NTPC LIMITED

3X660 MW NTPC BARH STPP STAGE I
(FGD System Package)

TECHNICAL SPECIFICATION

FOR

HVAC SYSTEM

SPECIFICATION NO.: - PE-TS-442- (571-13000-A)-A001 (REV-0)

BHARAT HEAVY ELECTRICALS LIMITED
POWER SECTOR
PROJECT ENGINEERING MANAGEMENT
PROJECT ENGIEERING INSTITUTE BUILDING
SECTOR-16A, PLOT NO.-25, NOIDA, INDIA

CONTENTS

This Technical specification consists of two sections:

SECTION - I

SECTION - II

SECTION - I

SECTION-I

SUB-SECTION-A

INTENT OF SPECIFICATION

1.0 INTENT OF SPECIFICATION

1.1 The specification covers design, engineering, manufacture, supply / procurement, inspection and testing at vendor's / sub vendor's / manufacturer's works, painting, forwarding, proper packing and shipment and delivery at site, unloading, handling & transportation, storage, preservation , security / safety at site , Erection & Commissioning, minor civil & structural (as applicable) works as required on FOR site basis, Performance and guarantee testing / demonstration testing and handing over to BHEL's customer of **HVAC SYSTEM** as per details in different sections / volumes of this specification and various pre award agreements for **3X660 MW NTPC BARH STAGE-I (FGD SYSTEM PACKAGE)**, Patna District, Bihar.

1.2 The contractor shall be responsible for providing all material, equipment & services, which are required to fulfil the intent of ensuring operability, maintainability, reliability and complete safety of the complete work covered under this specification, irrespective of whether it has been specifically listed herein or not. Omission of specific reference to any component / accessory necessary for proper performance of the equipment shall not relieve the contractor of the responsibility of providing such facilities to complete the supply, erection and commissioning, performance and guarantee/demonstration testing of **HVAC SYSTEM.**

1.3 It is not the intent to specify herein all the details of design and manufacture. However, the equipment shall conform in all respects to highest standards of design, engineering and workmanship and shall be capable of performing the required duties in a manner acceptable to purchaser who will interpret the meaning of drawings and specifications and shall be entitled to reject any work or material which in his judgement is not in full accordance herewith.

1.4 The extent of supply under the contract includes all items shown in the drawings, notwithstanding the fact that such items may have been omitted from the specification or schedules. Similarly, the extent of supply also includes all items mentioned in the specification and /or schedules, notwithstanding the fact that such items may have been omitted in the drawing. Similarly, the extent of supply also includes all tems required for completion of the system and not withstanding that they may have been omitted in drawings / specifications or schedules.

1.5 The general term and conditions, instructions to tenderers and other attachment referred to elsewhere are made part of the tender specification. The equipment materials and works covered by this specification is subject to compliance to all attachments referred to in the specification. The bidder shall be responsible for and governed by all requirements stipulated herein.

1.6 While all efforts have been made to make the specification requirement complete & unambiguous, it shall be bidders' responsibility to ask for missing information, ensure completeness of specification, to bring out any contradictory / conflicting requirement in different sections of the specification and within a section itself to the notice of BHEL and to seek any clarification on specification requirement in the format enclosed under

Vol-III of the specification **within 10 days of receipt of tender documents.** In absence of any such clarifications, in case of any contradictory requirement, the more stringent requirement as per interpretation of Purchaser / Customer shall prevail and shall be complied by the bidder without any commercial implication on account of the same. Further in case of any missing information in the specification not brought out by the prospective bidders as part of pre-bid clarification, the same shall be furnished by Purchaser/ Customer as and when brought to their notice either by the bidder or by purchaser/ customer themselves. However, such requirements shall be binding on the successful bidder without any commercial & delivery implication.

1.7 The bidder's offer shall not carry any sections like clarification, interpretations and /or assumptions.

1.8 Deviations, if any, should be very clearly brought out clause by clause along with cost of withdrawal in the format attached with GCC (Annexure-II Deviation sheet (Cost of withdraw), otherwise, it will be presumed that the vendor's offer is strictly in line with NIT specification.

1.9 In the event of any conflict between the requirements of two clauses of this specification documents or requirements of different codes and standards specified, Section - C shall prevail over section – D, however more stringent requirement as per the interpretation of the owner shall apply.

1.10 In case all above requirements are not complied with, the offer may be considered as incomplete and would become liable for rejection.

1.11 For definition of word like Contractor, bidder, supplier, vendor, Customer/ Purchaser Employer, consultant, please referred relevant clause

SECTION: I

SUB-SECTION: B

PROJECT INFORMATION WITH WIND AND SEISMIC DESIGN CRITERIA

SUB-SECTION-II-A10

PROJECT INFORMATION- BARH-I 3X660 MW

1.00.00 **BACKGROUND**

Barh Super Thermal Power Project, Stage-I (3x660 MW) & Stage-II (2 x 660MW) coal based is being set up by NTPC near Barh town in Patna district of Bihar.

1.01.00 **LOCATION AND APPROACH**

The proposed power station is located at the latitude and longitude of 25 deg 29' 10" (N) and 85 deg. 45' 40" (E) respectively. The plant site is situated between National Highway (NH-31) and Patna-Mokama main railway line. The ash disposal area is located on the south of the railway line. Barh, the narest town, is about 4.0 kms away from the project site. The nearest rail head Barh Railway Station on Patna - Mokama Section of main trunk route, is approximately 3.0 km away from the project site. The nearest airport at Patna is located at a distance of approximately 75 kms from the project site. The Vicinity Plan of the project is enclosed at drawing section at Annexure-I. The nearest airport at Patna is located at a distance of approximately 75 kms. from the project site.The Vicinity Plan of the project is enclosed at ANNEXURE-I. Further to the information's given in this sub-section, Bidders are also advised visit the project site and collect data on local site conditions.

1.02.00 **LAND**

About 3200 acres of land is acquired/under acquisition under Stage-I of the project. No additional land is envisaged to be acquired under Stage-II. The plant, ash disposal and township shall be accommodated within the land acquired/under acquisition under Stage-I.

1.03.00 **WATER**

The project site is located near the river Ganges. The make up water requirement for the expansion project is approximately 71 cusecs and the same is proposed to be drawn from river Ganges near village Nawada, at a distance of 2.0 kms. Make-up water pump house is already constructed at the river end in Stage-I with space provision for Stage-II pumps and the plant water requirement will be pumped to the plant through makeup water piping.

1.04.00 **COAL**

a) Coal requirement for the project shall be met from Amrapali block of North Karanpura Coalfields of CCL.

b) The coal quality parameters and Fuel oil characteristics are attached below.

1.05.00 **RAILWAY SIDING**

For brining the equipment and material to the power house through rail, a permanent railway siding is proposed to be constructed near the project site to provide rail access to unloading bays and transformer yard.

1.06.00 Steam Generator and ESP data: refer Table-6.

2.00.00 NOT USED

3.00.00 **Capacity**

Stage-I : 3 x 660 MW - Under Construction -Present proposal

Stage-II : 2 x 660 MW - Under Operation

4.00.00 **METEOROLOGICAL DATA**

The meteorological data from the nearest observatory at Patna is placed as ANNEXURE-II.

5.00.00 CRITERIA FOR EARTHQUAKE RESISTANT DESIGN OF STRUCTURES AND EQUIPMENT

All structures and equipment shall be designed for seismic forces adopting the site specific seismic information provided in this document and using the other provisions in accordance with IS:1893 (Part 1 to Part 4). Pending finalization of Part 5 of IS:1893, provisions of part 1 shall be read along with the relevant clauses of IS:1893:1984, for embankments.

A site specific seismic study has been conducted for the project site. The peak ground horizontal acceleration for the project site, the site specific acceleration spectral coefficients (in units of gravity acceleration 'g') in the horizontal direction for the various damping values and the multiplying factor (to be used over the spectral coefficients) for evaluating the design acceleration spectra are as given at Appendix-I.

Vertical acceleration spectral values shall be taken as 2/3rd of the corresponding horizontal values.

The site specific design acceleration spectra shall be used in place of the response acceleration spectra, given at figure-2 in IS:1893 (Part 1) and Annex B of IS:1893 (Part 4). The site specific acceleration spectra along with multiplying factors specified in Appendix-I includes the effect of the seismic environment of the site, the importance factor related to the structures and the response reduction factor. Hence, the design spectra do not require any further consideration of the zone factor (Z), the importance factor (I) and response reduction factor (R) as used in the IS:1893 (Part 1 to Part 4).

Damping in Structures

The damping factor (as a percentage of critical damping) to be adopted shall not be more than as indicated below for:

a)	Steel structures	:	2%
b)	Reinforced Concrete structures	:	5%
c)	Reinforced Concrete Stacks	:	3%
d)	Steel stacks	:	2%

1.01.00

Method of Analysis

Since most structures in a power plant are irregular in shape and have irregular distribution of mass and stiffness, dynamic analysis for obtaining the design seismic forces shall be carried out using the response spectrum method. The number of vibration modes used in the analysis should be such that the sum total of modal masses of all modes considered is at least 90 percent of the total seismic mass and shall also meet requirements of IS:1893 (Part 1). Modal combination of the peak response quantities shall be performed as per Complete Quadratic Combination (CQC) method or by an acceptable alternative as per IS:1893 (Part 1).

In general, seismic analysis shall be performed for the three orthogonal (two principal horizontal and one vertical) components of earthquake motion. The seismic response from the three components shall be combined as specified in IS:1893 (Part 1).

The spectral acceleration coefficient shall get restricted to the peak spectral value if the fundamental natural period of the structure falls to the left of the peak in the spectral acceleration curve.

For buildings, if the design base shear (V_B) obtained from modal combination is less than the base shear ($\bar{V}_B$) computed using the approximate fundamental period (T_a) given in IS:1893:Part 1 and using site specific acceleration spectra with appropriate multiplying factor, the response quantities (e.g. member forces, displacements, storey forces, storey shears and base reactions) shall be enhanced in the ratio of $\bar{V}_B$/ V_B. However, no reduction is permitted if $\bar{V}_B$ is less than V_B.

For regular buildings less than 12m in height, design seismic base shear and its distribution to different floor levels along the height of the building may be carried out as specified under clause 7.5, 7.6 & 7.7 of IS:1893 (Part 1) and using site specific design acceleration spectra. The design horizontal acceleration spectrum value (Ah) shall be computed for the fundamental natural period as per clause 7.6 of IS:1893 (Part 1) using site specific spectral acceleration coefficients with appropriate multiplying factor given in Appendix-I.

Design/Detailing for Ductility for Structures

The site specific design acceleration spectra is a reduced spectra and has an in-built allowance for ductility. Structures shall be engineered and detailed in accordance with relevant Indian/International standards to achieve ductility.

APPENDIX – I (Contd.)

SITE SPECIFIC SEISMIC PARAMETERS FOR DESIGN OF STRUCTURES AND EQUIPMENT

The various site specific seismic parameters for the project site shall be as follows:

1) Peak ground horizontal acceleration : 0.24g

2) Multiplying factor to be applied to the site specific horizontal acceleration spectral coefficients (in units of gravity acceleration 'g') to obtain the design acceleration spectra

   a) for moment resisting steel frames designed and detailed as per IS:800 : 0.072

   b) for braced steel frames designed and detailed as per IS:800 : 0.054

   c) for moment resisting RC frames designed and detailed as per IS:456 and IS:13920 : 0.043

   d) for RCC Chimney : 0.144

   e) for Liquid retaining tanks : 0.087

   f) for Steel chimney, Absorber tower : 0.11

   g) for design of structures not covered under 2 (a) to 2 (f) above and under 3 below : 0.072

3) Multiplying factor to be applied to the site specific horizontal acceleration spectral coefficients (in units of gravity acceleration 'g') for design of equipment and structures where inelastic action is not relevant or not permitted : 0.144

Note: g = Acceleration due to gravity

The horizontal seismic acceleration spectral coefficients are furnished in subsequent pages.

APPENDIX – I (Contd.)

HORIZONTAL SEISMIC ACCELERATION SPECTRAL COEFFICIENTS
In units of 'g' for BARH STPP

Period	Damping Factor (as a percentage of critical damping)					
(Sec)	0.80%	1%	1.60%	2%	3%	5%
0.000	1.000	1.000	1.000	1.000	1.000	1.000
0.030	1.000	1.000	1.000	1.000	1.000	1.000
0.040	1.373	1.361	1.327	1.310	1.275	1.212
0.050	1.755	1.728	1.653	1.615	1.539	1.406
0.058	2.066	2.026	1.913	1.856	1.744	1.552
0.059	2.106	2.063	1.945	1.886	1.770	1.570
0.060	2.145	2.101	1.978	1.916	1.795	1.588
0.061	2.184	2.138	2.010	1.946	1.820	1.605
0.062	2.224	2.176	2.043	1.976	1.845	1.623
0.065	2.343	2.289	2.140	2.065	1.920	1.675
0.070	2.542	2.478	2.302	2.214	2.044	1.760
0.071	2.582	2.516	2.334	2.244	2.069	1.776
0.074	2.702	2.630	2.431	2.332	2.143	1.826
0.084	3.107	3.012	2.754	2.627	2.385	1.987
0.094	3.516	3.398	3.077	2.919	2.622	2.142
0.104	3.930	3.787	3.398	3.210	2.856	2.292
0.114	4.349	4.178	3.720	3.498	3.086	2.436
0.120	4.608	4.414	3.912	3.671	3.222	2.521
0.121	4.608	4.445	3.944	3.699	3.245	2.535
0.123	4.608	4.445	4.018	3.757	3.290	2.563
0.124	4.608	4.445	4.018	3.798	3.313	2.577
0.126	4.608	4.445	4.018	3.798	3.368	2.604
0.133	4.608	4.445	4.018	3.798	3.368	2.708
0.601	4.608	4.445	4.018	3.798	3.368	2.708
0.604	4.586	4.445	4.018	3.798	3.368	2.708
0.617	4.489	4.348	4.018	3.798	3.368	2.708
0.622	4.453	4.314	3.982	3.798	3.368	2.708
0.632	4.383	4.245	3.919	3.739	3.368	2.708
0.667	4.153	4.022	3.714	3.543	3.192	2.708
0.767	3.611	3.498	3.229	3.081	2.776	2.356
0.867	3.195	3.095	2.857	2.725	2.456	2.084
0.967	2.865	2.775	2.562	2.444	2.202	1.869
1.067	2.596	2.515	2.321	2.215	1.995	1.694
1.167	2.374	2.299	2.123	2.025	1.824	1.548
1.267	2.186	2.118	1.955	1.865	1.680	1.426
1.367	2.026	1.963	1.812	1.729	1.557	1.322
1.467	1.888	1.829	1.688	1.611	1.451	1.232
1.567	1.768	1.712	1.581	1.508	1.359	1.153
1.667	1.662	1.609	1.486	1.418	1.277	1.084

