



STANDARD DESIGN CRITERIA/ GUIDELINES FOR BALANCE OF PLANT OF 2 x (500MW OR ABOVE) THERMAL POWER PROJECT



CENTRAL ELECTRICITY AUTHORITY
New Delhi – 110066

September 2010



GURDIAL SINGH
Chairperson
Central Electricity Authority

FOREWORD

The power sector is growing with unprecedented capacity addition. To achieve the sustained growth in power sector, the time required in pre-award activities needs to be minimized and standardization is considered an important tool towards this end. CEA has already issued the standard technical specification for Main Plant Package in September, 2008 for sub critical thermal power projects of 500 MW or higher capacity. Standardization of Balance of Plant packages has been taken up as a next step in this series.

Widely varying practices have been in use in BOP systems in the past and uniformity in approach would help both utilities as well as manufacturers in planning, engineering and execution of these systems. As standardization of specification of BOP packages (i.e. Coal Handling Plant, Ash Handling plant, Water System etc.) is difficult due to site specific variations, standard design criteria/ guidelines have been developed for major systems covering system description, design criteria, broad technical requirements, performance requirements etc. along with typical scope.

Views of major utilities, BOP manufacturers, consultants and EPC contractors have been considered while finalizing this document and as such this document reflects broad consensus of technical experts in the field.

I do hope that utilities as well as BOP manufacturers would find the document useful and its adoption would help in achieving our objective of faster capacity addition.

New Delhi
September, 2010


(GURDIAL SINGH)



CONTENTS

Clause No.	Description	Page No.
Section- 1 : General		
	General	1- 1
Section- 2 : Coal Handling Plant		
2.1	Introduction	2- 1
2.2	Brief description of coal handling plant system	2- 2
2.3	Design criteria and broad features	2- 5
2.4	Performance requirements	2- 17
2.5	Codes and standards	2- 19
Annexure-2A	Typical scope of work for coal handling plant	2- 23
Section- 3 : Ash Handling Plant		
3.1	Introduction	3- 1
3.2	System description	3- 2
3.3	Design criteria and broad features	3- 6
3.4	Performance requirements	3- 20
3.5	Codes and standards	3- 24
Annexure-3A	Typical scope of work for ash handling plant	3- 25
Section- 4 : Fuel Oil Handling Plant		
4.1	Introduction	4- 1
4.2	System description	4- 1
4.3	Design criteria and broad features	4- 3
4.4	Performance requirements	4- 9
4.5	Codes and standards	4- 9
Annexure-4A	Typical scope of work for ash handling plant	4- 11
Section- 5 : Water Treatment Plant		
5.1	Introduction	5- 1
5.2	System description	5- 2
5.3	Design basis	5- 5
5.4	Layout requirements	5- 9
5.5	Broad technical features	5- 10
5.6	Performance guarantees	5- 17
5.7	Performance guarantee tests	5- 19
5.8	Codes and standards	5- 19
Annexure-5A	Typical scope of work for water treatment plant	5- 22
Annexure-5B	Proforma for raw water analysis	5- 30



Clause No.	Description	Page No.
Section- 6 : Circulating Water System		
6.1	Introduction	6- 1
6.2	System description	6- 2
6.3	Sea water cooling	6- 3
6.5	Design Criteria	6- 4
6.5	Design requirements and broad features	6- 6
6.6	Performance and guarantee tests	6- 15
6.7	Codes and standards	6- 16
Annexure-6A	Typical scope of work for circulating water system	6- 17
Section- 7 : Fire Protection, Detection and Alarm System		
7.1	Introduction	7- 1
7.2	System description	7- 1
7.3	Design criteria	7- 4
Section- 8 : Electrical and Control & Instrumentation System		
8.1	Electrical system-Design criteria	8- 1
8.2	Electrical system-General technical requirements	8- 2
8.3	Control & instrumentation system-Design criteria	8- 27
Section- 9 : Civil Works		
9.1	General	9- 1
9.2	Specific Requirements	9- 23
Drawings		
CEA-TETD-CHP-001	Typical coal flow diagrams for 2 x 500MW thermal power plant (with wagon tippler and unidirectional yard conveyer)	
CEA-TETD-CHP-002	Typical coal flow diagrams for 2 x 500MW thermal power plant (with wagon tippler, trash hopper unloading and reversible yard conveyer)	
CEA-TETD-AHP-001	Typical flow diagrams for ash handling plant- 2 x 500MW coal based thermal power plant (vacuum system)	
CEA-TETD-AHP-002	Typical flow diagrams for bottom ash handling, ash disposal & water system plant- 2 x 500MW coal based thermal power plant (submerged scrapper chain conveyer system)	
CEA-TETD-AHP-003	Typical flow diagrams for bottom ash handling, ash disposal & water system plant- 2 x 500MW coal based thermal power plant (jet pump system)	
CEA-TETD-AHP-004	Typical flow diagrams for ash handling plant- 2 x 500MW coal based thermal power plant (pressure system)	
CEA-TETD-FO-001	Typical flow diagram – Fuel Oil unloading, Storage and Handling (HFO) for 2x500 MW coal based Thermal power plant	



Standard Design Criteria/Guidelines for Balance of Plant of Thermal Power Project
2 x (500MW or above)

CEA-TETD-FO-002	Typical flow diagram – Fuel Oil unloading, Storage and Handling (LDO) for 2x500 MW coal based Thermal power plant)
CEA-TETD-AS-01 (sheet 1 of 2)	Typical plant water scheme for 2 x 500MW coal based thermal power plant Fly Ash-Dry + Emergency wet, Bottom ash –wet with ash water recovery
CEA-TETD-AS-01 (sheet 2 of 2)	Typical plant water scheme for 2 x 500MW coal based thermal power plant Fly Ash-Dry + Emergency HCSD, Bottom ash –wet with ash water recovery
CEA-TETD-AS-02	Typical flow diagram for raw water PT plant for 2 x 500MW coal based thermal power plant
CEA-TETD-AS-03	Typical flow diagram for DM plant for 2 x 500MW coal based thermal power plant
CEA-TETD-AS-04	Typical flow diagram for CW system for 2 x 500MW coal based thermal power plant
CEA-TETD-EL-01	Key Single line diagram (Typical) 2x500MW & above coal based TPS



**STANDARD DESIGN CRITERIA/GUIDELINES FOR BALANCE OF PLANT OF
THERMAL POWER PROJECT 2 x (500MW OR ABOVE)
SECTION-1 : GENERAL**

A coal based thermal power plant consists of large number of integrated plants/systems and equipment having mechanical, electrical, instrumentation & control and civil components. The plant systems and equipment can be broadly classified into following two categories:-

- i) Main Plant comprising of steam generator, steam turbine and generator along with their associated auxiliaries.
- ii) Balance of Plants (BOP) system which includes all plants and equipment other than those included in main plant system. The major components of BOP system include coal handling plant, ash handling plant, fuel oil handling & unloading system, water treatment system, circulating water system and fire protection, detection & alarm system.

Requirement of Main Plant system can be standardized and are not site specific except for coal quality and cooling water temperature which are fairly uniform for indigenous coal and Indian ambient conditions. The equipment involved are highly technology oriented and world wide, there are limited manufacturers of main plant equipment as huge investment, infrastructure and R&D establishment are involved. CEA have already prepared Standard Technical Specification for main plant package of sub-critical thermal power project 2x (500 MW or above).

As regards BOP systems, a number of site specific input parameters are involved which have to be kept in view while designing various systems. For example while designing coal handling system the site specific points to be considered include station capacity, quality and source of coal, coal transportation mode, topography and geometry of the area while for ash handling system, station capacity, ash content in fuel, mode of ash disposal, ash utilization potential, layout and pumping distances have a bearing on the design of ash handling system. In view of site specific variations, it is very difficult to draft a standard technical specification incorporating for all possible alternatives of plant systems and equipment. Accordingly, attempt has been made to evolve standard design criteria/ guidelines which will be a useful reference document and help the utilities in sizing and selection of equipment and drawing up a detailed specification specific to the plant.



The draft standard design criteria/guidelines for balance of plant of thermal power projects was developed in association with NTPC and a copy of the same was uploaded in February, 2010 on CEA web site. Various Central/State Power Utilities/ EPC Contractors/BOP Manufacturers/Consultants were requested to offer comments on the documents. Following entities sent their comments:

1. BHEL, New Delhi
2. AP Genco, Hyderabad
3. TCE, Bangalore.
4. DCPL, Kolkata
5. Desein Pvt. Ltd., New Delhi.
6. BGR Energy Systems Ltd., Chennai
7. DCIPS Pvt. Ltd., Kolkata
8. Tata Power Co. Ltd., Mumbai
9. Lanco Anpara Power Pvt. Ltd., Gurgaon
10. Driplex Water Engg. Ltd., New Delhi
11. Techpro , Chennai

The comments received from above stakeholders were studied and a view was taken on the comments after detailed discussions with NTPC & BHEL from 19th July, 2010 to 26th July, 2010. The list of participants in the discussions is attached at Annexure-1. The document was then finalized based on the resolutions arrived at during discussions with BHEL & NTPC.

