hours.



- b) Muck Debris should be removed from the pile bore by air lift technique (by keeping the tremie & air pipe as close as to bottom of pile bore) i.e. after completion of boring, after completion of SPT (wherever applicable), after lowering reinforcement cage, but before start of concreting.
- c) Density of bentonite slurry shall be checked from the sample taken from the bottom of pile bore (not at 1.0 m above the bottom of the pile bore)
- d) While lowering the R/F cage into the pile bore, two hooks shall always be used to ensure balanced/symmetrical insertion of cage into the pile bore.
- e) Concrete cover blocks at the junction of two R/F cage shall be ensured before lowering the second segment.
- f) Surge concreting of about 1.0 cum shall be ensured at the start of concreting (i.e. in the first pour), by suddenly allowing to fall through the tremie pipe from the funnel. This will help in displacing left out muck/debris in the pile bore (by the impact).
- g) Continuous feeding of concrete shall be ensured by deploying at least two transit concrete mixers (if required to be deployed) and mixing done through concrete batching plant (if deployed). Cold joints in the pile shall be avoided.
- h) In a pile group, SPT shall be carried out at termination level in the pile, taken up first.
- i) Bentonite slurry circulation to be ensured from start of boring to start of concreting.
- j) Properties of drilling mud shall be checked prior to commencement of the piling work and thereafter, minimum once per week or as found necessary by the engineer. One sample consisting of 3 specimens shall be tested for the above.
- k) Low strain pile integrity test on all job piles and test piles shall be conducted as specified in the Technical Specification. This test shall be suitably used to identify the piles for routine tests. High Strain dynamic test shall be done as per the technical specification. The frequency of the test shall be as per the BOQ
- l) For Working Piles: Minimum one sample consisting of 6 test cubes shall be made for first ten piles. Out of these 3 shall be tested for 7 days' cube strength and 3 for 28 days cube strength. Minimum one sample of 6 test cubes for every 25 nos. of piles shall be tested, out of these 3 shall be tested for 7 days' cube strength and 3 for 28 days' cube strength.



#### 9.4.3.1 Pile load test

Pile load testing shall conform to the requirements of IS-2911 (Part IV) and the technical specification. Initial load tests as specified in the contract documents shall be conducted to assess the safe load carrying capacity of pile before start of work. To verify the load carrying capacity of the working piles, routine load test shall be conducted.

Pile load-testing procedure and the test setup / scheme shall be submitted for approval of Purchaser.

All the gauges and instruments shall be calibrated before the start of the tests on test piles and working piles and the calibration record shall be verified before start of execution of the test.

#### 9.4.4 Water Supply, Drainage & Sanitation

Material used for sanitary and plumbing fittings and fixtures shall conform to and be tested as per the requirements of relevant IS Codes specified in technical specification.

The obstructions in sewer lines shall be checked by inserting a smooth ball, of diameter 13 mm less than the pipe bore at the high end of the sewer or drain. If absence of any obstructions, such as yarn or mortar projecting through the joints, ball shall roll down the invert of the pipe and emerge at the lower end. The straightness shall be checked by means of a mirror at one end of the line and lamp at the other. If the pipeline is straight, the full circle of the light may be observed. The mirror will also indicate obstruction in the barrel, if the pipeline is not straight.

The service pipes shall be slowly and carefully charged with water, allowing all air to escape avoiding all shock or water hammer. The service pipe shall then be inspected under test / working condition of pressure and flow, when all draw-off taps are closed. The service pipes shall be checked for satisfactory support and protection from damage, corrosion and frost.

#### 9.4.5 Architectural & Misc. Works

Material used for sanitary and plumbing fittings and fixtures, floor finishes and allied work shall conform and tested as per the requirements of relevant IS Codes specified in Purchaser technical specification.

Fabricated item like metal doors, windows, ventilators, louvers, rolling shutters and grills etc. shall be checked for correctness of locations and smoothness of operation and fixtures. All controls and locking devices shall give fault free performance. Door and window shutters shall operate without jamming. The clearance at head and jamb for door shutters shall not exceed



1.5 mm. For double leaf doors, the gap at the meeting stiles shall not be more than 2.5 mm.

Materials used in glass and glazing shall be procured from source approved by Purchaser and shall conform to the requirements of the Technical Specification and IS Codes.

False ceiling panels shall be best quality material in thickness and properties called for in the specification / schedule of items. Material Test Certificate to be submitted before bulk supply.

All bought items covered in the scope of contract shall be procured from sources approved by Purchaser and shall conform to the requirements of the technical specifications and referred standards /codes.