HORIZONTAL SEISMIC ACCELERATION SPECTRAL COEFFICIENTS
In units of 'g' for BARH STPP

Period	Damping Factor (as a percentage of critical damping)					
(Sec)	0.80%	1%	1.60%	2%	3%	5%
1.767	1.568	1.518	1.402	1.337	1.205	1.023
1.867	1.484	1.437	1.327	1.266	1.140	0.968
1.967	1.408	1.364	1.259	1.201	1.082	0.919
2.067	1.340	1.298	1.198	1.143	1.030	0.874
2.167	1.278	1.238	1.143	1.090	0.982	0.834
2.267	1.222	1.184	1.093	1.042	0.939	0.797
2.367	1.170	1.134	1.046	0.998	0.899	0.763
2.467	1.123	1.088	1.004	0.958	0.863	0.732
2.567	1.079	1.045	0.965	0.921	0.829	0.704
2.667	1.039	1.006	0.929	0.886	0.798	0.678
2.767	1.001	0.970	0.895	0.854	0.769	0.653
2.867	0.966	0.936	0.864	0.824	0.743	0.630
2.967	0.934	0.904	0.835	0.796	0.718	0.609
3.067	0.903	0.875	0.808	0.770	0.694	0.589
3.167	0.875	0.847	0.782	0.746	0.672	0.571
3.267	0.848	0.821	0.758	0.723	0.652	0.553
3.367	0.823	0.797	0.736	0.702	0.632	0.537
3.467	0.799	0.774	0.714	0.682	0.614	0.521
3.544	0.782	0.757	0.699	0.667	0.601	0.510
3.559	0.778	0.754	0.696	0.664	0.596	0.508
3.666	0.756	0.732	0.676	0.645	0.561	0.479
3.765	0.736	0.713	0.658	0.611	0.532	0.454
3.865	0.717	0.694	0.624	0.580	0.505	0.431
3.965	0.699	0.677	0.593	0.551	0.480	0.409
4.017	0.690	0.668	0.578	0.537	0.468	0.399

6.00.00 **CRITERIA FOR WIND RESISTANT DESIGN OF STRUCTURES AND EQUIPMENT**

All structures shall be designed for wind forces in accordance with IS:875 (Part-3) and as specified in this document. See Annexure – B for site specific information.

Along wind forces shall generally be computed by the Peak (i.e. 3 second gust) Wind Speed method as defined in the standard.

Along wind forces on slender and wind sensitive structures and structural elements shall also be computed, for dynamic effects, using the Gust Factor or Gust Effectiveness Factor Method as defined in the standard. The structures shall be designed for the higher of the forces obtained from Gust Factor method and the Peak Wind Speed method.

Analysis for dynamic effects of wind must be undertaken for any structure which has a height to minimum lateral dimension ratio greater than “5” and/or if the fundamental frequency of the structure is less than 1 Hz.

Susceptibility of structures to across-wind forces, galloping, flutter, ovalling etc. should be examined and designed/detailed accordingly following the recommendations of IS:875(Part-3) and other relevant Indian standards.

It should be estimated if size and relative position of other structures are likely to enhance the wind loading on the structure under consideration. Enhancement factor, if necessary, shall suitably be estimated and applied to the wind loading to account for the interference effects.

Damping in Structures

The damping factor (as a percentage of critical damping) to be adopted shall not be more than as indicated below for:

a)	Welded steel structures	:	1.0%
b)	Bolted steel structures	:	2.0%
c)	Reinforced concrete structures	:	1.6%
d)	Steel stacks		As per IS:6533 & CICIND Model Code whichever is more critical.

ANNEXURE-B

SITE SPECIFIC DESIGN PARAMETERS

The various design parameters, as defined in IS: 875 (Part-3), to be adopted for the project site shall be as follows:

a)	The basic wind speed "V_b" at tenmetres above the mean ground level	:	47 metres/second
b)	The risk coefficient "K_1"	:	1.07
c)	Category of terrain	:	Category-2

7.00.00 SOIL DATA AND FOUNDATION SYSTEM

7.01.01 Employer has carried out geotechnical investigation in the areas near to this package. Logs of representative boreholes to be used for bidder's information in the vicinity of proposed area are enclosed with this Annexure-II. The bidder is required to carry out geotechnical investigation as per the clause no. 7.07.00 and ascertain the pile capacity and bearing capacity. The onus of correct assessment / interpretation and understanding of the existing subsoil condition / data is on the Bidder. Ground water table is encountered at a depth of about 0 to 1.0m below natural ground level (NGL) at the time of investigation. Fluctuation may occur in ground water table due to seasonal variation.

7.01.00 Finished Ground Level (FGL) generally corresponds to RL 46.20 within the plant area as shown in General Layout Plan (GLP). Controlled filling of thickness 3.5 to 4.0 m with soil has been done over Natural Ground Level (NGL) to achieve the FGL as indicated above.

7.02.00 For excavation depth upto 6.0 m from FGL, contractor shall make arrangements like shoring, strutting or any other method duly approved by the Engineer to retain the sides of excavated area. Contractor may also use sheet piling to protect the sides of excavated area if he so desires. For excavation 6 metres below FGL, sheet piling shall be provided. The design of the sheet pile shall be done by Contractor as per relevant IS codes. The Contractor shall submit the design of sheet piling for Engineers information.

7.03.00 The natural ground level is varying as per enclosed contour/spot level drawing.

a) The foundation system to be adopted for different structures shall be as given in Table – 1 below

Table – 1: Net Allowable Bearing Pressure

STRUCTURE	TYPE OF FOUNDATION TO BE ADOPTED
FGD and related structures	Open/Piles

b) During design the Allowable Bearing Pressure shall be as furnished in Table-2. Bidder is required to carry out geotechnical investigation in this area. The allowable bearing pressure shall be adopted after approval of geotechnical investigation report by owner. However, the maximum allowable bearing pressure shall be as per the approved geotechnical report and shall be limited to the values as furnished in Table-2.

Table – 2: Net Allowable Bearing Pressure

Structure	Founding Level in RL	1.02.00 Net Allowable Bearing Pressure 1.03.00 T/m^2		
		Isolated / Strip		Rafts (width > 6m) for 75mm settlement
		width upto 6 m for 25mm settlement	Width upto 6m for 40mm settlement	
FGD and related structures	1.5 m below NGL	5.0	5.5	7.0
	2.5 m below NGL	6.0	7.0	8.0

The net allowable bearing pressure higher than above mentioned values shall not be permitted. At intermediate levels the bearing capacity shall be same as the net allowable bearing pressure corresponding to the immediate shallower level mentioned above.

c) Permissible Settlement of Foundations:

For open foundations, the total permissible settlement and differential settlement shall be governed by IS: 1904 and from functional requirements whichever is more stringent. However, total settlement shall be restricted to the following:

Isolated, Strip & Raft (Mill foundations/machine foundation)	25 mm
Isolated & Strip (Other than Mill foundations/machine foundation)	40 mm
Raft (widths greater than 6 m) (Other than Mill foundations/machine foundation)	75 mm

In case the total permissible settlement is to be restricted to less than as above specified from functional requirements, then the net allowable bearing pressure shall be reduced after review in consultation with Engineer.

d) The diameter of pile, minimum length and maximum allowable capacity of piles shall be as given below:

Area/ Location	Pile Diameter (mm)	Minimum Length of Bored Pile Below Cut-off Level (m)	Safe Load Capacity in		
			Vertical Comp. (MT)	Pullout (MT)	Lateral (MT)
FGD and related structures	600	26.0	100.0	35.0	5.0
	600*	27.0*	100	35.0	5.0

Cut off Level (COL) is assumed at 3.0 m below FGL (RL (+) 46.2m). If the COL is shallower than the assumed COL, then the length of the pile shall be increased accordingly.

* Cut off Level (COL) is assumed at 1.5 m below FGL (RL (+) 46.2m). If the COL is shallower than the assumed COL, then the length of the pile shall be increased accordingly.

e) The criteria for Pile Termination (founding level) shall be as given below:

The termination level of the pile shall be decided based on the following criterion

i) Minimum length of the pile below COL (cut off level) shall be as specified above

ii) The minimum pile length for each group of piles shall be determined based on the nearest borelog. The SPT N value at pile termination level shall not be less than 40. For pile termination, SPT 'N' values shall be used from the nearby borelog data. The boreholes are in the bidder's scope and shall be conducted as per the enclosed scheme.

iii) However, in no case the length of pile shall be less than the minimum length determined as in (i) or (ii) above whichever is longer, for that pile group.

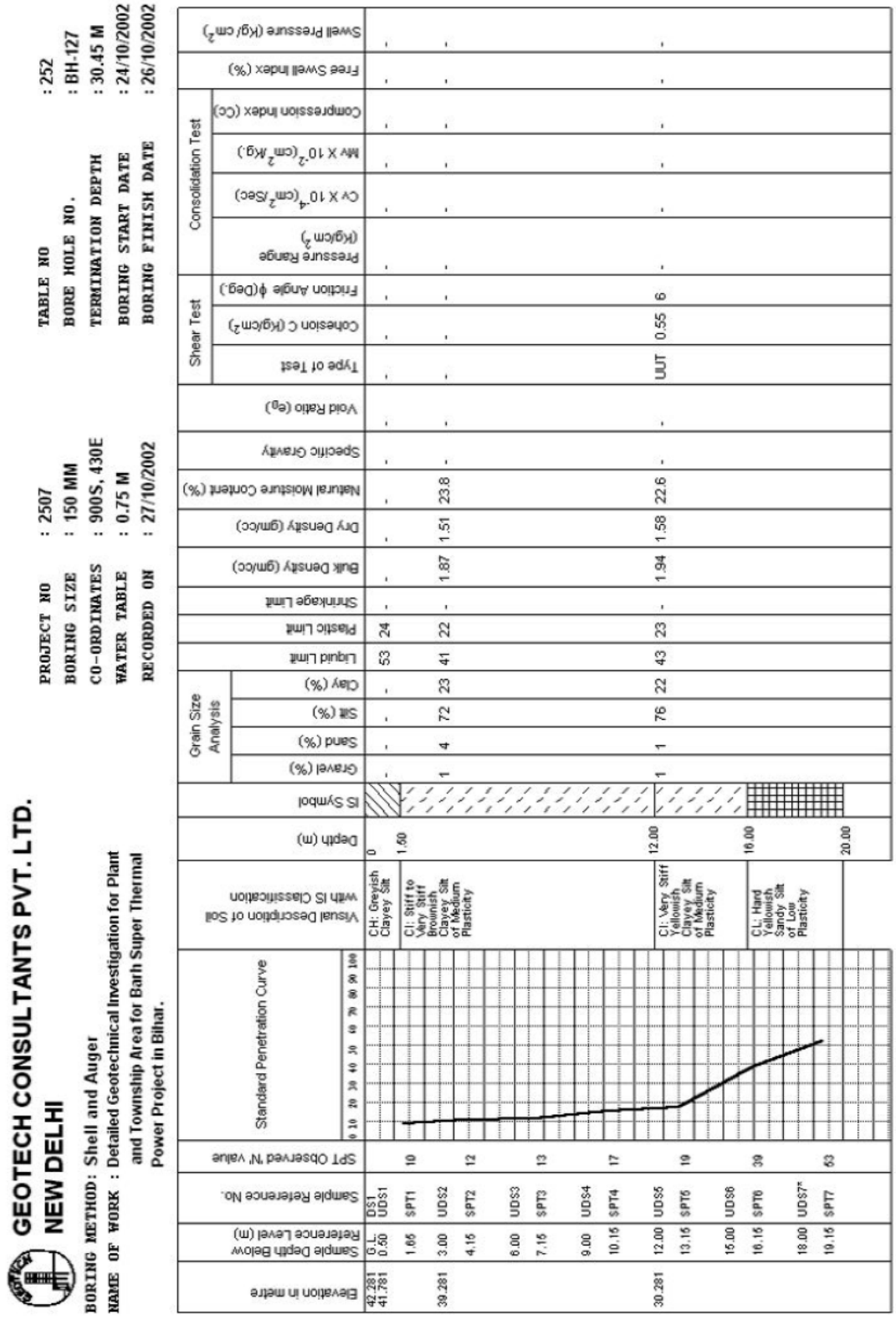
f) Special Requirements:

1) Chemicals in ground water and subsoil, as observed during investigation are:

Chemical	SO_3	Chlorides	pH
Ground Water	20 - 56 ppm	34 – 368 ppm	6.8 - 7.2
Sub-soil	0.024 - 0.04 %	0.01 - 0.03 %	6.1 - 7.2

2) In view of the above, the following shall be adopted.

Cement Type	As specified elsewhere in the specifications
Concrete Grade	M25 for piles Minimum cement content for piles shall be 400 kg/cum of concrete. Concrete shall be dense and durable. Admixtures in concrete are not permitted
Type of Reinforcement	As specified elsewhere in the specifications
Cover to Reinforcement	As specified elsewhere in the specifications


GEOTECH CONSULTANTS PVT. LTD.
NEW DELHI
BORING METHOD: Shell and Auger
NAME OF WORK : Detailed Geotechnical Investigation for Plant and Township Area for Barh Super Thermal Power Project in Bihar.
PROJECT NO : 2507
BORING SIZE : 150 MM
CO-ORDINATES : 900S, 430E
WATER TABLE : 0.75 M
RECORDED ON : 27/10/2002
TABLE NO : 252
BORE HOLE NO. : BH-127
TERMINATION DEPTH : 30.45 M
BORING START DATE : 24/10/2002
BORING FINISH DATE : 26/10/2002
Elevation in metre
Sample Depth Below Reference Level (m)
Sample Reference No.
SPT Observed 'N' value
Standard Penetration Curve
Visual Description of Soil with IS Classification
Depth (m)
IS Symbol
Grain Size Analysis
Gravel (%)
Sand (%)
Silt (%)
Clay (%)
Liquid Limit
Plastic Limit
Shrinkage Limit
Bulk Density (gm/cc)
Dry Density (gm/cc)
Natural Moisture Content (%)
Specific Gravity
Void Ratio (e0)
Shear Test
Type of Test
Cohesion C (Kg/cm2)
Friction Angle ϕ(Deg.)
Consolidation Test
Pressure Range (Kg/cm2)
Cv X 10-4(cm2/Sec)
Mv X 10-2(cm2/Kg.)
Compression Index (Cc)
Free Swell Index (%)
Swell Pressure (Kg/cm2)
CH: Greyish Clayey Silt
CI: Stiff to Very Stiff Brounish Clayey Silt of Medium Plasticity
CI: Very Stiff Yellowish Clayey Silt of Medium Plasticity
CL: Hard Yellowish Sandy Silt of Low Plasticity
UUT

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BORING METHOD: Shell and Auger
NAME OF WORK : Detailed Geotechnical Investigation for Plant and Township Area for Barh Super Thermal Power Project in Bihar.