This document is divided into nine sections as detailed below:

Section – 1	General
Section – 2	Coal handling plant
Section – 3	Ash handling plant
Section – 4	Fuel oil handling System
Section – 5	Water treatment plant
Section – 6	Circulating water system
Section – 7	Fire protection, detection & alarm system
Section – 8	Electrical and C&I System
Section – 9	Civil Works

Each section covers the technical description of the plant systems and their various alternatives, design criteria/ guidelines for selection of plant system & equipment, broad technical details, performance guarantees aspects and applicable codes & standards etc. A typical scope of work for a 2 x 500 MW plant including for mechanical, electrical, C&I and civil works is also given as an Annexure to each system. Wherever possible, drawing illustrating flow diagrams of the system have also been enclosed to enhance clarity of the text.



Annexure-1

**List of participants during the meetings from 19th July,2010 to 26th July, 2010
held at CEA, New Delhi**

CEA

1. Sh. Suresh Chander, Chief Engineer
2. Sh. Bibhas Kumar, Chief Engineer
3. Sh. T.K. Saha, Director
4. Sh. D. K. Gilhotra, Director
5. Dr. L. D. Papney, Director
6. Sh. Praveen Vasistht, Director
7. Sh. Kailash Kumar, Dy. Director
8. Sh. S. K. Kassi, Dy. Director
9. Sh. H.R. Arora, Dy. Director
10. Sh. A.K. Verma, Dy. Director
11. Sh. R.K. Kohli, Asstt. Director
12. Sh. B.R. Alwani, Asstt. Director

NTPC

1. Sh. Madhukar Anand, AGM
2. Sh. S.K. Jha, AGM
3. Sh. O.P. Oberoi, DGM
4. Ms. C. Saroj, DGM
5. Sh.S.S. Misra, DGM
6. Sh. H. Kundu, DGM
7. Sh.P.S. Chatterjee, Sr. Mgr
8. Sh. R. Sarangpani, CDE
9. Sh. Sikdar, Manager
10. Sh. S. Adi M. Rao, ACDE

BHEL

1. Sh. N.K. Aggarwala, Addl. GM
2. Sh. S. Sahadevan, Sr. DGM
3. Ms. Pankaj Jain, Sr. DGM
4. Sh. Rajneesh Goyal, DGM
5. Sh. S.K. Bhawmik, Sr. Mgr
6. Sh. Ravi Kumar, Sr. Mgr
7. Sh.Mallik Moazzam, Mgr
8. Sh. Sudhir Bhartiya, Mgr
9. Sh. Vishal Kr. Yadav, Mgr
10. Sh. Suresh Chand Sharma,Mgr



**STANDARD DESIGN CRITERIA/GUIDELINES FOR BALANCE OF PLANT OF
THERMAL POWER PROJECT 2 x (500MW OR ABOVE)
SECTION-2: COAL HANDLING PLANT**

2.1 INTRODUCTION

The coal handling plant (CHP) in a thermal power station covers unloading of coal, its crushing, storage and filling of boiler bunkers. The planning and design of the CHP is site specific and depends on the following factors:

- i) Station capacity
- ii) Coal source and quality
- iii) Coal transportation mode
- iv) Topography and geometry of the area for coal handling system

Station capacity

Station capacity determines the quantum of coal to be handled by coal handling plant and thus the capacity of coal unloading system, crushers, coal conveying system etc. Generally for unit size of 500 MW and above, one coal handling plant is provided to cater for two units. Coal conveying system may cater to maximum three units to limit the outage of units in the event of failure of coal handling plant. Provision of interconnection between separate CHP's may also be provided.

If a plant consists of non-identical units (in terms of size), then separate CHPs may be necessary to cater to different bunker floor levels due to non-uniformity of unit sizes. Alternatively, plants with non-identical units can have some facilities like unloading, crushing, storage in common and separate conveyors may be used to feed different bunker floors.

Coal source and quality

Sources of coal for a thermal power station may vary i.e. indigenous run of mine coal, indigenous washed coal or imported coal. Quality of the coal (GCV, HGI, moisture content etc.) determines the specification of coal handling equipment apart from the quantity of coal to be handled.

Presently need for providing facilities for blending of indigenous and imported coal is also being felt in view of the shortage of Indian coal. Some time coal blending may also be resorted for environmental reasons. Blending can be done in many ways. One method is to provide facility in coal handling system to lay indigenous and imported coal in layers on the belts while conveying coal to bunkers. These coal layers would get mixed while falling into bunkers. The other method is to stock indigenous and imported coal in



layers in stockyard. Yet another method in use is dedicating one mill for firing imported coal and then adjust the mill parameters to achieve the optimum heat load of the burners.

Coal transportation mode

The selection of particular mode of transportation of coal depends on the location of power plant with respect to coal mines/ coal sources and other site conditions. Various transportation means such as rail or other captive systems such as merry go round (MGR), belt conveyors are adopted. For coastal stations, coal is received at ports by ships/barges and transported through belt/pipe conveyor system or rail etc.

Most of the power stations receive coal through rail. Power stations located near to the indigenous coal source (i.e. mine mouth) receive coal through their own MGR and those located far away (load centre stations) from the coal mines receive coal rakes through Indian Railway network. Conveyor Belt may also be used as an alternative to MGR. This type of transportation system is preferred when the coal mine or port is close to the power plant.

The coal received at power station may be unloaded by means of track hopper or wagon tippler or by combination of both depending on the type of wagons (BOBR or Box-N wagons) in the coal rakes expected to be received at the station.

Topography and geometry of the area for coal handling system

Layout of coal handling system varies with topography, geometry of the area, coal storage requirements as well as wind direction. No. of transfer points may also vary with topography and geometry of the area.

2.2 BRIEF DESCRIPTION OF COAL HANDLING PLANT SYSTEM

2.2.1 Coal unloading system

As mentioned above, the coal received at power station may be unloaded by means of wagon tippler or track hopper or by combination of both depending on the type of coal rakes to be used for transportation of coal to the station. Generally coal rake consists of 59 wagons, each wagon carrying payload of 60 tons. The two unloading systems are briefly described below:

Track hopper unloading system

The coal received through bottom opening bottom release (BOBR) wagon rakes is unloaded in under ground R.C.C. track hopper. Paddle feeders are employed under track hopper to scoop the coal and feeding onto underground reclaim conveyors. Belt weigh scales are provided on these conveyors for measurement of coal flow rate.



Wagon tippler unloading system

The coal received from Box-N wagons is unloaded in underground RCC hoppers by means of rota side type wagon tipplers. Side arm chargers are employed for placement of wagons on the tippler table and removal of empty wagon from tippler table after tipping. Apron feeders are employed under each wagon tippler for extracting coal from wagon tippler hopper and feeding onto underground reclaim conveyors. Belt weigh scales are provided on these conveyors for measurement of coal flow rate. Provision is kept for shunting locomotives for placing the rakes in position for the side arm charger to handle and begin unloading operation.

2.2.2 Coal crushing

Coal unloaded in the wagon tippler hoppers/track hoppers is conveyed to crusher house by belt conveyors via pent house and transfer points depending on the CHP layout. Suspended magnets are provided on conveyors at pent house for removal of tramp Iron pieces. Metal detectors are also provided to detect non-ferrous materials present in the coal before crushers. In case the sized coal is received, then the coal is sent directly to stockyard and the crusher is by-passed.

Conveyors leading to crusher house have facility for manual stone picking, at a suitable location after penthouse. In line magnetic separators are also provided at discharge end of conveyors for removal of remaining metallic ferrous tramp from the coal before it reaches the crushers. Coal sampling unit is provided to sample the uncrushed coal.

The size of the coal received is normally (-) 300 mm which may, however, depend on coal tie up. The received coal is sized in crushers (ring granulators) from (-) 300 mm to (-) 20 mm. Screens (vibrating grizzly type or roller screens) provided upstream of the crushers screen out (-) 20 mm coal from the feed and (+) 20 mm coal is fed to the crushers. A set of rod gates and rack & pinion gates is provided before screens to permit maintenance of equipment downstream without affecting the operation of other stream.

The crushed coal is either fed to coal bunkers of the boilers or discharged on to conveyors for storage in coal stockyard through conveyors and transfer points.

2.2.3 Coal Stacking & Reclaiming at Stockyard

Crushed coal is sent to stockyard when coal bunkers are full. Stacking/ reclaiming of coal is done by bucket wheel type stacker-cum- reclaimer moving on rails. The stacker-cum-reclaimer can stack coal on either sides of the yard conveyor. During stacking mode coal is fed from conveyors on boom conveyor and while in reclaim mode, boom conveyor discharges coal on the yard conveyor for feeding coal to bunkers through conveyors and transfer points. The yard conveyor can be reversible type depending on layout requirement.