#### 9.4.6 **Pre Cast Concrete Works**

- i) All the materials used in Pre cast Concrete work shall be tested and conform to the requirements of IS codes and Purchaser Tech. Specification.
- ii) Concrete mix for Pre cast members shall conform to IS-456-2000.
- iii) All relevant QA requirements pertaining to cast in-situ concrete shall be applicable.
- iv) Load test on Pre cast members shall be carried out for the type of members as decided by Purchaser Engineer as per IS-456-2000.
- v) Pre Cast Concrete member shall be checked for dimensions (length, cross sectional dimensions, straightness, squareness, and flatness) and tolerances shall be as per Purchaser Technical Specification.

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## ANNEXURES

### Annexure-I

#### RAW WATER ANALYSIS

S.No	Constituent	as	mg per liter
1.	Calcium	CaCO <sub>3</sub>	34.0
2.	Magnesium	CaCO <sub>3</sub>	15.0
3.	Sodium & Potassium	CaCO <sub>3</sub>	19.0
4.	Bicarbonate	CaCO <sub>3</sub>	46.0
5.	Chloride	CaCO <sub>3</sub>	12.0
6.	Sulphate	CaCO <sub>3</sub>	10.0
7.	Carbonate	CaCO <sub>3</sub>	0
8.	Silica	SiO <sub>2</sub>	10.0
9.	Iron	Fe	2.0
10.	pH Value		7.6-8.2
11.	Turbidity	NTU	Up to 1000
12.	Temperature	°C	43



**Annexure-II**

**Cooling Water Analysis**

<b>S.No</b>	<b>Constituent</b>	<b>as</b>	<b>mg per liter</b>
1.	Calcium	CaCO <sub>3</sub>	148.0
2.	Magnesium	CaCO <sub>3</sub>	37.5
3.	Sodium & Potassium	CaCO <sub>3</sub>	47.5
4.	Bicarbonate	CaCO <sub>3</sub>	104.5
5.	Chloride	CaCO <sub>3</sub>	47.5
6.	Sulphate	CaCO <sub>3</sub>	81.0
7.	Carbonate	CaCO <sub>3</sub>	0
8.	Silica	SiO <sub>2</sub>	25.0
9.	Iron	Fe	0.75
10.	pH Value		7.6-7.9
11.	Turbidity	NTU	50

Note: The C.W system operate at about 4.0 Cycles of Concentration.





**Annexure-III**

**Clarified Water Analysis**

<b>S.No</b>	<b>Constituent</b>	<b>as</b>	<b>mg per liter</b>
1 .	Calcium	CaCO <sub>3</sub>	59.2
2.	Magnesium	CaCO <sub>3</sub>	15.0
3.	Sodium & Potassium	CaCO <sub>3</sub>	19.0
4.	Bicarbonate	CaCO <sub>3</sub>	41 .7
5.	Chloride	CaCO <sub>3</sub>	19.0
6.	Sulphate	CaCO <sub>3</sub>	32.5
7.	Carbonate	CaCO <sub>3</sub>	0
8.	Silica	SiO <sub>2</sub>	10.0
9.	Iron		0.30
10.	pH Value		7.6-8.2
1 1.	Turbidity	NTIJ	10
12.	Temperature CC)	°C	43

Note: At the outlet of clarifier of PT Plant



**Annexure-IV**

**DM Water Analysis**

Sl. No.	Characteristics	Value
1 .	Silica (Max.)	0.02 ppm as SiO <sub>2</sub>
2.	Iron as Fe	Nil
3.	Total hardness	Nil
4.	pH value	6.8 to 7.2
5.	Conductivity	Not more than 0.1



**Annexure-V**

**Limestone Analysis**

<b>S. No.</b>	<b>Constituents</b>	<b>(% by mass)</b>
1 .	CaO	45.9—51.0
2.	MgO	0.9-3.8
3.	Fe <sub>2</sub> O <sub>3</sub>	0.45-1 .0
4.	Al <sub>2</sub> O <sub>3</sub>	1 .19-2.1
5.	Si <sub>2</sub> O <sub>3</sub>	2.1-4.5
6.	Mn <sub>2</sub> O <sub>3</sub>	<0.12
7.	P <sub>2</sub> O <sub>5</sub>	Traces
8.	Cl <sub>2</sub>	<0.015
9.	Na <sub>2</sub> O	<0.16
10.	K <sub>2</sub> O	<0.01
11.	TiO <sub>2</sub>	<0.02
12.	Total Sulphur	<0.1
13.	LOI	38.0-41 .3
14.	Bond Index	13



भारत सरकार/Government of India  
विद्युत मंत्रालय/Ministry of Power  
केन्द्रीय विद्युत प्राधिकरण/Central Electricity Authority  
सचिव कार्यालय/ Office of Secretary

संख्या: के.वि.प्रा./टी.ई.डी.डी./एम.सी./2017/एम-5/935-43 दिनांक: 03.6.2017

### कार्यालय आदेश

विषय: **Preparation of Standard Draft Technical Specification for wet limestone based FGD Plant retrofit- reg.**