Elevation in metre	Sample Depth Below Reference Level (m)	Sample Reference No.	SPT Observed 'N' value	Standard Penetration Curve (0 10 20 30 40 50 60 70 80 90 100)	Visual Description of Soil with IS Classification	Depth (m)	IS Symbol	Grain Size Analysis: Gravel (%)	Grain Size Analysis: Sand (%)	Grain Size Analysis: Silt (%)	Grain Size Analysis: Clay (%)	Liquid Limit	Plastic Limit	Shrinkage Limit	Bulk Density (gm/cc)	Dry Density (gm/cc)	Natural Moisture Content (%)	Specific Gravity	Void Ratio (eg)	Shear Test: Type of Test	Shear Test: Cohesion C (Kg/cm²)	Shear Test: Friction Angle ϕ(Deg.)	Consolidation Test: Pressure Range (Kg/cm²)	Consolidation Test: Cv X 10⁻⁴(cm²/Sec)	Consolidation Test: Mv X 10⁻²(cm²/Kg.)	Consolidation Test: Compression Index (Cc)	Free Swell Index (%)	Swell Pressure (Kg/ cm²)
21.281	21.00	UDS8			CL: Hard Yellowish Sandy Silt of Low Plasticity	20.00		3	8	83	6	29	20	-	2.01	1.70	18.5	-	-	-	-	-	-	-	-	-	-	-
	22.15	SPT8	66																									
	24.00	UDS9*				24.00																						
	25.15	SPT9	55		CI: Hard Greyish Clayey Silt of Medium Plasticity																							
15.281	27.00	UDS10						2	1	78	19	39	22	-	2.00	1.68	19.2	-	-	UCT	1.35	-	-	-	-	-	-	-
	28.15	SPT10	42																									
	30.15	SPT11	40			30.45																						

GEOTECH CONSULTANTS PVT. LTD.
NEW DELHI

BORING METHOD: Shell and Auger
NAME OF WORK : Detailed Geotechnical Investigation for Plant and Township Area for Barh Super Thermal Power Project in Bihar.

PROJECT NO	: 2507	TABLE NO	: 254
BORING SIZE	: 150 MM	BORE HOLE NO.	: BH-128
CO-ORDINATES	: 900S, 520E	TERMINATION DEPTH	: 30.45 M
WATER TABLE	: 0.0 M	BORING START DATE	: 03/10/2002
RECORDED ON	: 06/10/2002	BORING FINISH DATE	: 05/10/2002

Elevation in metre	Sample Depth Below Reference Level (m)	Sample Reference No.	SPT Observed 'N' value	Standard Penetration Curve (0 10 20 30 40 50 60 70 80 90 100)	Visual Description of Soil with IS Classification	Depth (m)	IS Symbol	Grain Size Analysis: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Liquid Limit	Plastic Limit	Shrinkage Limit	Bulk Density (gm/cc)	Dry Density (gm/cc)	Natural Moisture Content (%)	Specific Gravity	Void Ratio (e_0)	Shear Test: Type of Test	Shear Test: Cohesion C (Kg/cm^2)	Shear Test: Friction Angle ϕ(Deg.)	Consolidation Test: Pressure Range (Kg/cm^2)	Consolidation Test: Cv X 10^{-4} (cm^2/Sec)	Consolidation Test: Mv X 10^{-2} (cm^2/Kg.)	Consolidation Test: Compression Index (Cc)	Free Swell Index (%)	Swell Pressure (Kg/cm^2)
42.295	G.L.				CH: Stiff Greyish Clayey Silt	0		-	-	-	-	50	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-
41.795	0.50	US1																									
	1.15	UDS1	10																								
		SPT1																									
	2.65	SPT2	9		CI: Medium to Stiff Brownish Clayey Silt of Medium Plasticity	2.00		3	4	73	20	38	22	-	1.86	1.49	24.7	-	-	UCT	0.45	-	-	-	-	-	-
	3.50	UDS2																									
38.795																											
	5.65	SPT3	8																								
	6.50	UDS3																									
	8.65	SPT4	11		CL: Stiff to Hard Yellowish Clayey Silt of Low Plasticity	9.00																					
	9.50	UDS4																									
	11.65	SPT5	44																								
	12.50	UDS5																									
	14.65	SPT6	10																								
26.795	15.50	UDS6																						0.5-1.0 1.0-2.0 2.0-4.0 4.0-8.0	9.58 7.71 6.27 5.57	1.36 1.00 0.73 0.43	0.090		
	17.65	SPT7	31																								
	18.50	UDS7*				20.00																					

GEOTECH CONSULTANTS PVT. LTD.
NEW DELHI

BORING METHOD: Shell and Auger
NAME OF WORK : Detailed Geotechnical Investigation for Plant and Township Area for Barh Super Thermal Power Project in Bihar.

PROJECT NO	: 2507	TABLE NO	: 255
BORING SIZE	: 150 MM	BORE HOLE NO.	: BH-128
CO-ORDINATES	: 900S, 520E	TERMINATION DEPTH	: 30.45 M
WATER TABLE	: 0.0 M	BORING START DATE	: 03/10/2002
RECORDED ON	: 06/10/2002	BORING FINISH DATE	: 05/10/2002

Elevation in metre	Sample Depth Below Reference Level (m)	Sample Reference No.	SPT Observed 'N' value	Standard Penetration Curve (0 10 20 30 40 50 60 70 80 90 100)	Visual Description of Soil with IS Classification	Depth (m)	IS Symbol	Grain Size Analysis: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Liquid Limit	Plastic Limit	Shrinkage Limit	Bulk Density (gm/cc)	Dry Density (gm/cc)	Natural Moisture Content (%)	Specific Gravity	Void Ratio (e_0)	Shear Test: Type of Test	Cohesion C (Kg/cm^2)	Friction Angle ϕ(Deg.)	Consolidation Test: Pressure Range (Kg/cm^2)	Cv X 10^{-4}(cm^2/Sec)	Mv X 10^{-2}(cm^2/Kg.)	Compression Index (Cc)	Free Swell Index (%)	Swell Pressure (Kg/cm^2)
17.795	20.65	SPT8	38		CI: Hard Greyish Clay of Medium Plasticity	20.00		1	3	72	24	44	23	-	2.03	1.70	19.6											
	21.65	UDS8																										
	23.65	SPT9	46																									
	24.60	UDS9																										
	26.65	SPT10	51																									
	27.60	UDS10																										
	30.15	SPT11	47			30.45																						

COOLING WATER ANALYSIS

Sl. No.	Constituent	as	mg per litre
1.	Calcium	$CaCO_3$	493
2.	Magnesium	$CaCO_3$	212
3.	Sodium	$CaCO_3$	250
4.	Potassium	$CaCO_3$	28
5.	Total Cations	$CaCO_3$	983
6.	Total Alkalinity	$CaCO_3$	643
7.	P-Alkalinity	$CaCO_3$	Nil
8.	Chloride	$CaCO_3$	233
9.	Sulphate	$CaCO_3$	107
9.	Total Anions	$CaCO_3$	983
11.	Silica (Reactive)	SiO_2	15
12.	Iron	Fe	1
13.	pH Value	-	8.6-9
14.	Turbidity	NTU	50

Note : The C.W system is expected to operate at about 2.5 Cycles of Concentration. As CW blow down water (Service Water) is tapped from discharge of CW pumps, the water quality of CW Blow down water shall be same as that above.

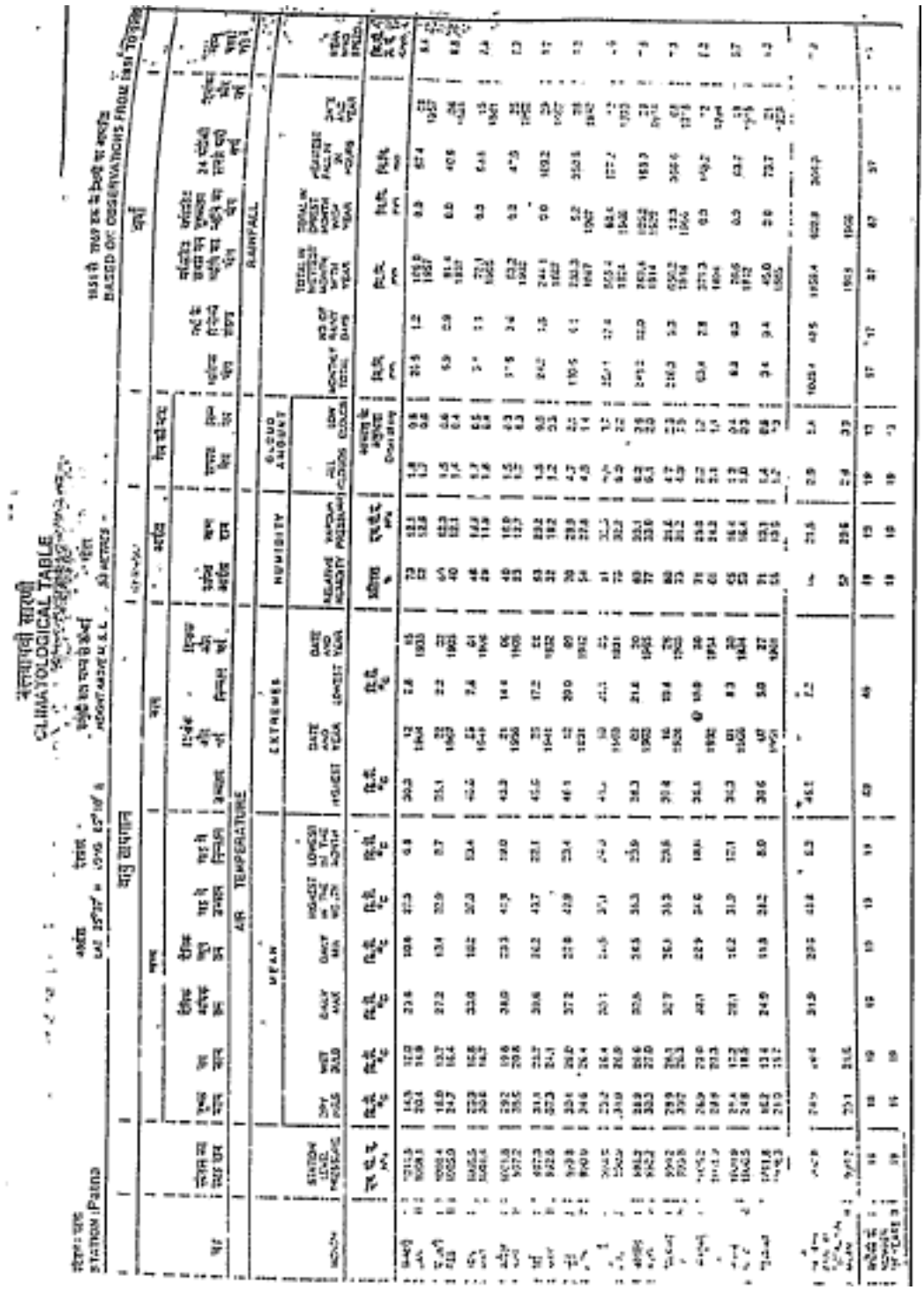
ANALYSIS OF DM WATER TO BE USED FOR MAKE-UP WATER TO CONDENSER

Sl.No.	Characteristics	Value
1.	Silica (Max.)	0.02 ppm as Sio2
2.	Iron as Fe	Nil
3.	Total hardness	Nil
4.	pH value	6.8 -7.2
5.	Conductivity	Not more than 0.1 excluding the effects of free CO2

ANNEXURE-I


MOKAMA
GANGA RIVER
ASH DISPOSAL AREA
PLANT AREA
T/SHIP
GANGA RIVER
BARH
PATNA
National Thermal Power Corporation Ltd
(A Government Of India Enterprise)
PROJECT
BARH MEGA POWER PROJECT
(2000 MW)
TITLE
VICINITY PLAN

ANNEXURE-II



जलवायविक सारणी
CLIMATOLOGICAL TABLE

CLIMATOLOGICAL TABLE

Table-4

S.No	Constituent	As	mg/l (except pH & turbidity)
1.	Calcium	$CaCO_3$	200.5
2.	Magnesium	$CaCO_3$	92
3.	Sodium + Potassium	$CaCO_3$	96
4.	Total Cations	$CaCO_3$	388.50
5.	Chloride	$CaCO_3$	106
6.	Sulphate	$CaCO_3$	58.5
7.	Alkalinity	$CaCO_3$	224
8.	Total Anions	$CaCO_3$	388.50
9.	Iron(total)	Fe	0.3
10.	Silica	SiO_2	10
11.	pH value	---	7.0-8.5
12.	Turbidity	NTU	10

Note: Clarified water is used for CW system as make up & the CW system is expected to operate at about 5.0 – 5.5 Cycles of Concentration (COC) with suitable chemical treatment program using acid, scale & corrosion inhibitor dozing. As CW blow down water is tapped from CW system, the water quality of CW blow down shall accordingly be arrived by the bidder.

Table-5

ANALYSIS OF DM WATER

Sl.No.	Characteristics	Value
1.	Silica (Max.)	0.02 ppm as SiO2
2.	Iron as Fe	Nil
3.	Total hardness	Nil
4.	pH value	6.8 to 7.2
5.	Conductivity	Not more than 0.1 µs/cm

SITE SPECIFIC SEISMIC PARAMETERS FOR DESIGN OF STRUCTURES AND EQUIPMENT

The various site specific seismic parameters for the project site shall be as follows:

1)	Peak ground horizontal acceleration	: 0.24g
2)	Multiplying factor to be applied to the site specific horizontal acceleration spectral coefficients (in units of gravity acceleration 'g') to obtain the design acceleration spectra	
a)	For special moment resisting steel frames designed and detailed as per IS:800	: 0.06
b)	For special concentrically braced steel frames designed and detailed as per IS:800	: 0.045
c)	For special moment resisting RC frames designed and detailed as per IS:456 and IS:13920	: 0.036
d)	for RCC Chimney	: 0.12
e)	for Liquid retaining tanks	: 0.072
f)	for Steel chimney, Absorber tower, Vessels	: 0.09
g)	for design of structures not covered under 2 (a) to 2 (f) above and under 3 below in general (excluding special structure/ configuration/materials)	: 0.06
3)	Multiplying factor to be applied to the site specific horizontal acceleration spectral coefficients (in units of gravity acceleration 'g') for design of equipment and structures where inelastic action is not relevant or not permitted	: 0.12

Note:

1. g = Acceleration due to gravity
2. For industrial structures, analysis for verification of mechanism shall be carried out as per IS:1893 (Part 4):2015

SECTION: I

SUB SECTION: C

TECHNICAL SPECIFICATIONS

SECTION: I

SUB-SECTION: C 1

SPECIFIC TECHNICAL REQUIREMENT

1. FUNCTION

The purpose of the system is to provide HVAC system for different areas of 3X660 MW NTPC BARH STPP STAGE I (FGD SYSTEM PACKAGE) under the scope of BHEL.