When direct unloading from rakes is not in operation, coal is reclaimed by the stacker – cum-reclaimer and fed to the coal bunkers. Emergency reclaim hopper (ERH) can be provided to reclaim coal by dozers when stacker –cum- reclaimer is not in operation. Emergency reclaim hopper can also be used for coal blending. Coal stockpile is provided



with required storage capacity depending on location of plant vis-à-vis coal source.

Metal detectors and in-line magnetic separators are also provided before feeding to bunkers for removal of metallic ferrous tramp from reclaimed crushed coal. Coal sampling unit is provided to sample crushed coal of (-) 20 mm size. Belt weigh scales are also provided, on conveyors for measurement of flow rate of as fired coal.

2.2.4 Dust Control System and Ventilation system

The dust control system is required for control of fugitive dust emissions from dust generation points such as transfer points, feeders, crushers etc. Dust control is achieved by dust suppression and extraction system. Dust suppression is achieved by two methods viz. Plain Water Dust Suppression System and Dry Fog Type Dust Suppression System.

Ventilation system is provided for all the working areas/ locations/ buildings/ underground structures of CHP. The required ventilation is achieved by mechanical ventilation system/ pressurised ventilation system depending on the area requirement. The pressurized ventilation system is capable of pressurizing slightly above atmospheric pressure to prevent ingress of dust from outside. The MCC/switchgear room areas of coal handling plant are provided with pressurised ventilation system while other areas have mechanical ventilation. The control rooms, office room and RIO (Remote Input/ Output) room are provided with air conditioning system.

2.2.5 Miscellaneous facilities

The Coal Handling Plant is also provided with sump pumps at suitable location in underground buildings to drain out water. Necessary monorails with manual or electric hoist are provided for handling various equipments of CHP. Flap Gates or movable head system are provided at transfer points for dropping coal from one conveyor to other conveyor and also changing the coal flow stream. Necessary service water, potable water and cooling water system is provided in CHP area as per requirement.

2.2.6 Typical scope of work for 2x500 MW thermal power project is attached at Annexure 2A

Typical flow diagrams (as listed below) of coal handling system for 2 x 500 MW are enclosed :

1. Drawing no. CEA-TETD-CHP-001 (Typical coal flow diagram for 2x500 MW thermal power plant (with wagon tippler unloading and unidirectional yard conveyor)
2. Drawing no. CEA-TETD-CHP-002 (Typical coal flow diagram for 2x500 MW thermal power plant (with track hopper & wagon tippler unloading and reversible yard conveyor)



2.3 DESIGN CRITERIA AND BROAD FEATURES

2.3.1 Capacity of CHP and Major Equipment

- i) Peak daily coal requirement shall be met by 14 hrs operating hours of coal handling plant so that balance 10 hrs per day are available for upkeep and maintenance. Ten (10%) percent margin shall be considered over the peak daily coal requirement (based on GCV of worst coal and normative heat rate) for arriving at the rated capacity of the coal handling plant. Margin is provided to take care of the variation in the GCV of the coal received, aging of the equipment and different operating conditions of the CHP equipment. Typically for a 2x500 MW plant, capacity is worked out as under:

Plant Capacity	1000	MW
Heat Rate	2450	kCal/kWh
PLF	100	%
GCV of Worst Coal	3150	kCal/kg
Specific coal requirement	0.78	kg/kWh
Daily Coal Requirement	18666.67	Tons
Hourly Coal Requirement	777.78	TPH
Peak daily coal requirement for BMCR flow	833.00	TPH
Working Hours	14	Hrs
Plant Capacity	1428.00	TPH
Add 10% margin	142.80	TPH
Rated Capacity	1570.80	TPH
Rated Capacity (rounded off)	1600.00	TPH

Typically, two streams of conveyors and equipment shall be provided for coal handling system with rated capacity of 1600 TPH for a 2 x 500 MW power plant. The two streams of conveyors shall be interlinked at transfer points for conveyor changeover for flexibility of operation in the event of breakdown of any conveyor. Rated capacity would vary with calorific value of the coal intended to be used.



Standard Design Criteria/Guidelines for Balance of Plant of Thermal Power Project
2 x (500MW or above)

Section- 2 (Coal Handling Plant)

ii) Capacities of different equipment for 2x500 MW plant shall be under.

SI No	Equipment	No. of equipment	Typical rated capacity of each equipment for 2x500 MW plant
1A	Track Hopper [@] Paddle Feeder	01 2x75% (W)+ 2x75% (S)	4500 MT 1200 TPH
OR	Wagon Tiplers	2 (W) +1 (S)	20 Tiplings/hr
1B*	Apron Feeders	2 (W) +1 (S)	1200 TPH
2	Crushers	2x55% (W)+ 2x55% (S)	880 TPH
3	Vibrating grizzly screens	2x55% (W)+ 2x55% (S)	880 TPH
4.	Vibro - feeders for emergency reclaim hoppers	4 nos.	450 TPH
5.	Stacker-reclaimer * (S-R)	1X100%	1600 TPH
6	Conveyors	2x100% (1W+1S)	1600 TPH
7	Yard Conveyor	1 per S-R	1600 TPH

[@] Applicable for track hoppers served by MGR. In case of coal supply by Indian Railways, track hopper capacity may be considered as 6000 MT.

*Normally a CHP should require only 1x100% S-R for 2x500 MW units. At some sites, depending on layout of stockpiles, 2x100% S-R may be required due to constraint in stock pile length.

2.3.2 DESIGN REQUIREMENTS

2.3.2.1 Mechanical Equipment / Systems

General

The sizing and selection of the vital equipment viz. crushers, screens, paddle feeders etc. covered under the system shall be based on the following characteristic of coal and operating conditions:

- i) All mechanical, civil and structural system design shall consider:
 - a) Simultaneous running of both conveyors at rated capacity.
 - b) Round the clock operation of coal handling plant



- ii) The coal delivered to the power station shall be of size 300 mm & below. However occasionally 1-2% coal of 400 mm lump size may also be encountered.
- iii) HGI of the coal shall be between 45 to 65. Normally moisture content in coal will vary between 12% to 15%. However for design purposes, moisture content of 20% shall be considered.
- iv) Due to open cast method of mining involved, the coal may contain shale and sand stone as high as 20%. Also occasionally metal pieces like broken shovel teeth, brake shoe, wires etc., may also come alongwith coal from open cast mine.
- v) The coal “as received” shall contain varying percentage of fines. Coal with such fines may tend to form adhesive lumps, particularly during monsoon when surface moisture is at its maximum value.
- vi) For the purpose of volumetric computation, the bulk density of the coal shall be taken as 800 kg/m³. Therefore, for calculation of belt conveyor capacity, their drives and drive motors kW requirement, and sizing (volume calculations) of chute, hoppers etc. the above bulk density shall be considered. For all other purposes viz. for stresses/ load on structures, torque calculations the bulk density of the coal shall be taken as 1200 kg/ m³.
- vii) The motors, gear boxes, couplings and pulleys for conveyors shall be standardized and no. of types shall be limited to minimum possible.
- viii) All hoppers and tunnels shall be provided with sump pumps (1 operating + 1 standby). The drive motor of all the sump pumps shall be mounted at least 1.0 metre above the floor / ground level. The sump pumps shall be suitable to handle coal slurry and impeller shall be of non-clog type.
- ix) The Coal Unloading System shall be capable of unloading the rake within the time as stipulated in the latest Commercial Policy (Freight) of Indian Railways. The currently applicable Policy of 2007 stipulates 7 hours unloading time for a coal rake for BOX, BOX-N, BOXNHA etc type wagons and 2 hours 30 min for BOBR type wagons.

Wagon Tiplers

- x) Wagon tiplers shall be suitable to handle any type of wagons being used by Indian Railways as on date for transportation of coal as per IS-10095 (Latest edition) and shall conform to all stipulations with regard to suitability for handling wagons having width, height and length over coupler faces as indicated by RDSO at the time of approval of wagon tipler drawings.
- xi) The wagon tipler shall be ‘rotaside’ type suitable to unload a coal wagon by lifting and rotating it sideways. The angle of tip shall be at least 150° giving 60° angle to the side of the wagon for emptying the coal contents into the hopper below. The



wagon tippler design shall conform to latest edition of G-33 and its amendments issued by RDSO.

- xii) The tippler shall be designed to allow passage of all standard broad gauge (1676 mm) Indian Railways diesel locomotives over tippler table at creep speed. The tippler shall be designed to accommodate 150 Tons locomotive as per G-33 requirement.
- xiii) An electronic static weighing system shall be provided to measure / record the quantum of coal, wagon wise on the wagon tippler table before & after tipping. It shall have a minimum accuracy of 1% of the gross weight of the wagon.

Side arm charger

- xiv) The side arm charger shall be suitable to handle 59 nos. of loaded wagons weighing 110 Tons. Thus, side arm charger shall be used for indexing forward the rake of 59 nos. loaded wagons, placing decoupled wagons on the tippler table and out hauling the empty wagons.