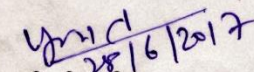
As you are aware that compliance of MoEF&CC new emission norms notified on 7.12.2015 requires existing/ new/ under construction thermal power plants to be fitted with flue gas desulphurization (FGD) system to restrict emission of SO<sub>2</sub> within permissible limits. The majority of the thermal power plants in the country are expected to be provided with wet limestone based FGD system. CEA intends to prepare a standard technical specification of wet limestone based FGD system which could serve as a guiding document to the utilities. In this respect, it has been decided to constitute a committee to prepare the standard technical specification of wet limestone based FGD system. The committee shall comprise of the following:

- |                                 |                  |
|---------------------------------|------------------|
| 1. Chief Engineer (TETD), CEA   | Chairman         |
| 2. Chief Engineer (TCD), CEA    | Member           |
| 3. Representative from NTPC     | Member           |
| 4. Representative from BHEL     | Member           |
| 5. Representative from UPRVUNL  | Member           |
| 6. Representative from TANGEDCO | Member           |
| 7. Representative from Toshiba  | Member           |
| 8. Representative from L&T      | Member           |
| 9. Representative from Alstom   | Member           |
| 10. Director (TETD), CEA        | Member-secretary |

The Committee may co-opt any other member, as deemed necessary. The expenditure incurred on TA/DA etc. of the external Members of the Committee shall be borne by the respective organization.

The Committee shall prepare and finalize the standard technical specification of wet limestone based FGD system within three (3) months from issue of this notification.

This issues with the approval of Chairperson CEA.

  
(पी. सी. कुरील)  
सचिव, के.वि.प्रा.



## Annexure-VII

### **Record Notes of Discussion of 1<sup>st</sup> meeting of the Committee for Review of Draft technical specification for FGD Plant retrofit as prepared by CEA held on 11.08.2017 at CEA**

*(Issued by CEA vide email dated 14.08.2017)*

List of Participants is enclosed as Annexure:

At the outset, Chief Engineer (TETD) welcomed all the participants and apprised about the background and necessity for framing the specification for wet limestone FGD technology. He apprised that soft copy of preliminary draft prepared by CEA has already been made available to the committee members. He further apprised about basic scheme and components of wet limestone FGD system included in the draft specification. The gist of the discussion held in the meeting regarding review of draft technical specification as prepared by CEA is as below:

1. GE Power enquired whether specifications being draft covers only functional aspects (basic design) or it's a detailed specification covering equipment details as well. It was clarified that a comprehensive technical specification including general technical aspects, scope of work, guaranteed parameters (including liquidated damages), equipment specification, Quality Assurance Plan and mandatory Spares etc. The general condition of contract, QR and commercial aspects etc. shall be covered by the utility.
2. L&T suggested to include transportation of lime stone through railways for larger capacity plant and its handling/ storage. Further, in case lime stone is available in crushed form, the option of excluding the lime crushing system may be included in the specification.
3. NTPC raised the issue of whether GGH should be made mandatory for FGD. It was discussed that GGH has advantage of reducing the temperature of inlet raw flue gas to the absorber which reduces potential of damage to scrubber internals in case of flue gas excursion and mal- operation etc. Reheating of treated flue gas helps in increased buoyancy of flue gas exiting from the chimney resulting in dispersion of pollutants over a wider area and consequently reduced ground level concentration of pollutants. However, GGH has high cost, requires additional space, results in additional pressure drop, has leakage issues and other operational problems. Further, irrespective of whether GGH is provided or not, chimney needs to be provided with acid resistant lining. As such, it was opined that requirement of GGH may not be made essential for the FGD system.
4. CEA asked the views of members about partial treatment of flue gas for older plants to achieve the prescribed emission limits of 600 mg/Nm<sup>3</sup>. The members from manufacturers' side apprised that variation in level of SO<sub>2</sub> in the treated flue gas to achieve stipulated MoEF&CC norms can be achieved by suitably sizing the absorber and also by varying the limestone feed during operation. Further, operation of bypass damper was indicated to be complex and prone



to operational issues. The committee members agreed to the view that part scrubbing of the flue gas and blending with remaining untreated flue gas should be avoided.

**5.** BHEL suggested to include the option of providing common scrubber for multiple (smaller) units to save cost and space since many older smaller sized units are having space scarcity.

**6.** BHEL/ L&T intimated that only one type of scrubber i.e. multiple spray type has been covered in the specification and that there are other proven types viz. bubble, fountain (single spray) etc. available with wet limestone and these need to be covered for more acceptability and competitiveness. CEA suggested that technical details of FGD scheme indicated in the draft specification may be reviewed by committee members specifically M/s BHEL/ L&T/ GE/ Toshiba and furnish their inputs to make it more broad based to cover other proven wet limestone based technologies.