2. SYSTEM DESCRIPTION

2.1 AC SYSTEM

AC –Plant

AC plant, in FGD control room building is provided to cater the air conditioning requirements of the control room for FGD control room building.

The air conditioning plant shall comprise of 4x50% Air cooled condensing units (D-X type) type air conditioners with AHUs of suitable capacity with 4x50% configuration and other accessories as per the system/specification requirement. These AHU shall be located in AHU rooms located adjacent to air-conditioned areas. The conditioned air from AHUs is distributed to the air-conditioned areas by galvanised sheet steel ducting and extruded Aluminium grilles / diffusers with volume control dampers and supporting frames.

Controls for the AC & Ventilation (common) shall be DCS based.

For balance offsite areas, SPLIT TYPE AIR CONDITIONERS shall be provided as enumerated below: -

Split type air conditioners (air cooled) shall be provided to cater to the air conditioning requirements of for auxiliary plant. Local isolator / MCB shall be provided with split units.

Hand operated remote and other accessories as specified. Local Distribution Boards containing Switch / MCB shall be provided for Split Air Conditioners, and FCUs. Each split unit shall also be provided with suitable rating stabiliser.

Single phase electrical feeders of following ratings shall be provided for split units. Bidder to ensure the suitability as per these feeder requirements.

Capacity of Split AC	Single phase supply feeder
1.5 TR	32 Amp
2 TR	

2.2 VENTILATION SYSTEM

2.2.1 The Ventilation System is provided within the FGD control room building by MODULAR TYPE UAF.

2.2.2 Battery and Battery charger room.

Please refer to relevant clauses of customer technical specifications section C-2 for other detail of system description.

3. DESIGN CRITERIA

3.1 The outside design conditions considered are as follows: -

	Summer	Monsoon	Winter
DBT (°C)	43.0	38.0	7.0
WBT (°C)	27.5	29.5	5.8

3.2 AC system: -

The inside design conditions for Air conditioned area to be maintained are as follows: -

- Temperature 24°C ± 1^0C & RH 50% ± 5%

A minimum design margin of 10% shall be considered while designing the AC Plant capacity for each area.

Following safety factor to considered while designing the AC system

- Minimum 12.5% in RSH
- Minimum 10% in RLH
- 10% margin on dehumidified CFM

For winter heating load calculation, 50% of combined light load and eqpt. /panel load as available in the room shall be considered.

3.3 Ventilation system: -

The inside design conditions for Ventilated area to be maintained are as follows: -

- Inside temperature shall be minimum 3 deg.C below the design ambient temperature during summer for evaporative cooled areas.
- Inside temperature shall be maximum 3 deg.C above the design ambient temperature during summer for mechanically ventilated areas.

The ventilation philosophy in various areas shall be as under

S.No.	Area	Type of Ventilation	ACPH
1.	FGD control room building	Ventilation with MODULAR TYPE UAF. Motorized Fire dampers will be provided in the supply air ducting of Cable Spreader room/MCC	8
2.	General areas, like pump house, building etc.	Combination of Supply and exhaust fan	20
3.	MCC / Switchgear rooms etc.	Supply fan & back draft dampers	30
4.	Battery rooms & Oil room and other areas where gaseous fumes/ vapours are generated.	Combination of intake louvers & Exhaust air/Roof extractor fans.	30

*In addition to above mechanical ventilation for other auxiliary buildings under BHEL scope shall also be provided.

3.4 All equipment shall be designed for continuous duty.

3.5 For other design parameters refer to section C2-A, customer specifications.

4. SYSTEM CAPACITY AND CONFIURATION:

a) For AC Plant: -

4x50 % (2W + 2S, minimum 40 TR Actual capacity) DX- type air cooled condensing unit (1 working + 1 Standby) shall be provided.

b) For Ventilation system: -

Minimum 1,75,000 CMH capacity MODULAR TYPE UAF shall be provided.

5. LAYOUT CONSIDERATIONS:

a) AC PLANT

I. Air cooled DX-type condensing units for AC Plant shall be housed at the roof of FGD control room building.

II. The AHUs for this AC Plant would be located inside AHU room.

III. 1 T Capacity Chain pulley block with/without Monorail arrangement shall be provided for the AHU for maintenance purpose.

b) Ventilation system

I. MODULAR TYPE UAF shall be placed at the roof of FGD control room building.

II. MODULAR TYPE UAF shall be placed in open, exposed to ambient conditions and no masonry room shall be provided.

III. The exhaust air from battery room shall be taken out through MS duct having epoxy coating and the air shall be released above roof of the building.

For other design parameters refer to section C2-A, customer specifications

6. EQUIPMENT DETAILS:

6.1 AC EQUIPMENT DETAILS

6.1.1 Air cooled condensing unit

Refer to relevant clauses of section C2-A, customer specifications

6.1.2 AIR HANDLING UNIT (DOUBLE SKIN TYPE)

a) Motors shall be installed inside the AHU.

b) Accessories, valves, pressure gauges, water flow switches, controls and instruments etc. shall be provided per customer approved PID

c) Drain piping from the AHUs up to nearest drain point.

d) Serrated rubber pads for vibration isolation

e) For other details please refer to relevant clauses of section C2-A, customer specifications.

6.1.3 STRIP HEATER PACKAGE AND HUMIDIFICATION PACKAGE

a) One set of electrical strip heater package of suitable capacity shall be provided in supply air duct. Heater package shall be connected with thermostat / Humidistat which will be provided in return air path inside AHU Room / Package AC Room.

Temp gauge, temp element shall also be provided and the same shall be hooked with DCS system. RH and temp sensor shall be provided and the same shall be hooked with DCS system.

b) One No. pan humidifier comprising heater, humidistat, water tank, low level switch over flow, draining, make up connection, float valves etc for each AHU Room.

c) For other details please refer to relevant clause of section C2-A, customer specifications

6.1.4 Insulation

Please refer to relevant clause of section C2-A, customer specifications.

6.2 VENTILATION EQUIPMENT DETAILS

6.2.1 MODULAR TYPE MODULAR TYPE UAF

Each MODULAR TYPE MODULAR TYPE UAF shall comprise of:

a) Centrifugal fan and pump, efficiency of centrifugal fan and pump shall not be less than 70%.

b) Pump along with fan and other accessories shall be housed in sheet metal body as per Customer technical specification section C-2A

c) Please refer to relevant clauses of Customer technical specification section C-2A for MODULAR TYPE UAF construction.

6.2.2 CENTRIFUGAL FLOW FAN UNITS

a) Please refer to relevant clauses of Customer technical specification section C-2A for centrifugal fan.

6.2.3 WALL MOUNTED AXIAL FLOW FAN

a) Adjustable damper, vibration isolators, nuts and bolts, back draft dampers etc. Shall be provided.

b) These fans shall cater to the areas as indicated in the fan schedule of ventilation system

c) Please refer to relevant clauses of Customer technical specification section C-2A for detail construction of axial flow fan.

6.2.4 ROOF EXTRACTOR UNIT

a) Each roof extractor unit shall be complete with foundation bolts including screen at bottom.

b) Please refer to relevant clauses of Customer technical specification section C-2A for detail construction of RE Unit.

6.2.5 INSULATION

a) Thermal insulation shall be provided for the duct exposed to sun / rain only.
b) Please also refer to other relevant clauses of Customer technical specification section C-2A for detail construction of insulation.

6.2.6 WATER PUMP SETS

Each circulating water pump set for MODULAR TYPE MODULAR TYPE UAF shall comprise of the following

a) Pump (as per the specification) of adequate capacity to match the system requirement MODULAR TYPE MODULAR TYPE UAF spraying arrangement.
b) One no. adequately sized TEFC sq. cage induction motor suitable for 415V, 3 phase, 50 Hz AC supply.
c) One no. Pot/Y type strainer at inlet complete with screen, drain arrangement etc.
d) 150 mm dia. Dial Type pressure gauges one each at suction & discharge side of the pump set.
e) One no. non-return (check) valve at discharge side of pump set.
f) One set of base plate, coupling, coupling guard, anti-vibration mountings, foundation bolts etc.
g) Rain protection canopy for the pumps and motors, if located at outdoor shall be provided.
h) Please also refer to other relevant clauses of Customer technical specification section C-2A for detail construction of water pump.

6.3 COMMON FOR BOTH AC AND VENTILATION SYSTEM

6.3.1 SHEET METAL WORK

a) Air distribution would be done through ducting system, grilles and diffusers. All ducting shall be designed on equal friction method and fabricated as per IS: 655
b) Supply air diffusers / grilles (Frame and Louvers of Diffuser/Grilles shall be of extruded aluminium of 1.2 mm thick section, duly powder coated) with volume control dampers. Return air Diffusers will have no Volume Control Damper.
c) For other details please refer to relevant clauses of section C2-A, customer specifications

6.3.2 FIRE DAMPERS

a) Motorized fire damper shall be installed at supply and return air duct at suitable locations where duct pass through wall & floors for ease of isolation, maintenance and as well as for emergency operation. Fire damper in the supply and return air duct shall close on receiving fire signal from fire protection system and shall also be possible manually from remote control panel. Necessary arrangement shall be incorporated in the duct for providing duct mounted multi- sensor detectors in the return air duct for all air conditioned areas. Also respective Air Handling Units, Air washers/MODULAR TYPE UAFs shall trip on receiving fire signal from fire protection system.
b) For fire damper refer to relevant clauses of section C2-A, customer specifications.

6.3.3 PIPING VALVES ETC

a) Refer to relevant clauses of section C2-A, customer specifications

7. ELECTRICAL ITEMS:

Refer to relevant clauses of section C2-A, customer specifications and section C-3, electrical portion of specifications.

8. CONTROL PHILOSPHY

A DCS based control system shall be provided for AC & Ventilation system. The DCS based control system shall cover the followings.

- AC system for FGD control room building.
- MODULAR TYPE UAF unit for FGD control room building.
- Refer to clause of section, C-4 of specification.

8.1 SAFETY CONTROLS

All necessary measuring – control instruments & control system shall be provided. With following compressor & evaporator interlock in the control panel of the condensing unit.

a) High discharge pressure cut-out (HP) as applicable
b) Low suction pressure cut out (LP) as applicable
c) Oil pressure cut-out (OP) as applicable
d) Anti-freeze thermostat (AFT) as applicable
e) Any other essential safety control as per the OEM

8.2 OPERATING CONTROL

All operating control as necessary shall be provided. However, following minimum control shall be provided: -

a) Automatic capacity control system as applicable.
b) Automatic unloaded starting device
c) Operating Thermostat
d) Unloading solenoid valves (if applicable)
e) 3-way flow control valve at the AHU's (if applicable)
f) Operation / Sequence Interlock of the Air conditioning system shall be as under:

I. Condenser fan is started.

II. The Air Handling Unit is started.

III. Chilling unit is started

8.3 INTERFACE WITH DCS

Following hardwired signals shall be provided in the DCS for monitoring purpose for AC system

a) Temperature & Humidity.
b) AC Plant On / Off Status.
c) Pump Run / Trip.
d) AHU Run / Trip.
e) General AC Plant Warning.

8.4 INDICATIONS PROVIDED FOR MODULAR TYPE UAF IN LOCAL CONTROL PANEL

FAN RUNNING

FAN STOP

PUMP - 1 RUNNING

PUMP - 1 STOP

FAN MOTOR OVERLOAD.

PUMP - 1 MOTOR OVERLOAD.

The water sump of each Unitary Air Filtration Units shall be provided with a level transmitter which will initiate an alarm and will trip the pump sets, in case the water level falls below the predetermined level.

9. SPECIFIC REQUIREMENT

- Efficiency of centrifugal fan and pump shall not be less than 70%.
- All ventilation system shall operate on 100% fresh air.
- MODULAR TYPE UAF shall have 60% saturation efficiency.
- Ventilation ducts shall be provided with motorized type fire dampers at the supply duct in electrical area like MCC / Switch gear room/ cable spreader room, as well as Electrical areas which will close in case of fire.
- The fire damper shall close the air flow inside the duct on receiving fire alarm signal from FPS. Also respective fan shall trip once the fire damper is closed.
- Air Velocity through different system equipment should be maintained as the specification. However higher velocity of air shall be selected in case of layout constraint to run the ducting.
- Roof Exhausters and wall mounted Exhaust Fan motors shall be designed for a minimum 55 degree C ambient while the supply air fan motors shall be designed for a min.50 degree C.
- Design margin shall be maintained as follows:
    - For Pump a) Head-10% b) Flow-10%
- RE / wall mounted fans shall be selected so as to have motor rating and wall / slab opening as under. Feeder suitable for following ratings only shall be provided by BHEL.

1.	Roof extractor units with 15 mmwc static pressure.		
	Capacity	Motor rating	Roof / Slab opening
a.	40,000 CMH	5.5 KW	1320mm
b.	20,000 CMH	2.2 KW	1140mm
2	Axial flow supply fans with 30 mmwc static pressure.		