Wagon Tippler Hopper

- xv) The wagon tippler hopper shall be of RCC construction and adequately sized to accommodate the coal load for at least three (3) nos. 8 wheeled wagons (180 tons) of RDSO design used by Indian Railways.
- xvi) For effective volumetric capacity computation of the hopper, the angle of repose of coal shall be considered as 37°. The minimum valley angle of the hopper shall be considered as 60°.
- xvii) Steel gratings of mesh size 300 mm x 300 mm over wagon tippler hopper shall be provided. The hopper and gratings shall be designed for movement of front end loader/bulldozer over them. Bull-dozer weight shall be considered as about 35T.

Track Hopper

- xviii) Track Hopper shall be under ground RCC structure and gunited with 50mm thick guniting with effective coal holding capacity of 4500 Tonnes. The valley angle shall not be less than 60 deg. Track hopper complex shall be provided with covered structural shed. Track hopper shall be 200 m long with one maintenance bay of 15 m on each side of track hopper with hatches & monorail with hoist. Provision shall be made for compressed air connections for opening / closing the wagon doors during unloading. Track hopper shall have removable type steel grating cover with opening of 300 mm x 300 mm.

In case of coal supply by Indian Railway wagons, the track hopper capacity may be 6000 MT with hopper length of 300 meters in line with Railway guidelines. Track hopper capacity of 6000 MT with hopper length of 250 m is also acceptable but the invert level of track hopper shall increase in such a case.



- xix) For effective volumetric capacity computation of the hopper, the angle of repose of coal shall be considered as 37°.
- xx) There shall be Electric hoist / manual hoist for handling of the equipment during maintenance. The path way of monorail shall be close enough for easy handling of the equipment to be lifted. Extension of the monorail out side the building shall be minimum three (3.0) meter from the out side of the wall / column of the building.

Apron Feeder

- xxi) Apron feeders shall be of robust construction and designed for handling ROM coal as specified and without any choking particularly during rainy season when coal is wet. A dribble conveyor shall be provided below apron feeder for proper clean up.

Paddle Feeder

- xxii) Each paddle feeder shall have capacity to scoop out coal at the guaranteed capacity in both forward and reverse motions with no indication of wheel slipping.
- xxiii) The carriage shall automatically reverse its motion, when two paddle feeders operating on the same track come within a predetermined distance. Suitable anti-collision device (infrared and mechanically operated limit switch type) shall be provided.
- xxiv) Rope actuated stop switches shall be provided along the traveling structure for emergency use.

Metal Detector

- xxv) Metal detectors shall have high reliability with enough sensitivity to detect 25mm aluminum sphere below the burden of coal in case of synthetic belting. However, for steel cord belting the sensitivity shall be 40 mm. It shall also detect other metals, like brass, copper, stainless steel, manganese steel, bars, scraps etc. It should ignore magnetite/iron and shall distinguish between metal pieces and magnetite/iron.

Electronic Belt Weigher

- xxvi) The electronic belt weighers for measurement of coal flow rate and quantity shall be provided at following locations:
 - a. Unloading conveyors to determine coal receipts rates.
 - b. Boom conveyor of stacker-reclaimer to know the coal reclaim rates.
 - c. ERH belt conveyors to know the quantity of coal reclaimed/blended.
 - d. Conveyors feeding bunkers to know fuel feed rates to coal bunkers.
- xxvii) The electronic belt weigher System shall be complete with flow rate indicator,



totaliser, control panel etc. These shall be designed for continuous automatic weighing, metering and printing of coal flow rate.

- xxviii) Belt weigher shall be designed for a range of 20% to 120% of rated capacity with an accuracy of atleast (\pm) 0.25 percent throughout its range. Belt weigher provided on Stacker Reclaimer Boom Conveyor shall have accuracy (in the horizontal position of Boom) of (\pm) 1 percent for the range of 20% to 120% of boom conveyor rated capacity.

In-line Magnetic Separator and Suspended Magnet

- xxix) The magnet shall be able to separate M20 bolts & nuts, and 50 kg MS plates / MS bars of L/D ratio of less than 5. Strength of magnet at the specified mounting height shall not be less than 1000 gauss (at the centre point of belt). Mounting height shall be 450mm in the conveyors carrying uncrushed coal & 400 mm in the conveyors carrying crushed coal measured between top of conveyor belt or bottom of falling material trajectory and the surface of magnetic separator belt.
- xxx) The magnetic separator shall be located such that it picks-up tramp iron from coal trajectory after it has been discharged from head pulley.

Coal Sampling Unit

- xxxi) The coal sampling units suitable to give "Samples" conforming to ASTM-D-2234 shall be provided for taking samples from any of the two streams running at guaranteed capacity.
- xxxii) The normal input feed size shall be considered as (-) 300 mm for coal sampling unit before coal crusher. However occasionally (-) 400 mm lumps may also arrive. Coal lump size after crusher (as fired coal) shall be (-) 20mm. However occasionally (-) 50 mm lumps may also arrive in crushed coal.

Vibrating Grizzly Screen

- xxxiii) The screen shall be capable to segregate the (-) 20 mm size of coal alongwith coal dust, any muck & muddy coal (which is likely to be encountered during rainy season) etc. The segregated material shall be directly fed onto the corresponding belt conveyors/feeders through separate hoppers/chutes provided under each screening feeder. The width of vibrating screening feeder shall match to feed the material uniformly over the entire length of crusher rotor without any deflectors in the feeding chute.

Crushers

- xxxiv) Ring granulator type crusher shall be provided for sizing the input coal to (-) 20 mm size. Crusher shall be supplied complete with accessories and subsystems. The crusher shall be capable of delivering the normal rated output even when handling damp sticky coal having maximum moisture content. No clogging or building up of



material on the crushing element shall develop. The entire inside surface of crusher coming in contact with coal shall be provided with abrasion resistant steel liners of requisite thickness.

Stacker – cum- Reclaimer

- xxxv) Stacker-cum-reclaimer shall operate on rail track running for adequate length to cover the entire coal stockyard. The wheel load of stacker-reclaimer shall not exceed 27.0 tonnes. The ratio of boom length (as specified) to the rail track gauge shall not exceed 5. Top of rail level shall be maintained at 0.7 m above the ground level, i.e., coal pile base level unless specified otherwise. Suitable number of rail scrappers shall be provided.
- xxxvi) The minimum track gauge for Stacker-cum-Reclaimer shall be 7 m.
- xxxvii) Buckets shall be sized for 125% of rated capacity. Rate of bucket discharges shall not exceed 55 per minute.

Stockpiles

- xxxviii) The stockpiles of coal will have adequate storage for at least as per the table given below and the coal consumption for this purpose shall be based on normative heat rate and average GCV of design and worst coal.

Sl No	Plant location	Coal stock (in terms of no. of days of coal consumption)
1.	Pit head	15 days requirement
2.	Load center	30 days requirement
3.	Coastal	30 days requirement

Maximum coal stockpile height shall be 10 m. Angle of repose of stored crushed coal shall be 37 degree.

A coal pile run off pit shall be provided close to the stockpile area. Drains shall be provided around the stockpile. During monsoon, the rain water from the coal pile would be collected in drains and led to the coal pile run off pit. The size of the pit would depend on the intensity of rainfall in the area and size of the stockpile. Pit shall be of RCC construction with a baffle wall in the middle. Coal particles in water collected in the pit would settle down in the first compartment and relatively clear water would flow to the second compartment. The water would be pumped from the second compartment to guard pond for further utilisation. Coal particles shall be removed from the pit using backhoe and trucks. Suitable ramp for the movement of backhoe shall be provided. This coal will be dumped in coal stockpile.

Chutes and Hoppers

- xxxix) The minimum valley angle of chutes shall be 60 degrees from horizontal. Hoppers and Chutes shall be made of minimum 20 mm thick TISCERAL / SAILHARD /



LSLAS07 or equivalent material. Sliding zones & adjacent sides shall be 20 mm thick, while non striking/ non sliding zones shall be 10 mm thick MS. In case of vertical chute (valley angle more than 80 degree) complete chute work shall be 20mm thick TISCERAL / SAILHARD / LSLAS07 or equivalent.

- xl) Transfer chutes shall be adequately sized and sloped to ensure smooth flow of coal without any accumulation anywhere. Minimum cross sectional area of chute should be 5.0 times the area of cross load of the preceding conveyor.
- xli) Direct impact of material on conveyor belt shall be avoided by providing an inclined surface at 60 degrees valley angle at the feeding point to guide the material in the direction of belt travel. Further, chute construction below flap gate shaft shall be such that there will not be any accumulation of coal dust between chute and flap gate in that zone.