**7.** BHEL suggested that lime stone handling and slurry preparation be specified as different facilities under scope of work. Further, the same concept should be adopted for gypsum dewatering and handling/ storage.

**8.** NTPC raised concern about disposal of FGD effluent. CEA suggested that there are many areas of low grade application in the plant such as ash handling and coal dust suppression etc. where FGD waste water can be utilized/ disposed.

**9.** Toshiba/ GE suggested to design FGD plant based on design coal and guarantees shall be based on flue gas parameters mentioned in the specification. CEA requested them to furnish the suggested requirement of plant input conditions associated with design and guarantee criteria mentioned in the specification.

**10.** Toshiba suggested to incorporate PM guarantees also at FGD outlet. The members were of the opinion that FGD is being installed primarily for capturing SO<sub>2</sub> only.

**11.** The issue of LD for shut down period for interconnection of FGD plant was discussed. Toshiba/ GE/ BHEL were opined that there should not be any penalty clause on this aspect since lot of issues crop up during execution and these are site specific. CEA opined that indefinite leverage can not be extended on this account as the project will suffer huge generation loss and LD for the same is must. Further, BHEL/L&T/GE/Toshiba requested to exclude consumption of lime stone from guarantees under Cat. I. CEA clarified that since consumption of lime stone has direct bearing on operating cost and hence required to be included for tender evaluation. CEA apprised that auxiliary power consumption, limestone consumption and shut down period



have been included in Category- I guarantees, SO<sub>2</sub> concentration in exit flue gas in Category- II guarantees and SO<sub>2</sub> removal efficiency has been included under category- III guarantees. Indicative LD values have also been indicated in the draft specification. Committee members were requested to review the same.

**12.** Members raised concerns that chimney lining may be an issue for FGD retrofit to be done as per delivery schedule and integrating FGD with existing plant. Option of constructing a new chimney needs to be explored to reduce the shut-down period from about 5-6 months resulting in huge generation loss to 2-3 weeks required for integration only. Further, acid resistant lining of existing chimney involves huge cost also. It was opined that construction of new wet chimney of smaller height and its inter-connection with FGD system should be included in the proposed specification of FGD plant.

**13.** Issue of SO<sub>2</sub> guaranteed values to be indicated in specification so as the plant after retrofit operates at below guaranteed values at part load was discussed. For MoEF&CC notification requirement of 200 mg/Nm<sup>3</sup>, the specified value of 150 mg/Nm<sup>3</sup> in the specification was found to be in order.

**14.** Plant operation with FGD during start-up with oil firing was discussed in context with damage to lining and GGH safety. NTPC clarified that rubber lining is not suitable and metallic surfaces of absorber specified in their latest tenders can take care of this issue. CEA requested NTPC to provide copy of their latest specification. NTPC agreed.

**15.** L&T/ NTPC proposed that guarantee values for HCl/ HF in flue gas and permissible quantity of waste water from FGD should be indicated in the specification.

**16.** It was agreed that BHEL shall provide typical FGD scheme and layout drawings to be incorporated in the specification.

**17.** NTPC shall provide the section on Quality Assurance Plan to be annexed with the specification.

**18.** It was agreed that committee members shall furnish the information sought and also their inputs on the draft specification to CEA through e- mail latest by 31<sup>st</sup> August, 2017.

**19.** The meeting ended with a vote of thank to the chair.

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**List of Participants of 1<sup>st</sup> meeting of the Committee for Review of Draft technical specification for FGD Plant held in CEA on 11.08.2017**

1. Dr. L.D. Papney, Chief Engineer (TETD), CEA
2. Shri Chander Shekhar, Chief Engineer (UMPP), CEA
3. Shri Gorakh Thakur, Chief Engineer (TCD), CEA
4. Shri Narender Singh, Chief Engineer (TPE&CC), CEA
5. Shri Ramesh Kumar, Director (UMPP), CEA
5. Shri Neeraj Kumar, Director (TCD), CEA
5. Shri H.R. Arora, Director (TETD), CEA
6. Shri B.R. Alwani, Director (TPE&CC), CEA
7. Shri Rajesh Kohli, Dy. Director (TETD), CEA
8. Shri Amit Kumar, Dy. Director (TCD), CEA
9. Shri Pankaj Kumar Verma, Asstt. Director (TETD), CEA
10. Shri S.Kalaiselvan, S.E., TANGEDCO
11. Shri Diwakar Swaroop, UPRVUNL
12. Shri Pravin Kumar, UPRVUNL
13. Shri G. Murali, GM (Marketing), BHEL
14. Shri Vivek Gupta, DGM (PE-Mech/SG), NTPC
15. Shri Kalyan Sahu, Vice President, Toshiba
16. Shri Ashutosh Singhvi, L&T
17. Shri Venkatesh Rao, GE Power