	Capacity	Motor rating	Wall opening
a.	10,000 CMH	2.2 KW	800mmx800mm
b.	7,500 CMH	1.5 KW	700mmx700mm
c.	6,000 CMH	1.1 KW	600mmx600mm
d.	4,000 CMH	0.75 KW	500mmx500mm
3	Axial flow supply fans with 20 mmwc static pressure.		
	Capacity	Motor rating	Wall opening
a.	10,000 CMH	1.5 KW	800mmx800mm
b.	7,500 CMH	1.1 KW	700mmx700mm
c.	6,000 CMH	1.1 KW	600mmx600mm
d.	4,000 CMH	0.75 KW	600mmx600mm
4	Axial flow exhaust fans (Bifurcated type) with 15 mmwc static pressure.		
	Capacity	Motor rating	Wall opening
a.	15,000 CMH	2.2 KW	900mmx900mm
b.	10,000 CMH	1.5 KW	800mmx800mm
c.	7,500 CMH	1.1 KW	700mmx700mm
d.	4,000 CMH	0.75 KW	600mmx600mm
e.	2,000 CMH	0.55 KW	500mmx500mm
5	Axial flow exhaust fans with 10 mmwc static pressure.		
	Capacity	Motor rating	Wall opening
a.	15,000 CMH	1.1 KW	900mmx900mm
b.	10,000 CMH	0.75 KW	800mmx800mm
c.	7,500 CMH	0.55 KW	700mmx700mm
d.	6,000 CMH	0.55 KW	600mmx600mm

e.	4,000 CMH	0.55 KW	600mmx600mm
f.	2,000 CMH	0.37 KW	500mmx500mm
6	Exhaust fan (propeller type) with 5 mmwc static pressure.		
	Capacity	Motor rating	Wall opening
a.	1000 CMH	100 W	330 mm circular

10. MATERIALS OF CONSTRUCTION

10.1 CENTRIFUGAL FAN

- Fan Casing (side plates & stiffeners): Mild Steel Sheets with spray galvanized to IS: 2062 Gr.B / IS: 1079 /Eq. The minimum thickness of casing shall be 3.00 mm.
- Impeller hub: Mild Steel
- Impeller back plate blade & shroud: Mild Steel to IS: 2062 Gr.B.
- Shaft: EN - 8 or eqv.
- Shaft sleeve: EN - 8 or eqv.
- Flexible connection at outlet/inlet: Fire resistant type plastic impregnated canvas with M.S. flange and cleats (3 mm thick).
- V Belt (matched sets): ISI marked (Reinforced rubber section to (IS: 4776)
- Bolts & nuts: Galvanized / MS (Epoxy painted).
- Vibration isolating cushy foot mountings, foundation bolts and nuts etc.
- Please refer to relevant clauses of Customer technical specification section C-2A for MOC of centrifugal fan.

10.2 AXIAL FAN

- Hub: As per manufacturer std. (AL- LM6)
- Neoprene rubber pads: As required.
- Supporting frame for mounting: Required.
- Protective screen at inlet: Yes (Min 14 SWG Galvanized wire knitted in 1" square mesh).
- Mounting flange on casing: At inlet and outlet.
- Painting / protecting coating – All the MS parts shall be galvanised or protected with three coats of epoxy paint.
- Please refer to relevant clauses of Customer technical specification section C-2A for MOC of axial flow fan.

10.3 ROOF EXTRACTOR UNIT

- Please refer to relevant clauses of Customer technical specification section C-2A for MOC of RE Unit.

10.4 Unitary Air Filtration

- Piping: MS Heavy class Galvanised to IS: 1239 Part I / IS 3589 depending on size.
- Please refer to relevant clauses of Customer technical specification section C-2A for MOC of pipe.

10.5 Valves:

- Valves shall have full sizes port and suitable for horizontal and as well as vertical installation.
- Valves for regulating duty shall be of globe type suitable for controlling throughout its lift.
- Gate, Globe and stop check valves shall have bonnet back seat to facilitate easy replacement of packing with the valves in service.
- All safety / relief valves shall be so constructed that the failure of any part does not obstruct the free discharge.
- Manual gear operators be provided for valves of size 200 NB and above.
- Please refer to relevant clauses of Customer technical specification section C-2A for MOC of valve.

10.6 CENTRIFUGAL PUMP

- Impeller: Bronze as per Grade IS: 318 Grade 2
- Pump shaft: SS 316
- Casing: 2% Ni Cast iron to IS: 210 GR. FG-260.
- Shaft Sleeve: SS 316.
- Bolt and nuts: M.S. (Epoxy painted / Galvanised).
- Type of seal: Mechanical
- Pump motor coupling: Pin & bush type.
- Please refer to relevant clauses of Customer technical specification section C-2A for MOC of pump.

11. GENERAL

1) Basis of design all calculations including heat load calculations for summer seasons, equipment selection criterion, layout drawings/ schemes/G.A. dwg and documents like data sheet/ technical particulars etc are subject to Customer approval during detail engineering stage.

2) Vendor to furnish characteristic curves for all major equipment offered indicating duty point during detailed engineering.

3) All drawings and documents shall be computer based.

4) Vendor to include the Back wash arrangement of pot strainer with gate valve, piping etc for the MODULAR TYPE UAF.

5) Vendor to include level gauge & level transmitter for each MODULAR TYPE UAF tank for alarm & trip of the pumps. Also include one no. Pressure transmitter for each MODULAR TYPE UAF pump. Temperature elements, electronic transmitters etc. are to be provided for all the cases. Acceptance of use of process actuated switches is subject to customer approval.

6) All commissioning spares & consumables for trouble free operation shall be provided.

7) Quality Requirements in the Technical Specification are indicating minimum requirements for inspection and testing. Vendor shall note that quality plan is subject to Customer & BHEL-approval during detail engineering stage. Standard QP format is enclosed in the technical specification.

8) Indicative list of makes is enclosed as per Annexure-I however these equipments / items shall be subject to Customer & BHEL approval during detail engineering Stage.

9) Inserts or any support arrangement for fixing ducting, fans, piping etc. shall not be provided by BHEL. Necessary supports may be taken from nearest structure / walls / roofs / floors etc. by Vendor.

10) Fixing frame works for diffusers and grilles in the scope of Vendor.

11) Anchor fastener shall be used by vendor for fixing duct pipes etc. wherever applicable.

12) Necessary supports and structures / frames etc. as required for supporting the duct / piping / equipments etc. as lump-sum basis is in the scope of Vendor and no unit rates shall be applicable for these items.

13) Drain piping within room up to the drain point to be provided by the Vendor.

14) Vendor to furnish schedule of power and control cables. Vendor to furnish cable termination details interconnection drawings etc. during detail engineering stage.

15) The tools and machine required for erection of equipment shall be arranged by Vendor.

16) Tools & tackles as required for regular maintenance shall be supplied by Vendor.

17) Instruments required for performance testing of various equipment / system of the package shall be arranged by Vendor at site.

18) Instrument for testing shall be calibrated by Air-conditioning plant supplier before taking up testing.

19) Pressure gauges shall have provision for air venting. Three way valves shall be used which shall have air venting provision.

20) Matching sockets / stubs (weld type) for flow switches and other instruments shall be supplied (as per attached instrumentation installation diagram)

21) Bidders shall guarantee to maintain specified inside design conditions during summer, monsoon and winter and also even if the internal equipment load varies from 100% to 25%.

22) Besides the system performance as above, bidder shall guarantee major technical parameters of various equipments as per design basis / details furnished.

23) The guarantee tests shall cover but not limited to the following rated parameters for smooth operation of air conditioning and ventilation system.

- Design dry bulb temperature and relative humidity of conditioned air, Auxiliary power consumption, Vibration and noise level etc.
- Performance test of the Air conditioning system shall be carried out at site after proper installation. The site test shall include performance testing of equipment for minimum 72 continuous hours in summer or monsoon and minimum 24 continuous hours in winter. Bidder, as may be required to carry out site tests shall arrange all instruments, tools etc.
- All calibrated instruments to be used for the tests at manufacturer's works/site shall be arranged by the bidder. Any Electrical/C&I items and accessories like junction box, glands etc. shall be included by vendor in his scope.

24) For group of motorized fire damper / 3 Way valve actuators / motorised valves, single phase power supply shall be provided by BHEL in AHU room and near MODULAR TYPE UAF. Suitable transformer shall be provided by bidder (if required) to derive the power input. Further distribution through junction box / distribution board shall be in vendor scope and shall have provision for isolation of individual fire damper/ valves.

25) Tender drawings enclosed form the part of specification and the bidder shall check the space requirements for installing the equipment as per the specification and layout requirements given in the specifications.

26) Bidder should suitably group the signals coming from various instruments etc. & the same shall terminate in local JB, from Local JB common cable to DCS / panel / MCC shall be selected. Any Electrical / C&I items and accessories like junction box, glands etc. shall be included by vendor in his scope.

27) In the event of any conflict between the requirements of two clauses of this specification documents or requirements of different codes and standards specified, the more stringent requirement as per the interpretation of the owner shall apply.

28) Bidder to note that BHEL reserve the right for drg/doc submission through web based Document Management System. Bidder would be provided access to the DMS for drg/doc approval and adequate training for the same. Bidder to ensure proper internet connectivity at their end.

29) Quality requirements in the Technical specification are minimum requirements for inspection and testing. Vendor to note that quality plans are subject to Customer approval during detail engineering stage. Standard QP format is enclosed in the technical specification.

30) The drawings/ documents submitted by vendor shall be complete in all respects with revised drawing submitted incorporating all comments. Any incomplete drawing submitted shall be treated as non- submission with delays attributable to vendor’s account. For any clarification/discussion required to complete the drawings, the bidder shall himself depute

his personal to BHEL / Customer's place any number of time as per the requirement for across the table discussions/ finalizations/ submissions of drawings.

31) Sealing of duct opening, grouting of foundation / foundation bolts etc. including special type of grouting like GPX2 etc. are in the scope of Air-conditioning system vendor.

32) Flat, platform type RCC / PCC foundation shall be provided for installing Chiller/ PUMP, AHU and FAN etc. Vendor shall fix the equipment using anchor fasteners to secure the equipment obtain parameters related to vibration and noise.

33) Bidder to note that the P&ID shows only the bare minimum requirement of valves and instruments. Any instrumentation & valves as required for the completion of the system in line with technical specification shall be provided by bidder during detailed engineering without any commercial implication.

34) Supplier to furnish drawings/ documents as per the dwg. / documents distribution as per project requirement.

35) Each motor terminal box shall be provided with cable gland and lugs for the size and type of power and control cable of respective motor.

36) All electrical equipment shall be suitable for the power supply fault levels and other climatic conditions indicated in project information / synopsis / specifications enclosed.

37) The bidder's proposal shall be for equipment in accordance with the tech. Specification.

38) The bidder shall furnish complete tech. Particulars in data sheet and schedules as specified elsewhere in the specification during detail engineering

39) Necessary duct mounted Booster fan (if required) to maintain the static pressure for Precision package AC/Package AC shall be provided without any implication.

40) Motorized fire damper will be installed at supply air duct in electrical areas like MCC / Switchgear room / cable spreader room etc. in FGD control building. Fire damper will close on receiving fire signal from fire protection system and shall also be possible manually from remote control panel. Also MODULAR TYPE UAF shall trip on receiving fire signal from fire protection system.

41) All openings required in brick wall for installing the axial supply and exhaust fans, propeller fans, duct opening, louvers and damper openings etc. shall be done by vendor. Grouting of fans along with anchor fasteners shall also be done by vendor. The openings shall be finished properly. In case openings are done once the wall have been painted, repainting, to match with the existing wall paint shall also be done by the vendor. Sealing of duct opening, grouting of foundation / foundation bolts etc. including special type of grouting like GPX2 etc. are in the scope of Ventilation system vendor.

42) Flat, platform type RCC / PCC foundation shall be provided for installing MODULAR TYPE UAF and MODULAR TYPE UAF fan / pumps etc. Vendor shall fix the equipment using proper anchor fasteners to secure the equipment and obtain parameter related to vibration and noise.

43) All codes and standards shall be as per contract specifications

44) Wherever air washer is mentioned (in the complete technical specification) same shall be read as MODULAR TYPE UAF and wherever chiller/chilling unit is mentioned (in the complete technical specification) same shall be read as air cooled condensing unit.

45) Wherever Project name BARH FGD STAGE-II (2X660 MW) is mentioned (in the complete technical specification) same shall be read as BARH FGD STAGE-I (3X660 MW).

12. EXCLUSIONS

Items of works listed below are excluded from scope of the HVAC system supplier.

a) Construction of AC plant room, air handling unit room, foundations for HVAC equipment's.

b) False ceiling, drop ceiling.

c) Slab cut out for running ducts, pipes, cables, grilles/dampers. Underground masonry trenches and masonry risers. However minor civil work like making opening to suit / finishing of opening, sealing of duct opening, grouting of foundation bolts including special type of grouting like GPX2 etc. are in the scope of HVAC system vendor.

d) Provision of drain traps / points.

e) For Electrical scope, refer Electrical scope matrix sheet.

13. CODES AND STANDARDS

Design, manufacture, inspection and testing of the equipment covered by the specification shall unless otherwise specified conform to the latest edition of the standards and codes including all addenda mentioned below:

IS-659	: Safety code for air-conditioning
IS-660	: Safety code for mechanical refrigeration
ASHRAE-23	: Standard method of testing and rating [67 Standards] air conditioner.
ARI-450-6	: Standards for water cooled refrigerant Condenser.
ASME Sec. VII	: Unfired pressure vessels
IS-4503	: Shell and tube type heat exchanger.
ASHRAE 22-72	: Method of testing for rating water cooled refrigerant condenser.
ASHRAE-15-2007	: Safe Standard for Refrigeration System
ASHRAE-30-1995	: Method of testing liquid chilling packages

ANSI-8-31.5	: Refrigeration piping.
ANSI-8-9.1	: Safety code for mechanical refrigeration.
AR1-410	: Standard for air cooling and air heating coils.
AR1-210	: Standard for unitary air conditioning equipment.
IS-3588	: Specification for electrical axial flow fans.
AMCA-210	: Methods of performance test for fans.
BS-2831	: Methods of test for air filters used in AC and general ventilation.
IS-4671	: Expanded polystyrene for thermal insulation purpose.
IS-702	: Industrial bitumen
IS-1239	: Heavy class Pipes for sizes up to 150 mm dia.
IS-8188	: For Water conditioning
IS-325	: 3 phase induction motors
IS-4029	: Guide line for testing 3 phase induction motor
IS-210	: Specification grey iron casting
IS-2062	: Structural steel
AMCA – Bulletin No. 210	: Standard code of testing centrifugal and axial flow fans
IS-2825	: Code of practice for welding mild steel
IS-2676	: Dimensions for wrought aluminium and aluminium alloy sheets and strips.
ASHRAE Code	: For various filter
ASHRAE-62-2004	: Ventilation rates
IS-655	: Specification for metal air ducts
IS-1520	: Pump design and testing

SECTION: I

SUB-SECTION: C 2

CUSTOMER SPECIFICATIONS

SECTION: I

SUB-SECTION: C 2A

CUSTOMER SPECIFICATIONS
TECHNICAL REQUIREMENT

SUB-SECTION-III-A2

AIR CONDITIONING, VENTILATION SYSTEM & COMPRESSED AIR SYSTEM

1.00.00 **AIR CONDITIONING SYSTEM**

a) **General**

The scope includes Engineering, Supply, Construction, Erection, Testing and Commissioning for Complete Air conditioning system consisting of D-X units with refrigerant piping & valves, Air handling units, Hi-wall split air conditioner /Cassette Air conditioners, Packaged Air Conditioners, Fresh air fans, air distribution system (ducting, filters, isolation dampers, motorized fire dampers, diffusers, grills, volume control dampers, etc.) etc., along with all electrical equipment and instrumentation as required for all the buildings which are in the scope of the bidder, as detailed out in Part-B of Section-VI.

b) **Air-conditioning system for F.G.D Control Room Building and ZLD control room building (if provided)**

Air cooled condensing units (D-X type) type air conditioners with AHU of suitable capacity with 100 % redundancy (as per actual heat load calculation) shall be provided .

c) SO2 analyzer room (if required) and other air conditioned offices/areas covered under this package shall be provided with Ductable/Non ductable Split air conditioners etc. as per Design criteria specified in Chapter Salient Design Data. Non ductable Split air conditioner shall conform to minimum three (3) star (***) rating and above of latest version of Bureau of Energy Efficiency (BEE) HVAC code issued by Ministry of Power, Govt of India.

d) Supply of Mandatory spares as specified.

e) Any additional items required to make the system complete.

f) For Air conditioning system, the Bidder shall provide all Instrumentation systems, accessories and associated equipment, which are included in Bidder's scope, in a fully operational condition acceptable to the Employer. The Bidder shall also provide all material, equipment and services which may not be specifically stated in the specifications but are required for completeness of the equipment/systems furnished by the Contractor and for meeting the intent and requirements of these specifications.

g) Contractor shall provide microprocessor/PLC/GIU based control system for control and monitoring of air conditioning system as per manufacturer's standard practice. However relative humidity and temperature measurement of all control rooms and all major air-conditioned areas shall be made available in FGD/ ZLD control system. Control and monitoring of air conditioning system from FGD/ZLD control system is also acceptable.

h) Apart from the above, any area/building which are in the scope of the bidder and require air conditioning, the same shall be provided with air conditioning system, as detailed out in Part-B of Technical Specification.