Drive Selection

- xlii) All equipment drives except crusher drive shall be capable of starting on full load.
- xliii) The motor rating for belt conveyors shall have a minimum margin of 20% over the required kW. For all other drives, a minimum margin of 10% over the required kW shall be taken. The service factor for selection of gearboxes, flexible couplings, brakes, etc., shall be minimum 1.5 on the motor rating.
- xliv) Single LT drive motors shall be used for conveyor drive ratings up to 160 kW. For conveyor drive rating beyond 160 kW, single HT drive shall be used for conveyors. However for boom conveyor drive and intermediate conveyor drive on stacker-reclaimer, single LT motor may be used above 160 kW also. For the bunker conveyor (tripper conveyors) drives only, single snub LT drive motor shall be used upto 200 kW rating.
- xlvi) The type of high speed coupling between motor and gear box shall be as follows:
 - a) For motor rating up to 30 kW - Resilient type flexible coupling
 - b) For LT motors of above 30 kW - Traction type fluid coupling/ Delayed fill type fluid coupling
 - c) For HT motors - Actuator operated scoop type fluid coupling

Belt Conveyor System

- xlvi) Belt conveyor system shall be designed as per the latest edition of as per IS:11592. or 'Belt Conveyors for Bulk Materials' published by Conveyor Equipment Manufacturer's Association'
- xlvi) Slopes of conveyors, wherever applicable, shall not exceed 16 degree depending on the lump size and other governing factors. The conveyor shall be horizontal at the



feed point as far as possible. In case the same is not possible, the inclination at the feed point shall be limited to 6 degree.

Suitable hold back devices for preventing running back of the conveyor belt in case of conveyor being stopped in loaded conditions due to power failure or during normal operational delays shall be provided to give positive protection. The hold back shall instantaneously engage without shock and be capable of protecting equipment and personnel. It shall be released instantly when 'power' resumes or the 'delay' is removed. The holdback devices shall be integral with gearbox.

- xlvi) The belting shall be of either synthetic fabric such as Nylon-Nylon/Polyster-Polyamide, Steel Cord. etc. with rubber covers of adequate flexibility to give a troughing angle of 35 deg.
- xlix) Fire resistant covers shall be provided for all conveyor belting breaker fabric shall be provided for all belts. The covers shall be FR Grade conforming to CSA-M422M87 type-C / Equivalent DIN 2.2 to 3 of Canadian Bureau of Mine specification belting for surface installation. The belt shall have 5 mm top cover & 3 mm bottom cover (min). Minimum number of plies shall be four (4). Ratio of calculated maximum working tension to rated belt tension shall not exceed 0.8 Accordingly belt selection shall be done. The flame test shall be carried out as per ISO 340 stipulation.
- l) All overground and overhead conveyors shall be located in suitably enclosed bridge structure. The conveyor bridge shall have permanently colour coated steel sheeting covers on roof and both sides, properly screwed or locked to steel structure as required. Adequate provision of windows shall be kept. A continuous slot opening of 500 mm shall be provided on both sides just below the roof sheeting.

Belt Protection Equipment

- li) Pull chord type (manually reset type) emergency stop switches shall be located on both sides of belt conveyors at a spacing of 20 m along the walkways for the entire length of conveyors for emergency stopping of conveyor.
- lii) Belt sway switches of self resetting type shall be provided at a spacing of 45 m to limit belt sway to permissible extent.
- liii) Zero speed switch shall be non-contact (proximity) type electronic switch.
- liv) One no. chute blockage switch of proven type shall be provided at a suitable height on each leg of the conveyors discharge chute, vibrating screens by pass chutes, crusher feeding chutes, tripper discharge and feeding chutes nearest to the skirt boards. Chute blockage switch shall trip the feeding conveyor in case of chute blockage and protect the feeding conveyor equipment. Chute blockage switch shall also be provided at each leg of mobile tripper and shall trip the tripper conveyor.



Stone Picking

- lv) Manual Stone Picking arrangement at a suitable location in the conveyor gallery before the crusher house shall be provided complete with platforms, overhead lighting, handrailings, suitable seating, safety hook & holding arrangement for manual pickers, disposal chutes to ground level etc.

Dust Control (Dust Extraction and suppression) System

- lvi) Design and construction features of Dust control system shall be generally in conformity with the recommendation of “American Conference of Governmental Industrial Hygienists”.
- lvii) Type of dust suppression system to be provided at various locations shall be as given below:
- Around the track hopper and wagon tippler – Plain water dust suppression.
 - Wagon Tippler hopper complex - Dry fog type dust suppression system
 - Crusher receipt and discharge points - dry fog type dust suppression
 - For all transfer points - Dry fog type dust suppression system
 - For stock pile - Plain water type dust suppression system with swiveling nozzles.
 - Boom belt discharge of stacker – reclaimer - Dry fog type dust suppression system
- lviii) Plain water type dust suppression system:
- a) Pressure at inlet (Plain water) shall be 2.5 kg/sq. cm for Track Hopper and 4.5 Kg/sq. cm for wagon tippler, coal stock piles.
 - b) Spray heads shall comprise of swiveling type spray units spaced at an interval of approximately 40 meters around each coal pile.
- lix) Dry fog type dust suppression system:
- Spray head pressure at inlet (dry fog) shall be min. 0.5 kg/cm² for water and min 5 kg/cm² for air
- lx) Dust extraction System shall be provided at following locations:
- For Bunker floor
 - For crusher house
- lxi) The dust extraction system shall be of Venturi scrubber system. One independent dust extraction system for each stream shall be provided. The dust collection efficiency shall be 95% down the 10 micron size.

Ventilation System

- lxii) Ventilation system shall be designed and installed conforming to “Industrial



Ventilation” (American Conference of Governmental Industrial Hygienists/Committee on Industrial Ventilation).

- lxiii) The MCC/switchgear room areas shall be provided with pressurised ventilation system while other areas shall have mechanical ventilation.
- lxiv) The pressurized ventilation system shall be designed considering 15 air changes per hour to maintain these areas pressurised slightly above atmospheric pressure to prevent ingress of dust from outside.
- lxv) The air quantity for mechanical ventilation system shall be estimated based on equipment and solar heat loads and the temperature rise inside the building. Necessary air filters shall be provided to supply only clean air into building. Exhaust air shall be discharged at a suitable height above building.
- lxvi) No. of air changes per hour shall not be less than 10 supply air changes & 7 exhaust changes for over ground building. No. of air changes per hour shall not be less than 15 supply air changes & 7 exhaust air changes for underground areas.

2.3.2.2 Electrical System

For design requirements of Electrical System, Section 8 of this document may be referred to.

2.3.2.3 Instrumentation and Control

- i) Control System for coal handling plant shall be Programmable Logic Controller (PLC) based or shall be implemented through micro-processor based distributed control system (DCS) covering total functional requirements of sequence control, interlock & protection, monitoring, alarm and data logging. Remote I/O cabinets shall be provided wherever required depending upon distance/location.
- ii) It shall be possible to select any coal flow path from the Operator’s work station located in the CHP control room viz.
 - a) Wagon tippler/ track hopper to coal bunkers
 - b) Wagon tippler/ track hopper to crushed coal storage via stacker cum reclaimers
 - c) Wagon tippler/ track hopper – one stream to crushed coal stockpile and other stream to coal bunkers
 - d) From crushed coal stockpile to coal bunkers via stacker cum reclaimers
 - e) From crushed coal stockpile to coal bunkers via emergency reclaim hoppers



- iii) Entire CHP shall be controlled from following points:
 - a) CHP control room near crusher house consisting of Operator Work Station (OWS) and Large Video Screen (LVS) for the control of entire CHP. Some I/O may be located remotely in Wagon tippler MCC room and on bunker floor.
 - b) OWS for the control of each stacker cum reclaimers.
 - c) OWS for the control of wagon tippers/track hoppers.
 - d) Dust extraction / suppression system shall be operated from the respective control panel provided locally with the equipment / system. Dust extraction/suppression system shall operate when the coal conveying system is in operation and bunker ventilation systems shall operate round the clock. DE / Dust suppression system shall be provided with remote operation from main CHP control room except for Bunker floor DE operation which will be local.
 - e) Control system for stacker cum reclaimers, wagon tippers, dust extraction / suppression system shall be interfaced to the CHP control room.
 - f) Local start/stop push button stations, de-interlock switches to be mounted near each equipment for start / stop during maintenance of the system.
- iv) For design requirements of Control & Instrumentation system, Section 8 of this document may be referred to.

2.3.2.4 Civil Works

For design requirements of Civil works, Section 9 of this document may be referred to.

2.3.2.5 Layout and Maintenance Requirements

- i) The sizes of the junction towers, transfer points and crusher house and the floor elevations shall be finalized considering a minimum clear walkway space of 1200 mm around the equipment in each floor. The clear distance between the floors shall be minimum 3000 mm and the headroom shall be suitable for handling / removing the equipment at the head end and tail end.
- ii) Adequate space around the crusher in the crusher house shall be provided for opening the cage of the crusher and for removal of the shaft. Partitions with slide doors shall be provided in the crusher house between the crushers to enable maintenance of standby crusher when the other crusher is operating. Adequate maintenance space and handling facilities shall be provided on both sides of the partition wall
- iii) All transfer points shall have separate debris disposal chute upto last operating floor.