1.02.00 **Redundancies of equipments:**

100% standby unit shall be kept for FGD/ZLD control room, SO2 analyzer room (if required) and other air conditioned offices/areas.

2.00.00 VENTILATION SYSTEM

a) **General**

The scope includes Engineering, Supply, Construction, Erection, Testing and Commissioning for Complete Ventilation system consisting of Modular type Unitary air filteration Units, Supply air fans, water pumps, exhaust air fans, louvers, filters, ducting, diffusers, piping, instrumentation etc., for all the buildings which are in the scope of the bidder, as detailed out in Part-B of Section-VI.

b) **Non-A/C areas of F.G.D Control Room Building and ZLD control room building (if provided)**

Minimum One (1) nos. of Evaporative type Unitary Air Filtration (UAF) unit (of metallic construction- modular type) of suitable capacity with all accessories, DIDW centrifugal fan (1 x 100%), circulating water pump (1 x 100%), etc. as detailed out in technical specification shall be provided.

c) **Miscellaneous areas:** All other areas like Limestone Grinding system building, Gypsum dewatering building, Recirculation pump & Oxidation blower/compressor building etc & all other non-air conditioned areas covered under this package shall be ventilated by a combination of supply/exhaust fans and fresh air in-take / back draft louvers. For ventilation of Battery rooms and Oil rooms, fans with flame proof motor shall be used. Further, toilets shall be provided with propeller type exhaust air fans.

d) Supply of Mandatory spares as specified.

e) Any additional items required to make the system complete.

f) For Ventilation system, the Bidder shall provide all Instrumentation systems, accessories and associated equipment, which are included in Bidder's scope, in a fully operational condition acceptable to the Employer. The Contractor shall also provide all material, equipment and services which may not be specifically stated in the specifications but are required for completeness of the equipment/systems furnished by the Contractor and for meeting the intent and requirements of these specifications.

g) Contractor shall provide microprocessor/PLC/GIU based control system for control and monitoring of ventilation system as per manufacturer's standard practice. Control and monitoring of ventilation system from FGD /ZLD control system is also acceptable.

3.00.00 COMPRESSED AIR SYSTEM

a) Two (2) numbers (1 working+ 1 standby) oil free, rotary screw type air compressors for Instrument air and service air applications for FGD and ZLD plant (if provided) each of adequate capacity & adequate pressure, with their motor drives and other accessories as per equipment sizing criteria mentioned in Part A, Sub-section 'Salient design data' of technical specification. However, minimum capacity of each air compressor shall be 15Nm^3/min at discharge pressure of 8.5 Kgf/cm^2 (g).

b) Two (2) numbers (1 working+ 1 standby) Air Drying Plants (one for each air compressor) of adequate capacity with all interconnecting piping, valves, fittings, etc.

c) Two number Air Receiver each of capacity 2 m^3 (normal) at the discharge of each Air compressor.

d) One number Air Receiver of capacity 2m^3(normal) for ZLD plant if ZLD plant is far away from compressor location.

g) Monorail with Chain pulley block of minimum 2 tons or 125% of heaviest parts of equipment to be lifted whichever is more.

h) Complete instruments, control system with panels as required for compressed air system.

i) Complete compressed air and piping network for service air and instrument air application in FGD and ZLD system (if provided).

j) Supply of Mandatory spares as specified.

k) Any additional items required to make the system complete.

4.00.00 General

i. All associated Civil & structural work for air conditioning and Ventilation system and compressed air system.

ii. Set of commissioning spares as may be required during erection and commissioning.

iii. One (1) set Special tools and tackles required for maintenance of all the Mechanical, Electrical and C & I equipment under the scope of bidder.

iv. All steel / cast iron inserts, plates, bolts, nuts, sleeves, metallic-fasteners etc. to be grouted in concrete work and used to hold/ support the equipment/piping / ducting being supplied and erected under this specifications.

v. Any additional items required to make the system complete.

vi. Initial charge of all lubricants and grease, etc. Further, all consumables required for PG tests shall also be in Bidder's scope of supply. Grouting, dressing and final finishing of all foundations of various equipment, etc.

vii. Repairing and making good/ sealing of cutouts / openings in floors, roofs and walls, for executing the works under this system and making them water tight as directed by the engineer.

Corrosion protection painting for all equipment / items by Bidder as detailed in relevant clauses of technical specification.

torque, drive & structural load requirements the density of lime stone shall be taken as 1700 kg/m3. For gypsum, the bulk density shall be taken as 900 kg/m^3 for volumetric computation and 1250 kg/m3 for torque, drive & structural load requirements.

7.00.00 AIR CONDITIONING SYSTEM

GENERAL REQUIREMENTS

1. All equipments shall be located indoor unless otherwise agreed to by the Employer. The equipment and layout shall generally be in accordance with the General Layout Plant drawings.
2. The layout of all equipment and accessories shall be developed in a way to facilitate easy accessibility and maintenance of all equipments.
3. Each equipment shall be provided with suitable lifting arrangement, e.g. Lifting lugs, eye bolts, etc to facilitate maintenance.

7.01.00 DESIGN PHILOSOPHY FOR AIR CONDITIONING

1. Design ambient conditions for all air conditioning system shall be as per **Appendix-A**
2. All equipments of Air Conditioning system shall be designed for continuous duty.
3. All air conditioned areas shall be maintained at 24 deg. C ± (plus or minus) 1 deg. C and relative humidity of 50% ± (plus or minus) 5%.
4. The fresh air quantity for air-conditioned areas of FGD Control Room etc. shall be 0.45 M^3/minutes/person or 1.5 air change per hour whichever is greater. Fresh air fan capacity shall be minimum 10% of the total CMH value of working indoor units.
5. Lighting load shall be minimum 2 Watts/Sq. feet.
6. The occupancy for general area shall be minimum one person per 10 Sq. M and for conference room the same shall be one per 3 Sq.M. In the equipment rooms etc, the occupancy may be one person per 25 Sq.M (Minimum).
7. In Air conditioning system for FGD Control Room, return air shall be routed back to AHU room through plenum space.
8. The supply and return air ducts shall be provided with automatic (motorised) fire dampers (of 90 minutes fire rating) at locations where ducts pass through walls & floors. Operation of these dampers shall be interlocked with the fire alarm system and shall also be possible to operate manually from

the remote control panel. Required electrical contacts in control panel of A/C plant and further wiring upto fire alarm panels shall be done by Bidder.

9. Soft water make up (if required) for complete air conditioning system shall be provided by the bidder in-line with terminal point specified in technical specification.

10. Coil face area of Air Handling units shall be designed considering a face velocity of not more than 2.5 m/sec.

11. Air distribution system shall be sized to have a constant frictional drop along its length and velocity through ducts shall not exceed 7.6 m/sec.

12. Requirement of Underdeck Insulation (for A/C area)

Underdeck insulation of 50 mm nominal thickness of glass wool (32 Kg/cu.m) or rock wool (48 Kg/cu.m) shall be provided if

i) Non A/C area is located just above the A/C area. In this case, underdeck insulation shall be provided underneath of the ceiling of A/C area.

ii) Non A/C area is located just below the A/C area. In this case, underdeck insulation shall be provided underneath of the ceiling of Non A/C area.

iii) Underneath the ceiling of AHU room located below the A/C area or exposed to Atmosphere.

13. AHU's shall be provided with two stage of filteration i.e. pre and fine filter. All fresh air supply shall also be filtered using pre and fine filter.

14. A minimum design margin of ten (10) % shall be considered in design of A/C Plant Capacity for each area.

15. For areas, where A/C load is of the order of 25-60 TR, Direct Expansion (D-X) type Condensing unit (with AHU) shall be provided depending on the availability of space/ layout etc. For areas, where A/C load is of the order of 15-25TR, ductable split/packaged A/C shall be provided. Smaller areas which are away from the D-X type Condensing unit /central chilling units which may require air conditioning upto 15 TR rating shall be served with Hi-wall Split/Cassette air conditioner units as per requirement.

16. Insulation for supply and return air ducts: Supply and return ducts shall be insulated. All types of Insulation used for HVAC application shall be CFC/HCFC free.

7.02.00 REDUNDANCY OF EQUIPMENTS

7.02.01 Redundancy of various A/C system equipments shall be as follows:

a) FGD Control Room Building

i) Air Cooled condensing units Air conditioners: ~~2X100%~~ 4x50%

ii) AHU (with VVVFD): ~~2 X 100%~~ 4x50%

b) 100% standby shall be provided for area served by Cassette / Hi-wall Split /Ductable split AC/Package type air conditioners for all other control rooms covered in the scope of this package.

c) Fresh air fans shall be 1 x 100 % Capacity for each AHU room.

7.03.00 DESIGN PHILOSOPHY – Ventilation System

1. Air changes per hour in evaporative/ mechanically ventilated areas shall be as follows:

i)	For all evaporative cooled areas	-	8
ii)	General areas	-	20
iii)	MCC / Switchgear rooms and Battery rooms& other areas where gaseous fumes/ vapours are generated	-	30

2. However in areas producing lot of heat, temperature shall be the criteria as follows:-

a) Inside temperature shall be minimum 3 deg.C below the design ambient temperature during summer for evaporative cooled areas.

b) Inside Temperature shall be maximum 3 deg.C above the design ambient temperature during summer for mechanically ventilated areas.

Note : Dry bulb temperature during summer = 45 Deg C.

The criteria which gives higher number of air changes/higher quantity of air of either of condition (Cl. 1 or 2) flow shall be selected.

3. All ventilation systems shall operate on 100% fresh air. All mechanically ventilated areas shall be positively ventilated by means of supply air fans fitted with filters and exhaust fans for ventilation of heat generating areas combination of supply air fans with exhaust air fans shall be provided. MCC / switchgear and cable gallery areas shall be provided with gravity operated back draft dampers in association with supply air fans in order to maintain positive pressure. Battery rooms and other fumes/odour generating areas shall be negatively ventilated by means of exhaust air fans / roof exhausters and intake louvers. All other areas like pump house, Blower/compressor house (if any), etc shall be positively ventilated by a combination of supply air fan and exhaust air fan. Supply air fan catering for electrical areas (MCC & Switchgear rooms) shall be provided with pre-filters and fine filters and for other areas shall be provided with pre-filter only. For Positive ventilation CFM of exhaust air shall be 60% of CFM required for supply air. Similarly for

negatively ventilated area, CFM of supply shall be 60% of total CFM exhaust.

4. All the equipments of Ventilation system shall be designed for continuous duty.

5. The supply air ducts of evaporative type ventilation system entering into switchgear room, cable galleries etc. shall be provided with automatic (motorised) fire dampers (of 90 minutes fire rating). Operation of these dampers shall be interlocked with the fire alarm system and shall also be possible to operate manually from the remote control panel. Required electrical contacts in control panel of A/C plant and further wiring upto fire alarm panels shall be done by Bidder.

6. Circulating water Capacity for Air washer units shall be minimum 0.7 Cu.M/hr per 1000 Cu.M /hr of air flow. Velocity through piping shall be limited to 2.0 m/sec and for gravity flow the same shall be limited to 1.5 m/sec. Air distribution system shall be sized to have a constant frictional drop along its length and air velocity through ducts shall not exceed 12.5 m/sec.

7. For pumps, continuous motor rating (at 50^{O}C ambient) shall be atleast 10% above the maximum load demand of the pump in the entire operating range.

   For fans, compressors and blowers continuous motor rating (at 50^{O}C ambient) shall be atleast 10% above the maximum load demand at the design duty point.

8. Supply air fans, exhaust air fans & ventilations of each area shall be provided with local starter panels.

Barh Stg-I (3x660)	Summer	43.0	27.5
	Monsoon	38.0	29.5
	Winter	7.0	5.8

SUB-SECTION-I-M2

AIR CONDITIONING & VENTILATION SYSTEM

1.00.00 GENERAL

1.01.00 This section of specification covers details of system specifications, detailing the areas to be air conditioned, basis of design, brief description of the system, equipment and services to be furnished by bidder.

The Design, Engineering, Supply, Construction, Erection, and Testing & Commissioning of all the equipments & works listed here shall be on the basis of single point responsibility in bidder's scope of work for satisfactory completion of the system in all respect.

2.00.00 AREAS TO BE AIR CONDITIONED

2.01.00 The areas to be air-conditioned shall be as follows:

a) Air cooled condensing units (D-X type) type air conditioners with AHU of suitable capacity with 100 % redundancy (as per actual heat load calculation) shall be provided for each FGD Control room building and ZLD control room building (if provided).

b) Cassette and Hi-wall Air-conditioners for Other auxiliary control room /control room buildings not listed above but covered in the scope of Bidder.