- iv) Minimum clearance between the bottom of the tail pulley and floor in junction tower / crusher house / transfer house / tunnel shall be 600 mm.
- v) Wherever the conveyor crosses the road, a minimum clearance of 8 M shall be provided below the structure. At the rail crossings, this clearance shall be as per the Indian Railways requirement.
- vi) Side and central walkways for double stream conveyors shall be 800mm and 1100mm wide respectively. The side walkways for single conveyors shall be 800 mm on one side and 1100mm on the other side.
- vii) Provision shall be kept with platforms and ladders for crossing over the conveyors at approximately every 100m intervals of route length and minimum one per conveyor.
- viii) Cage ladder at every 100M shall be provided to approach / escape from the galleries from ground. Spacing of monkey ladders on trestles shall be as given below:
 - (a) Where height of conveyor gallery (walkway level) is 10 m or more: every trestle.
 - (b) Where height of conveyor gallery (Walkway level) is less than 10m: On alternate trestle

2.4 PERFORMANCE REQUIREMENTS

2.4.1 System Performance Requirements

The coal handling system and equipment shall perform satisfactorily to meet the guarantee requirements as stated hereunder:

- i) After the coal handling system is ready, the same shall be tested at rated capacity to prove the performance of the system and equipment. The guarantee requirements shall be met without undue vibrations in the conveyor supports, junction towers, crusher house, transfer houses, etc.
- ii) Each crusher shall be capable of crushing rated capacity with specified maximum lump size of coal even while handling damp and sticky coal having 20% moisture (including surface moisture) during monsoon season. The largest size of output particles shall not exceed those specified in the specification.
- iii) Screens shall screen out 95% of material having dimension of (-) 20 mm even during rainy season.
- iv) Stacker / reclaimers shall be stable under specified design condition and shall meet all the requirements specified. The bucket wheel reclaimer shall reclaim coal at the rated capacity specified while handling well compacted, damp and sticky coal during rainy



seasons. The capacity shall be arrived at on working for 4 hours over complete cross section of the stockpile. Also, the stacker shall stack coal at the rated capacity specified.

- v) All drive motors shall be suitable for direct-on-line starting and capable of starting fully loaded conveyors / feeders.
- vi) Noise level produced by any rotating equipment (other than crusher) individually and collectively should not exceed 85 dBA at a distance of 1.5 metres from it in any direction under any load condition.
- vii) Vibration level of equipments at bearings shall not exceed the following limits for different equipment. Vibration levels shall conform to the limits specified below and shall be measured as per VDI 2056 / BS 4675. Equipment Peak to peak limit:

At the bearing of drive pulley, motor and gear box for the following equipment: i) Boom conveyor of stacker/ : Reclaimer	115 microns
ii) All other equipment/ : Conveyors/feeders etc.	75 microns
On the floors and columns of junction towers, Crusher house and conveyor, Gallery walkways	200 microns
Crusher	160 microns for speed of 750 rpm

- xii) At the outlet of the dust extraction system, the dust concentration shall not exceed 100 mg/Nm³.
- xiii) Simultaneous operation of both the paths in conveyor streams at rated capacity shall also be demonstrated to confirm healthiness of the system.

2.4.2 Performance Guarantee tests:

Before conducting Performance Guarantee test, the coal handling plant shall be on trial operation during which necessary adjustments can be made to enable full capacity range operation. The duration of Trial Operations of the complete equipment shall be fourteen (14) days with minimum twelve hours daily operation. For successful Trial Operation, the trial shall necessarily include steady operation of the plant at its rated flow path capacity for at least one hour duration per day on an average.

Normal duration of the P.G. test shall be four hours. However, minimum one (1) hour continuous & steady operation shall be required to establish the guaranteed capacities. Power consumption measurement shall be done only for one hour after the conveyor flow rate stabilizes at the guaranteed capacity.



Performance Guarantee Tests shall be conducted in such a way that all the conveyors in both the streams are covered. For this purpose it may be necessary to repeat the Performance & Guarantee tests until all the conveyors are covered. Tests to be conducted shall include:

- i) Capacity in T/Hr (equivalent to 100% of rated) of conveyor system including the intermediate equipments for each of the two parallel conveyor streams separately or any combination thereof. For the purpose of conducting guarantee test coal, flow shall be divided into following coal flow paths:
 - a) Wagon tippler/ track hopper to coal bunkers
 - b) Wagon tippler/ track hopper to crushed coal storage via stacker cum reclaimer
 - c) Wagon tippler/ track hopper – one stream to crushed coal stockpile and other stream to coal bunkers
 - d) From crushed coal stockpile to coal bunkers via stacker cum reclaimer
 - e) From crushed coal stockpile to coal bunkers via emergency reclaim hoppers
- ii) Guaranteed capacity in T/Hr of the following :
 - a) Paddle Feeders
 - b) Apron Feeders
 - c) Crushers
 - d) Stacker Reclaimer
 - e) Wagon tippler with side arm charger
- iii) Total power consumption for all the equipments including auxiliaries with single stream operation of longest flow path (listed at 2.4.2.i.a) at guaranteed capacity except intermittent loads such as lighting, hoists, coal sampling units, sump pumps, elevators, dust suppression/elevation, ventilation, service/potable water system.

2.5 CODES AND STANDARDS

The design, manufacture, inspection and testing of the Coal Handling System shall comply with all the currently applicable statues, regulations and safety codes in the locality where the equipment is to be installed. The equipment shall confirm to the latest



edition of the following standards & codes. Other internationally acceptable standards/codes, which ensure equal or higher performance, shall also be accepted.

Belt Conveyor System

IS:11592 : Code of practice for selection and design of Belt Conveyors.

“Belt Conveyors for Bulk Materials” published by Conveyor Equipment Manufacturers’ Association.

IS:7155 : Codes of Practice for Conveyor Safety.

IS:1891 (Part-I) : General Purpose Belting

IS:8598 : Idlers and Idler Sets for Belt Conveyors

IS:4009 (Part-II) : Conical Head Grease Nipples

IS:8531: Pulleys for Belt Conveyors.

IS:226 : Structural Steel (Standard Quality)

IS:4682 : Codes of Practice for Lining of Vessels and Equipment for Chemical Processes.

IS:11592 :Code of practice for selection and design of Belt Conveyors.

CAN / CASA - M422 M87 : Canadian standard association.

IS:2062 Steel for General Structural Purposes - Specification

Drive equipment like gears etc.

IS:3688 : Dimensions for shaft ends

IS:3681: General plan for spur & helical gears

IS:7403 : Code of practice for selection of standard worm and helical gear boxes

Belt Scales/ Weighers

NEMA Standards

NEC For electronic circuit enclosures.

IS:11547 Electronic weighing in motion system.

Dust Control Equipment

IS:778 : Gun Metal gate, globe & check valves for general purpose.

BS:5150 :Cast Iron Gate Valve for water works purposes

BS:5152 :Cast Iron Globe Valve for water works purposes

BS:5312 :Cast Iron Check Valve for water works purposes

IS:1239 : Mild Steel tubes & fittings.



IS:2379 :Colour for the identification of pipe line.
IS:3589 :Electrically welded steel pipes for water, gas & sewage (200 to 2000 mm)
IS:5312 : Swing check type reflux (non return) valves.
IS:1520 : Horizontal centrifugal pump for clean, cold fresh water.
IS:5120 :Centrifugal pump for clean, cold & fresh water.
BS: 5169 & BS:1123 : Air Receivers.
ANSI B 31.1:Code for pressure piping.
Hydraulic institute Standards of U.S.A
IS:210 Cast Iron
IS:318 Bronze

Ventilation equipment

IS:3588 : Specification for electrical axial flow fans.
IS:2312 :Propeller type AC Ventilation fans
IS:3963 :Specification for roof-extractor units
IS:4894 :Centrifugal Fans
IS:655 :Specification for Metal Air Duct
ARI:210 :Standard for Unitary air conditioning equipment.
ARI:270 :Standard for application, installation and servicing of unitary equipment.
IS:8183 :Specification for bonded mineral wool.
IS:661 :Thermal insulation for cold surfaces.
IS:4671:Expanded polystyrene for thermal insulation purpose.
IS:8148 :Packaged Air conditioners.

Crushers & Vibrating Screens

IS:8723 Dimensions for vibrating conveyors and feeders with rectangular or trapezoidal trough
IS:286 Austenitic-Manganese Steel Castings - Specification

Monorail and Hoists

IS:3938 : Specification for Electric Wire Rope Hoist
IS:3832 : Chain pulley blocks
IS:2429 : Round steel short link chain



**TYPICAL SCOPE OF WORKS FOR THERMAL POWER PROJECT
(2x500MW) : COAL HANDLING PLANT**

2A.1.0 SCOPE OF WORK

The scope of coal handling plant typically covers the design, engineering, manufacture, inspection and testing at manufacturer's works, supply, packing and delivery at project site, unloading, storage and in plant transportation at site, erection, supervision, pre-commissioning, testing, successful commissioning, performance testing and handing over of coal handling plant of the thermal power project. Scope of work shall include all mechanical, electrical, C&I, accessories, civil, structural and architectural works to make the system complete.