3.00.00 AREAS TO BE VENTILATED

3.01.00 (i) Unitary Air Filtration (UAF) units of min. capacity 75,000 m3/hr or capacity calculated considering 8 air changes per hour whichever is higher, shall be provided for Non-Air Conditioned areas of FGD and ZLD (as provided) control building (e.g. Switch gear rooms, cable galleries, etc.)

(ii) Mechanical Ventilation (using Roof extractors/ Supply and/or Exhaust fans) shall be provided for various other areas/buildings in the scope of bidder as under:

a) Grinding system building
b) Gypsum dewatering building
c) Recirculation pump & Oxidation blower/compressor building.

(iii) Toilets etc in above building (i) & (ii). Any other area not listed above but covered in the scope of Bidder.

iv) For other miscellaneous areas/ buildings not listed above but covered in the scope of Bidder, mechanical type ventilation system using Supply and/or exhaust air fans/ roof exhausters shall be provided.

3.02.00 All non-air conditioned areas covered under this package shall be ventilated by a combination of supply/exhaust fans and fresh air in-take / back draft louvers as detailed below:

S.No	Area	Type of Ventilation system
(i)	General area like pump house, buildings etc	Combination of Supply air fan & Exhaust air fans
(ii)	MCCs and Switchgear room etc	Supply air fan & Back draft dampers
(iii)	Battery rooms & Oil rooms and fumes/odor generates	Combination of Supply air fan & Exhaust air fans. Motors shall be flame proof.
(iv)	Toilet/pantry etc	Propeller type exhaust air fan

4.00.00 EQUIPMENT DESCRIPTION – AIR CONDITIONING SYSTEM

4.01.00 **Condensing Unit (Air-Cooled D-X type)**

Condensing unit

Type : Air cooled scroll type

Vibration isolators : Steel spring / Neoprene rubber cushy foot type with isolation efficiency not less than 85%.

Compressor

Type : The Compressor shall be scroll, serviceable, either hermetic type or semi-hermetic type with automatic capacity control (minimum 3 steps).

Type of drive : Motor driven, direct or through V-belt.

Refrigerant : The refrigerant shall be R-134a/ R-410A/R-407C or any other environment friendly refrigerant.

Accessories : High/Low pressure cutouts, oil pressure switches, relief valves, pressure gauges at each stage, lube oil and control oil pressure gauges, suction & discharge stop valves, Muffler, Crank case heaters, oil filters, magnetic oil separators, temperature indicators for lube oil/heaters, oil level indicators, safety thermostat for crank case heater, vibration isolators, etc.

Motor Rating : 10% more than the power required by the compressor at 50 deg C design ambient temperature.

	Capacity	:	Minimum capacity shall be suitable for the identified/selected at evaporating temperature and condensing temperature and shall be indicated.

4.02.00 **Air Handling Unit (AHU)**

4.02.01 Each AHU shall consist of casing, fan impeller section, cooling coil section, damper section, steel frame with anti vibration mountings (AVMs) having minimum 85% vibration dampening efficiency and flame retardant, water proof neoprene impregnated flexible connection on fan discharge. Isolation dampers at the suction and discharge of each AHU shall be provided, in case return air duct is directly connected to AHU. However, in case AHU room is used for return air, isolation dampers are required to be provided only at AHU discharge of each AHU. Pre-filter at the suction and fine (micro-vee type) and absolute (HEPA type) filters (wherever applicable) at the discharge of each individual AHU, and heater section in the common discharge of AHUs shall be provided.

4.02.02 The casing of AHUs shall be of double skin construction. Double skin sandwich panels (inside and outside) shall be fabricated using minimum 0.63 mm (24g) galvanized steel sheet (thickness of galvanization as per manufacturer's standard) , with 25mm thick polyurethane foam insulation of minimum 38 Kg/Cum density in between. Suitable reinforcements shall be provided to give structural strength to prevent any deformation/buckling.

4.02.03 Sloping condensate drain pan shall be made of minimum 1.2 mm thick Stainless Sheet Steel. It shall be isolated from bottom floor panel through 25mm thick heavy duty treated for Fire (TF) quality expanded polystyrene or polyurethane foam. Drain pan shall extend beyond the coil.

4.02.04 Cooling coil (min. 4 row deep) shall be made of seamless copper tubes with aluminium fins firmly bonded to copper tubes and shall be provided with suitable drains and vents connections.

4.02.05 All filter plenum shall be provided with a walking platform inside the plenum chamber for filter cleaning purpose. Inspection door shall be provided at the plenum chamber and a removable type ladder shall be attached to plenum.

4.02.06 **Centrifugal fan for AHU**

a)	Fan Type	:	Double Width Double Inlet (DWDI) Centrifugal Type
b)	Fan impeller	:	Backward curved blades
c)	Casing material	:	GI /Mild steel with minimum thickness of 3 mm.
d)	Impeller material	:	Carbon steel
e)	Shaft	:	EN 8 Steel

	f)	Fan bearings	:	Self aligning type, permanently lubricated, heavy duty with a design life of 10,000 operating hours.
	g)	Critical speed	:	First critical speed of rotating assembly shall be at least 25% above the operating speed.
	h)	Drive	:	Motor driven with removable belt guard. Motor driven with removable belt guard. Motor rating (at 50 deg.C ambient) shall be atleast fifteen percent (15%) above the maximum load demand of drives at the design duty point.
	i)	Fans	:	For AHUs of capacity 50,000 CMH and above, Bidder may offer two (2) Nos. centrifugal fans of equal capacity for each AHU provided all such AHUs are accommodated within the space identified by the Employer.

4.02.07 **Mixing Box:**

Mixing box shall be complete with fresh and return air dampers. Mixing box shall be provided whenever the return air is ducted back to the AHU. Further, wherever return air is led back directly to AHU room, no mixing box is required.

4.02.08 **Pan Humidifier:**

Pan humidifier shall be made of 22 gauge SS 304 tank, duly insulated with 25 mm thick resin bonded fiber glass insulation (min. 24 Kg/m3 density) with 0.5 mm GSS cladding. The humidifier shall be complete with stainless steel immersion heaters, safety thermostat, float valve with stainless steel ball, sight glass, overflow and drain connections, steam outlet nozzle and float switch. Step controller shall be provided for switching on / off heater banks as per system requirement.

4.03.00 HI-WALL SPLIT/CASSETTE AIR-CONDITIONERS

4.03.01 Hi-wall Split/cassette air conditioners shall in general consist of the following:

i) Casing

ii) Hermetically sealed rotary/scroll Compressor

iii) Condenser and condenser cooling fan

iv) Evaporator along with fan

v) Cooling coil

vi) Filters

vii) Piping, valves, refrigerant strainer, etc.

viii) Controls, instruments, control panel/starter panels.

ix) Vibration isolator pads, etc as required.

x) Refrigerant as per manufacturer practice.

4.03.02 Indoor unit of Ceiling Mounted Cassette Type Unit (Multi Flow Type):

The housing of the unit shall be powder coated galvanized steel. All the indoor units regardless of their difference in capacity should have same decorative panel size for harmonious aesthetic point of view.

Unit shall have four way supply air grills on sides and return air grill in center.

Each unit shall have high lift drain pump and very low operating sound.

4.04.00 **SPLIT/PACKAGED AIR CONDITIONERS**

4.04.01 Split/packaged air conditioners shall in general consist of following:

I. Casing
II. Compressor
III. Condenser
IV. Evaporator and condenser cooling fan
V. Cooling Coil
VI. Filters
VII. Piping, Valves, refrigerant strainer etc.
VIII. Control, instruments, control panel/starter panels.
IX. Vibration isolator pads, ducting (if applicable) etc as required.

5.00.00 EQUIPMENT DESCRIPTION - VENTILATION SYSTEM

5.01.00 Unitary Air Filtration

5.01.01 Each modular unitary air filtration shall consist of Casing, Tanks, Fans, Distribution plates, Moisture eliminator and water repellant type nylon filter with frame and support, Header and standpipe with support, Spray and flooding type nozzle. Screen type suction strainer, Pumps, Necessary controls & Instrumentation, and all other required accessories.

5.01.02 The housing/ casing of air washer unit shall be double skin construction. Double skin panels shall be made of 22G galvanized sheet on outer side and 20G galvanized sheet inside with 25mm thick polyurethane foam insulation of minimum 38 kg/cub. Mtr. Density in between. Frame work for section shall be joined together with soft

	rubber gasket in between to make the joints air tight. The entire fan section shall be mounted on rolled formed GSS channel frame work.
5.01.03	The unitary air filtration tank shall be fabricated from MS plate of minimum 6 mm thick and inside and outside surface of the tank shall be spray galvanized **(minimum 60 microns DFT).** Minimum depth of the tank shall be 600 mm. Tank construction shall be such that the suction screen can be replaced while the unit is operating. Tank shall be provided with overflow, drain with valve, float valve makeup connection with a gate valve backup, quick fill connection with globe valve etc. The overflow pipe shall be connected to drain pipe after isolating valve on drain pipe.
5.01.04	The distribution plate shall be fabricated out of 18G galvanized steel sheets & galvanized steel angle supports with minimum 50% free area.
5.01.05	Unitary air filtration shall be one-bank construction. All header and stand pipes shall be galvanised. Cat walks of suitable width shall be provided for maintenance of nozzle, filter etc.
5.01.06	The spray nozzles shall be of brass or bronze with chrome plating and shall be self cleaning type. The nozzle shall be designed to produce fine atomised spray and shall be properly spaced to give a uniform coverage of the air washer section. The pressure drop through the nozzle should be in the range of 1.4 to 2.4 Kg/cm2.
5.01.07	The eliminator plates shall be of 24G thick GS sheets class 275 or from 100% virgin PVC of minimum finished thickness of 2 mm. The eliminator section made of GSS shall have minimum six bends. The PVC eliminators shall be UV stabilised using Titanium di-oxide and shall withstand the weathering test as per IS:4892 for 500 hrs. Type test report of the compound testing carried out in any reputed laboratory shall be submitted for approval. All supports, tie rods and space bar shall be of either galvanised steel or PVC construction and shall be complete with suitable drip tray and drain pipe.
5.01.08	Air tight inspection doors of suitable size shall be provided for suction chamber. Spray chamber and fan suction for easy accessibility and maintenance and a water marine light be provided for each unitary air filtration.
5.01.09	Suitable number of brass screen shall be provided in the air washer tank to arrest the dirt entering the circulating water pump suction. Suitable GI grid shall be used inside the screen for reinforcement.
5.01.10	The specification for centrifugal fans shall generally be as indicated below. However, the fan shall be of DIDW type for UAF unit.
5.01.11	Saturation efficiency of Unitary Air Filtration units shall be minimum 60%.
5.02.00	**Centrifugal Fan**
5.02.01	The casing shall be of welded construction fabricated with heavy gauge galvanised sheet steel or MS sheet with spray galvanization (**minimum** 60 micron DFT). The minimum thickness of casing shall be 3 mm. It shall be rigidly reinforced and supported by structural angles. The seams shall be permanently sealed air-tight. Split casings shall be provided on larger sizes of fans. Casing drain with valves shall be provided wherever required. The impeller shall have die-formed backward-curved blades tie welded to the rim and back plate to have a non overloading characteristic of the fan. Rim shall be spun to have a smooth contour. If required intermediate stiffening rings shall be

	provided. Shaft sleeves shall be furnished wherever required. The impeller, pulley and shaft sleeves shall be secured to the shaft by key and/or nuts.
5.02.02	The bearing shall be self aligning, heavy duly ball, roller or sleeve bearing. They shall be adequately supported. They shall be easily accessible and lubricated properly from outside.
5.02.03	Inlet guard shall be spun to have a smooth contour. Inlet screen, if provided, shall be of galvanised wire mesh of 25 mm square.
5.02.04	Base plate with necessary number of spring type vibration isolators or ribbed neoprene rubber pad or cushy foot mounting shall be provided. The vibration isolators should have a minimum of 70% efficiency.
5.02.05	The first critical speed of the rotating assembly shall be at least 25% above the opening speed.
5.02.06	The fans shall be provided with V-belts and sheaves. All belts shall be sized for 150% rated HP. All V-belt shall be equipped with removable belt guards that do not impede the air flow to the fan inlet. There shall be a minimum of two belts per drive. Motor rating (at 50 deg.C ambient) shall be atleast fifteen percent (15%) above the maximum load demand of drives at the design duty point.
5.03.0	**Roof Ventilators (If applicable)**
5.03.01	The roof extractors shall be "COWL" type.
5.03.02	Impeller shall be of axial flow type, cast Aluminium in one piece and dynamically balanced. Casing shall be heavy gauge sheet steel construction of 3 mm thick for impeller upto 750 mm diameter and 5 mm for fans with impeller of diameter 750 and above. In casing, access door with locking arrangement be provided.
5.03.03	The cowl shall be designed for weather protection of the fan also inside of the roof on which the extractor is installed. Galvanised bird screen of 15 mm Square be provided with the cowl. All accessories, steel supports as required will be provided.
5.03.04	The speed of the fan be limited as per limitation given above for axial fans.
5.03.05	All accessories rain protection exhaust hood, transformation piece, vibration isolators, steel supports vibration isolators, bird screen, etc. as required shall be provided.
5.03.06	The vibration level for fans shall be as per ISO: 14694.
5.04.00	**Centrifugal Pumps**

a)	Type	:	Horizontal Centrifugal, Axially or radial split type casing pump or end suction, top discharge horizontal centrifugal pump
b)	Impeller	:	Closed type
c)	Material of Construction		
	i) Casing	:	2% Ni Cast Iron : IS:210 Gr. FG-260

	ii) Impeller	:	Bronze IS:318 Gr-2
	iii) Wearing rings	:	Bronze
	iv) Shaft	:	SS 316
	v) Shaft sleeve	:	SS 316
	vi) Lantern ring	:	Brass / Bronze
	vii) Packing	:	Asbestos free
	viii) Base Plate	:	Carbon steel as per IS:2062
	ix) Speed	:	Maximum 1500 rpm
	x) Other requirements	:	To refer to **Annexure-I** titled "Horizontal Pumps" of this sub section.