Typical scope of work for 2x500 MW thermal power project includes:

2A.2.0 Mechanical

- i) Underground RCC track hopper with four (4) Nos. paddle feeders
OR

Three (3) nos. rota side wagon tippers alongwith side arm chargers and electronic weighing bridges, three (3) nos. wagon tippler hoppers and three (3) nos. apron feeders

Note: Stations with track hoppers may also additionally have wagon tippers to take care of eventuality of non- availability of BOBR wagons. In such a case, two (2) nos. wagon tippers may be provided with hoppers and apron feeders

- ii) Belt conveyors (2x100% streams) from wagon tippler hoppers/track hopper upto crusher house complete with tunnel, conveyor gallery, pent house and transfer points. Covered conveyor galleries with steel trestles shall be provided for all over-ground conveyors. Following shall also be provided on each belt conveyer before crusher house:
- a) Suspended magnets for removal of tramp iron pieces
 - b) Metal detectors
 - c) Electronic belt weighers
 - d) Manual stone picking platforms
 - e) Coal sampling unit alongwith online analysers
 - f) In-line magnetic separators for removal of small and tramp iron pieces escaped from suspended magnets
- iii) Four (4) nos. vibrating grizzly screens before crushers.



- iv) Sets of gates each comprising of one rod gate and one actuator operated rack & pinion gate at inlet to each of the vibrating grizzly screens and at inlet to vibro feeders in emergency reclaim hoppers.
- v) Crusher house (CH) accommodating four (4) nos. crushers and associated vibrating grizzly screens, gates, passenger cum goods elevator, conveyors, chute work alongwith actuator operated flap gates, monorails & hoists, hoist maintenance platform, external and internal staircases, hand rails and other equipments such as coal sampling unit, dust suppression, dust extraction system etc.
- vi) Four (4) nos. crushers including crusher supporting foundations, vibration isolation system with springs & viscous dampers, vibration monitoring system etc.
- vii) Belt conveyors (2x100% streams) from crusher house upto coal bunkers complete with conveyor gallery and transfer points.
- viii) Belt conveyors (2x100% streams) from crusher house upto yard conveyor for coal stacking complete with conveyor gallery and transfer points.
- ix) Reversible Yard conveyor (1x100%) with independent drives for stacking and reclaiming modes.
- x) One (1) nos. reversible Stacker cum Reclaimers with electronic belt weighers mounted one on each reversible stacker reclaimer.
- xi) Emergency reclaim hoppers with vibro feeders and belt conveyors (2x50%) complete with conveyor gallery and transfer points for interconnection with conveyor between crusher house and bunkers.
- xii) Belt conveyors from yard conveyor complete with conveyor gallery and transfer points for interconnection with conveyor between crusher house and bunkers.
- xiii) Following shall also be provided on each belt conveyer before coal bunkers:
 - a) Electronic Belt weighers
 - b) Coal sampling unit alongwith online coal analyser
 - c) In-line magnetic separators
 - d) Metal detectors
- xiv) Complete chute work and motor operated flap gates between various conveyors in all Transfer points and crusher house.
- xv) Four (4) Nos. motorized traveling trippers, two (2) nos. for each unit.
- xvi) Two (2) nos. passenger - cum – goods elevators to serve various floors of the crusher house (CH) and one (1) no. passenger – cum – goods elevator in transfer point near



- boilers.
- xvii) Adequate number of ventilation equipment for ventilating the track hopper, wagon tippler hoppers, emergency reclaim hoppers, underground tunnels, transfer points, crusher house and bunker bays (housing tripper conveyors)
 - xviii) Pressurised ventilation system for all switchgear rooms, MCC rooms.
 - xix) Exhaust fans in all battery rooms and toilets
 - xx) Air conditioning of main CHP control room, local control rooms for track hopper, wagon tipplers, stacker/reclaimer and office rooms.
 - xxi) Adequate number of sump pumps in hoppers, transfer points complete with individual discharge piping with fittings and valves upto nearest plant drain.
 - xxii) One (1) No. belt vulcanizing machine along with belt jointing facilities
 - xxiii) Complete dust suppression system for control of fugitive dust in track hopper/wagon tippler hopper, paddle feeder, transfer points, crusher house, coal stock yard complete with enclosed pump houses, water tanks, pumps, drives, hoisting arrangements, piping, valves etc. as briefly specified below :
 - a) Plain water dust suppression around the Track Hopper top and wagon tippler top through fogging nozzles.
 - b) Plain water dust suppression around stockyard through swiveling sprinklers
 - c) Complete plain water dust suppression system with two (2) nos. pumps and one (1) tank mounted on paddle feeder or on trolley including ring header inside track hopper for supplying plain water.
 - d) Complete dry fog type dust suppression system at all Transfer Points, wagon tippler complex, S-R boom conveyor discharge and Crusher House (both at discharge and loading points) including all electrical and accessories.
 - e) Belt Sealing arrangement in Bunker bays for control of dust coming out of coal Bunkers.
 - xxiv) Complete dust extraction system for control of fugitive dust in crusher house and bunker floor with complete water tanks, pumps, drives, hoisting arrangements, piping, valves etc.
 - xxv) Service water, potable water system and cooling water system for complete coal handling plant.
 - xxvi) Monorails and electrically operated hoist blocks as well as hand operated chain pulley blocks for servicing/installation/easy replacement of drive machinery, different types of pulleys for all conveyors and other equipment from ground level to their locations and vice-versa.



- xxvii) Four number bull dozers of minimum 400 BHP diesel engine for dosing coal into emergency reclaim hoppers and coal stockpile maintenance
- xxviii) Drainage of all CHP buildings, track hopper, wagon tippler hopper, emergency reclaim hoppers, tunnels, conveyor galleries and coal stock yard including all civil & structural works.
- xxix) Fire protection provisions to meet TAC and IS – 3034.

2A.3.0 Electrical System / Equipment

Two no. feeders shall be provided from 11 kV Station Switchboards for Coal Handling Plant. Further, distribution of power supply at 3.3kV and 415V voltage levels and all other required electrical equipment for putting coal handling plant into successful operation shall be in the scope of work of CHP supplier. The 415V supply shall be arranged either through 11/ 0.433kV or 3.3/ 0.433kV LT auxiliary transformers. However, 415 V supply for boiler floor MCC shall be arranged from respective 415 V unit PMCC. Typically, following electrical equipment shall be included:

- i) 11/ 3.3kV and 11/0.433kV or 3.3/0.433kV auxiliary transformers
- ii) 11kV, 3.3kV and 415V Switchgears
- iii) HT and LT busducts
- iv) Power and control cables including cables from 11 KV station switchboards and 415 V unit PMCC.
- v) Cable laying alongwith cabling accessories, cable trays and termination/ jointing kits of cables, and fire sealing
- vi) HT and LT Motors
- vii) 220V DC system comprising of battery banks, chargers and DC distribution boards
- viii) Complete illumination system for internal and external lighting of associated plant and building
- ix) Complete grounding and lightning protections and its interconnection with nearest earth mat
- x) Emergency stop push button for all HT and LT motors



2A.4.0 Control & Instrumentation System (in case of PLC based system)

- i) Microprocessor based programmable logic control (PLC) system for operation, control and monitoring of the Coal handling plant from the coal handling system control room. Operator Work station housing TFT / keyboard, and Large Video Screen shall be provided in the main control room of CHP along with I/O racks, PLC panels and power supply arrangement. Remote I/Os may be provided depending on distance/location.

It shall be possible to monitor the coal handling plant from the main DCS in the Unit Control Room through soft link.

- ii) Independent PLC based control system, comprising of OWS, PLC panels, I/O racks and power supply arrangement etc., for stacker cum reclaimers with facility to communicate important signals with CHP control room through hard wiring.
- iii) PLC based control system comprising of OWS, PLC panels, I/O racks and power supply arrangement etc.. for coal unloading at wagon tippler/track hopper complex along with static weigh bridges
- iv) Local control panels for traveling trippers, dust extraction / suppression system. These local panels shall be interfaced to the CHP control room.
- v) Communication facility between CHP Control Room and all the strategic workings areas such as Wagon Tippler/track Hopper Control Room, Stacker-Reclaimer Control Cabin, bunker floor, unit control room etc.
- vi) Instrumentation and control cables including laying and termination
- vii) Power supply system for C&I system including redundant UPS system, batteries, charges etc.
- viii) All Instruments integral to CHP equipment for control, monitoring and operation of the equipment/plant/ systems such as:
 - a) Belt sway switches
 - b) Pull chord switches
 - c) One No. zero speed switch at tail end for each conveyor.
 - d) Vibration monitoring system for crushers and drives
 - e) Motor overload switches for conveyor drives
 - f) RTDs for conveyor drive motors and crusher motors (for HT motors only)



- g) Level switches in dust suppression system water tanks and other field devices as required.