5.05.0	**Axial Fans**
5.05.01	These fans shall have fixed / variable pitch cast aluminum blades of aerofoil design.
5.05.02	The fan casing shall be of heavy gauge sheet steel construction.
5.05.03	Necessary rain protection cowl, inlet and outlet cones, bird protection screen, adjustable damper, vibration isolators, back draft dampers etc. shall be provided.
5.05.04	The speed of the fan shall not exceed 960 rpm for fan with impeller diameter above 450 mm and 1400 rpm for fan with impeller diameter 450 mm or less. However for fans having static pressure of 30 mm WC or above the speed of the fan shall not exceed 1440 rpm for fan with impeller diameter of above 450 mm and 2800 rpm for fan with impeller diameter of 450 mm or less. The first critical speed of rotating assembly shall be atleast 25% above the operating speed.
5.05.05	All other accessories like supporting structure etc. as required shall be provided.
5.05.06	Fans of capacity 1000 m^3/hr & lower shall be of propeller exhaust type.
6.00.00	**BALANCE EQUIPMENT SPECIFICATION**
6.01.00	**Material of Construction for Piping & Fittings**

a)	Piping for Chilled and Condenser water lines	:	Heavy grade-IS:1239 or Equivalent upto150 NB and IS:3589 or Equivalent for pipes beyond 200 NB with thickness as indicated in **Annexure-II**
b)	Refrigerant piping :	:	Seamless steel tubes conforming heavy grade IS:1239 or copper tubes as per IS:2501 (copper material as per IS:191 hard copper grade).
c)	Drain piping	:	Same as (a) above & galvanized as per IS:4736.

	d) Fittings : 1) The steel fittings shall conform to ASTM A234 Gr. WPB and dimensional standard to ANSI B 16.9/ANSI B16.11 / equivalent for sizes 65 NB and above. 2) For sizes 50 NB and below, the material shall conform to ASTM A-105. 3) All steel flanges shall be of slip on type and shall conform to ANSI B 16.5 4) For pipe sizes above 350 NB, fabricated fittings from sheets of adequate thickness may be used. The bend radius in case of mitre bends shall be minimum 1.5 times the nominal pipe diameter and angle between two adjacent sections shall not be more than 22.5 deg and shall be as per BS:2633/BS:534. 5) Fittings, flanges and pipe joints of refrigerant piping shall conform to ANSI B31.5
6.02.00	**VALVES**
6.02.01	Valves shall have full sizes port and suitable for horizontal and as well as vertical installation.
6.02.02	Valves for regulating duty shall be of globe type suitable for controlling throughout its lift.
6.02.03	All safety /relief valves shall be so constructed that the failure of any part does not obstruct the free discharge.
6.02.04	Valves shall be furnished with back seating arrangement for repacking while working under full working pressure.
6.02.05	Manual gear operators be provided for valves of size 200 NB and above.
6.02.06	All valves shall be supplied with companion flanges, nut, bolts & washers, etc.
6.02.07	The refrigerant line valves shall have steel or brass body with TEFLON gland packing. The construction of disc shall be either globe or angle type. The valve seat shall have white metal lining or equivalent.
6.02.08	Gate valves shall be of Cast Iron body (confirming to IS:210 Gr FG 220/equivalent) for sizes 65 NB and above conforming to fIS :14846. Gun Metal construction for sizes less than 65NB shall be as per IS:778. Butterfly valves shall conform to latest revision of BS:5155 or equivalent standard of required class/rating.
6.03.00	**AIR FILTERS**
6.03.01	**Pre Filter** 1) Type : Flange / Cassette 2) Pre-filter shall contain washable non-woven synthetic fiber or High density Polyethylene (HDPE) media having 18G GSS / 16G Al alloy frame. The filter media shall be supported with HDPE mesh on air inlet side & Aluminium

expanded metal on exit side or G.I. wire mesh on both sides.

3) **Other requirements : (as applicable)**

a) Suitable aluminium spacers be provided for uniform air flow;

b) Casing shall be provided with neoprene sponge rubber sealing.

c) Capable of being cleaned by water flushing.

d) Density of filter medium shall increase in the direction of air flow in case of metallic filter.

e) Filter media shall be fire retardant and resistant to moisture, fungi, bacteria & frost.

4) **Efficiency :**

Average arrestance of 65 - 80 % when tested in accordance with BS:6540/ASHRAE – 52 – 76 / EN-779.

5) Minimum thickness : 50 mm

6) Face Velocity : Not more than 2.5 m/sec.

7) Pressure drop : Initial pressure drop - Not to exceed 5.0 mm WC at rated flow.

Final pressure drop - Upto 7.5 mm WC.

8) Location : a) At the suction of each AHUs

: b) At the suction of each Fresh air fan

6.03.02 **Fine Filters (Microvee type)**

1) Type : Flange / Cassette

2) Fine filter shall contain washable non-woven synthetic fibre or High density Polyethylene (HDPE) media having 18G GSS / 16G Al alloy frame. The filter media shall be supported with HDPE mesh on air inlet side & Aluminium expanded metal on exit side or G.I. wire mesh on both sides.

3) Other requirements :

a) A neoprene sponge rubber sealing shall be provided on either face of the filter frame.

b) Capable of being cleaned by air or water flushing.

c) Filter media shall be fire retardant and resistant to moisture, fungi, bacteria & frost.

	4) Efficiency	:	Average arrestance > 90% when tested in accordance with BS:6540/ASHRAE–52-76 / EN-779.
	5) Minimum thickness	:	150 mm or 300 mm.
	6) Face Velocity	:	Not more than 1.2 m/sec for 150 mm and not more than 2.4 m/sec. for 300 mm.
	7) Pressure drop	:	Initial pressure drop - Not to exceed 10 mm WC at rated flow ; Final pressure drop-Up to 25 mm WC.
	8) Location	:	i) At the discharge of each individual AHU. ii) At the discharge of each Fresh air fan.

6.04.00 **LOW PRESSURE AIR DISTRIBUTION SYSTEM**

6.04.01 Material of air distribution system shall be through galvanized steel sheet (Conforming to Class 275 of IS :277) or Aluminium alloy (grade 19000 / SIC or 3100 / NS3 of IS:737). GI Sheets should be galvanized and galvanizing shall be of 275 gms/sq.m. (total coating on both sides) both for site fabricated and factory fabricated ducts.

6.04.02 **Thickness of rectangular ducts shall be as follows:**

Larger Dimension of duct (mm)	Thickness of GI sheet(mm)	Thickness of Aluminium sheet (mm)
up to 750 mm	0.63 (24 G)	0.80
751 to 1500	0.80 (22 G)	1.00
1501 to 2250	1.00 (20 G)	1.50
2251 & above	1.25 (18 G)	1.80

6.04.03 **Thickness of round ducts shall be as follows:**

Diameter of Round duct (mm)	Thickness of GI sheet(mm)	Thickness of Aluminium sheet (mm)
150 to 500	0.63	0.80
501 to 750	0.80	1.00
751 to 1000	0.80	1.00
1001 to 1250	1.00	1.50
1251 & above	1.25	1.80

6.04.04 **Duct Fabrication and Supports:**

a) Duct fabrication shall be as per the latest relevant BIS/SMACNA standard.

b) Ducts for A/C system may be **site fabricated or factory fabricated**.

c) The ducts routed inside the buildings with larger side greater than 2250 mm shall be supported by 16mm MS rods and 50x50x3 mm MS double Angles while those below 2250 mm shall be supported by 10mm MS Rods and 40x40x3 MS angles. The duct supports shall be at a distance of not more than 2000 mm for A/C system. The MS rods for these ducts routed inside the building shall be hung from the existing floor beams/wall beams/roof beams/columns with provision of necessary auxiliary or special steel members or by hooks or can be provided by dash fasteners fixed to the ceiling slab. No supports shall be taken from horizontal/vertical bracings of the structures. All items of duct support including MS rods, MS angles and double angles, auxiliary or special steel members, hooks, dash fasteners coach screws and all other supporting material required shall be provided by the bidder. Where ever ducts are running outside the building and or at locations where it is not possible to support the ducts from ceiling/floor due to non-availability of the same, the base steel frame/truss work and other auxiliary steel members, hooks, rods, etc. for supporting the duct work shall also be provided by the Bidder.

d) Where the sheet metal duct connects to the intake or discharge of fan units a flexible connection of fire retarding, at least 150 mm width shall be provided of closely woven, rubber impregnated double layer asbestos/canvas or neoprene coated fibre glass.

e) All curves, bends, off-sets and other transformations shall be made for easy and noiseless flow of air. The throat of every branch duct shall be sized to have the same velocity as in the main duct to which the branch duct is connected.

f) Wherever duct passes through a wall, the opening between masonry and duct work shall be neatly caulked or sealed to prevent movement of air from one space to the adjoining space.

g) Wherever pipe hangers or rods pass through the ducts, light and streamline easement around the same shall be provided to maintain smooth flow of air.

h) Access doors shall be provided in the duct work or casing on the both sides of the equipment to be serviced. All access doors shall be of adequate size and shall be lined with substantial felt edging to prevent air leakage. Access doors shall be of built up construction, structurally strong and each shall have at least two hinges. Access doors shall have two rust proof window sash of approved type. All doors shall be set so as to flush with insulation or plaster finish on the duct.

6.04.05 Splitters and dampers shall be provided for equipment/area isolation and for proportional volume control of system. The same shall be minimum 16 gauge GS

sheet of quadrant type with suitable locking device, mounted outside of duct in accessible position.

6.04.06 **Factory fabricated ducts :**

i) All ducting shall be fabricated of LFQ (Lock Forming Quality) grade prime G.I.

ii) Unless otherwise specified here, the construction, erection, testing and performance of the ducting system shall conform to the SMACNA-1995 standards ("HVAC Duct Construction Standards-Metal and Flexible-Second Edition-1995" SMACNA)

iii) All ductwork including straight sections, tapers, elbows, branches, show pieces, collars, terminal boxes and other transformation pieces must be factory fabricated by utilizing the machines and processes as specified in SMACNA or by equivalent technology. In equivalent method, the fabrication shall be done by utilizing the following machines and process to provide the requisite quality of ducts and speed of supply:

a) Coil lines to ensure location of longitudinal seams at corners/folded edges only to obtain the required duct rigidity and low leakage characteristics. No longitudinal seams permitted along any face side of the duct.

b) All ducts, transformation pieces and fittings to be made on CNC profile cutters for required accuracy of dimensions, location and dimensions of notches at the folding lines.

c) All edges to be machine treated using lock formers, flangers and roll-bending for turning up edges.

d) Sealant dispensing equipment should be used for applying built-in sealant in Pittsburgh lock where sealing of longitudinal joints are specified. Sealing of longitudinal joint is compulsory for the ducts over 2" w.g. static pressure

iv) All transverse connectors shall be 4-bolt slip-on flange system with built-in sealant, if any. To avoid any leakage additional sealant shall be used.

v) Factory fabricated ducts shall have the thickness of the sheet as follows:

Sl.No.	Size of Duct	Sheet Thickness
i)	upto 750 mm	0.63 mm
ii)	751 mm to 1500 mm	0.80 mm
iii)	1501 mm to 2250 mm	1.00 mm
iv)	2251 mm and above	1.25 mm

6.05.00 Diffusers, Grills & Dampers :

6.05.01 Supply air diffusers/grills with factory fitted volume control dampers be provided for all air-conditioned areas.

6.05.02 Return air diffusers of air-conditioned areas shall be without volume control dampers.

6.05.03 The diffusers/grills shall be of extruded Aluminum of minimum 1.2 mm thick with powder coating. The colour of power coating shall be as per the interior décor.

6.05.04	Supply air grills shall be of double deflection type and return air grills shall be of single deflection type.
6.05.05	All volume control (VC) damper shall be operated by a key from the front of the grills/diffusers and shall be of GI sheet.
6.05.06	The thickness of VC dampers shall be of minimum 20 gauge and thickness of louvers shall be of minimum 22 gauge.
6.05.07	Suitable vanes shall be provided in the duct collar to have uniform and proper air distribution. Bank of Baffles wherever required shall also be provided.
6.05.08	Fire dampers shall be motor operated type and shall have fire rating of minimum 90 minutes.
6.05.09	All plenum chambers of connections to fans, dampers etc shall be constructed in 18 gauge GS sheet and supported on MS angle frames.
6.05.10	All ducting surfaces coming in contact with corrosive fumes or gases shall be painted with three coats of epoxy paint over a coat of suitable primer.
6.06.0	**Thermal and Acoustic Insulation**
6.06.01	**A) <u>Application with Glass Wool / Rockwool</u>**
	(i) All surfaces to be insulated both thermally and acoustically shall be thoroughly cleaned, dried and an adhesive (CPRX compound of Shalimar Tar Products / Loid bond 83 or Equivalent) be applied @ 1.5 Kg /Sqm on the surface.
	(ii) Insulation material (either expanded polystyrene foam or Glass Wool/ Glass fiber / Rockwool) shall be struck to the surface. All the joints shall be sealed with bitumen.
	(iii) Insulation mass to be covered with 500 gauge polythene sheet with 50 mm overlaps and sealing all joints on hot side or alternatively aluminum foil can be used which can come as lamination over insulation.
	(iv) Insulation Finish of types specified under shall be provided thereafter..
	B) <u>Application with Nitrile Rubber</u>
	(i) All surfaces to be insulated shall be properly cleaned.
	(ii) A suitable adhesive such as SR 998 or equivalent shall be applied over the surfaces to be insulated and insulation material surfaces.
	(iii) Insulating material shall than be pasted onto the surfaces in a manner to avoid stretching and any air entrapment within.
	(iv) Two layers of Glass Cloth with a suitable adhesive as SR 998 or equivalent shall be then applied over the insulating material to avoid surface weathering.
	C) <u>Application with Polyurethane Foam & Polyisocyanurate Foam</u>
	i) All surfaces to be insulated shall be cleaned.

ii) A suitable adhesive such as CPRX or Loid Bond 83 or equivalent shall be applied over the surface to be insulated and insulation material surfaces.

iii) Insulating material with aluminum foil lamination shall then be pasted onto the surface in a manner to avoid stretching and any air entrapment within.

iv) Two layers of Glass Cloth with a suitable adhesive as Loid Bond 130 shall be then applied over the insulating material, to avoid surface weathering.

v) Insulation Finish of types specified under shall be provided thereafter.

6.06.02 Type of Insulation & Finish

Sl. No.	Surface	Insulation Material	Insulation Form	Thick (mm)	Finish (mm)
1.	Supply & return air duct of AC System	Resin bonded glass wool or	Roll /Slab	50	F-3
		Closed Cell Elastomeric Nitrile Rubber	sheet	19	As per manufacturer std.
		or Polyisocyanurate Foam	Slab	30	F-3
2.	Refrigerant (Suction and liquid lines)	Closed Cell Elastomeric Nitrile Rubber	tube	19	As per manufacturer std.
		or Rigid Polyurethane Foam	Pipe Section	50	F-1 (a)
3.	AHU drain pipe	Closed Cell Elastomeric Nitrile Rubber	tube	19	As per manufacturer std.
		or Rigid Polyurethane Foam	Pipe Section	50	F-1 (a)
4.	AHU condensate pan (insulation if required)	Mineral wool or resin bonded glass wool	Slab	25	As per manufacturer std.