2A.5.0 Civil Works

- i) The civil works to be performed shall cover providing all labour, materials, construction equipment, tools and plant, scaffolding, supplies, transportation, all incidental items necessary for successful completion of the work. The work shall involve earthwork in excavation including controlled blasting and very deep underground excavation, extensive de-watering, shoring and strutting, sheet piling, back filling around completed structures and plinth protection, area paving, disposal of surplus excavated materials, piling, concreting including reinforcement and form work, brick work, fabrication and erection of structural / miscellaneous steel works, inserts, architectural items & finishes such as plastering, painting, flooring, doors, windows & ventilators, glass and glazing, rolling shutters etc., permanently colour coated profiled steel sheeting, anchor bolts, R. C. C. trenches with covers, laying and testing of water pipes, sanitation, water supply, drainage, damp proofing, water proofing and other ancillary items.
- ii) The work shall be carried out both below and above ground level and shall include basements, equipment foundations including vibration isolation systems, grounding, slabs, beams, columns, footings, rafts, walls, steel frames, brick walls, stairs, trenches, pits, access roads, culverts, conveyer galleries, trestles, penthouses, track hopper, wagon tippler hoppers, emergency reclaim hoppers, underground tunnels, crusher house, transfer towers, buildings for switchgear and control room, finishes, complete architectural aspects, drainage, sanitation, water supply (from terminal points to various buildings, conveyor galleries) and all other civil, structural and architectural works associated with the complete Coal Handling Plant.
- iii) All buildings shall be complete with all electrical, civil, structural, architectural works, cable trenches, fire safety walls, foundation, earth mat, fencing, earthing for transformers. All cables, duct banks, trenches, cable trestles shall be complete with associated civil/ structural work and necessary civil foundations. Buildings to be provided shall include the following :
- a) Underground/partially underground transfer points (RCC construction)
 - b) Overground transfer points and Crusher House (steel construction)
 - c) Electrical & control buildings (RCC construction) listed below:
 - Main switchgear cum central control room building near crusher house
 - Wagon tippler/track hopper switchgear cum control building near wagon tippler/track hopper complex
 - Switchgear room for Stacker –cum- Reclaimer



Standard Design Criteria/Guidelines for Balance of Plant of Thermal Power Project
2 x (500MW or above)

Section- 2 (Coal Handling Plant)

- Office complex for O&M staff and storage rooms near main control room
- iv) Scope shall also include supply and laying earthing mat all around the periphery of buildings, structures, and outdoor equipments, as per the approved drawings.
- v) The analysis, design and detailed drawing for the structures like track hopper, wagon tippers tunnels etc. coming below the railway track shall be got approved from the concerned railway authority before taking up construction.
- vi) Arranging construction water from underground sources, storage in underground/overground tanks and taking the water to construction site through pipelines by pumping or by road tankers etc., including all necessary accessories, tools & tackles etc.
- vii) Access roads to all buildings/facilities of CHP including construction and maintenance of temporary access roads for approach to the building/facilities for construction/erection activities.



**STANDARD DESIGN CRITERIA/GUIDELINES FOR BALANCE OF PLANT OF
THERMAL POWER PROJECT 2x (500MW OR ABOVE)
SECTION-3 : ASH HANDLING PLANT**

3.1 INTRODUCTION

In a coal based thermal power plant, huge amount of ash is generated which has to be disposed off continuously. Typically for a 2x500 MW plant based on indigenous coal, the amount of ash generated is around 300 to 400 TPH depending on gross calorific value and ash content of worst coal. The ash handling system covers evacuation of ash and disposal in wet, semi wet and dry form.

The ash is produced in two forms viz. fly ash which is of fine texture and bottom ash which is comparatively coarser. The ash entrained in the flue gases and captured in electro-static precipitator (ESP) is termed as fly ash and the ash which falls at the bottom of the boiler furnace is known as bottom ash. Small quantities of ash are also collected in the air pre-heater, economizer and stack.

The design of ash handling system in a power station is based on the following considerations:

i) *Station capacity , gross calorific value and ash content of worst coal*

Station capacity, gross calorific value, BMCR requirement and ash content of worst coal determine the quantum of ash to be handled and thus the sizing of the equipment in Ash Handling Plant.

ii) *Utilisation potential and mode of ash disposal*

As per MOE&F stipulations, full capacity dry fly ash extraction system is provided to facilitate utilization of fly ash in dry form. Wet slurry system is additionally provided to cater to 100% ash and is used to dispose the balance unutilized fly ash till its full utilization is achieved. Alternatively high concentration slurry disposal system (HCSD) may be adopted. In cases where full utilization of fly ash is possible from the inception of the power plant on continuous basis, wet slurry disposal can be avoided for fly ash. The bottom ash is, however, disposed off in slurry form in most of the power stations. In some of the power stations, semi-wet method of disposing bottom ash is adopted by use of hydro-bins and the ash collected is then disposed off directly from hydro bins for end use. Lately dry bottom ash collection and disposal has been adopted in one of the power stations in the country.



iii) *Layout, conveying/pumping distances etc.*

Sizing of transport compressors for transporting ash up to silo, vacuum pumps / conveying compressors for ash evacuation from ESP, slurry pumps for transporting wet ash slurry upto ash pond depend upon layout of the plant, conveying/pumping distances, topography of the area, routing of pipelines etc. For example, elevation and distance of ash pond from pump house affects the size of the slurry pumps. Higher distance and elevation can lead to requirement of booster pumping in some cases.

As such the size of various ash handling equipment is site specific and depends on various factors as above.

3.2 SYSTEM DESCRIPTION

The ash handling system of a power station normally consists of the following:

3.2.1 Bottom Ash (BA) System

i) Bottom ash of each boiler is collected either in a water impounded hopper for disposal using jet pumps or in a dry type hopper using submerged scraper conveyor system as described below:

- a) Bottom ash of each boiler is collected in a water impounded, storage type, double V /“3-V” shaped hopper for intermittent removal. It is pertinent to note that shape of hopper depends on furnace configuration as well as amount of bottom ash generation, which varies from project to project, based on source of coal. Each bottom ash hopper has provision for continuous make-up and overflow. Two (2) discharge outlets (one working and one standby) are provided under each V-section. Each outlet is fitted with a feed gate and clinker grinder. The ash at the exit of the clinker grinder gets mixed with the water to form slurry while pumping with the jet pump. Each jet pump is provided with independent bottom ash slurry transportation pipeline upto common ash (fly ash & bottom ash) slurry pit for pumping finally to the ash pond.

Alternatively, semi-wet method of disposing bottom ash is adopted by use of hydro-bins and the ash collected is then disposed off directly from hydro bins in semi-dry form for end use.

- b) Dry type hopper with submerged scraper conveyor system is provided which evacuates bottom ash on continuous basis. The bottom ash slurry in this case may be sent to a bottom ash slurry sump through the ash slurry trench by the use of gravity flow to the extent possible. The bottom ash slurry may be pumped from bottom ash slurry sump to main ash slurry sump by use of centrifugal pumps, if gravity flow is not possible. The system consists of dry type bottom ash hoppers, hydraulic cylinder operated horizontal type hopper outlet gates, submerged scraper conveyors, clinker grinders, bottom ash slurry sump / trench upto common slurry sump etc.



As an alternative to disposal of bottom ash in slurry form, the ash may be conveyed in semi-wet form through belt conveyors to the ash dyke.

- ii) The coarse ash collected from the economizer hoppers is connected to the bottom ash hopper top (above the maintained water level) by means of an adequately sized sloping pipe (for transporting slurry by gravity) in case of jet pump system. However if calcium content is high in economizer ash or bottom ash hopper storage capacity is not adequate, then economizer ash is disposed off separately. For submerged scrapper conveyor (SSC) system, normally the ash from economiser, is evacuated and conveyed continuously in wet form and the ash slurry is led to ash slurry pump house, through trenches.

3.2.2 Fly Ash System (ESP, Air preheater)

- i) Evacuation and transportation of dry fly ash is done in two stages, i.e. from ESP collection hoppers to the intermediate surge hoppers by vacuum conveying system/pressure conveying system and from the intermediate surge hoppers to storage silos near plant boundary by pneumatic pressure conveying. Air pre-heater and duct hoppers ash can be conveyed pneumatically, and connected to intermediate surge hopper/collector tanks of ESPs. Alternatively, ash from air preheaters and duct hoppers can be evacuated and conveyed continuously in wet form and the ash slurry led to ash slurry pump house, through trenches.
- ii) In addition, wet disposal system (to be operated during initial period of plant operation till 100% fly ash utilization is achieved or during emergency when dry disposal is not possible) for fly ash is also provided which directs the fly ash to wetting units to form the slurry and thereafter pumping the same to common slurry pit using jet pumps. Wet disposal system can be medium slurry type or high concentration slurry type. The ash for HCSD disposal can be taken from silo or Intermediate surge hopper, based on the site layout.

3.2.3 Ash Water System

- i) The entire water requirement of the ash handling system is met from cooling tower blow down of the station and decanted recovery water from the ash pond. A connection from raw water is also provided for fast fill and emergency makeup purposes. Clear water as necessary for equipment sealing and cooling is provided from station clarified water. DM water may also be used for cooling purposes in closed cycle.

In case of once through system in coastal stations using sea water, water for ash handling is tapped from return header of CW system.

- ii) Ash water system consists of ash water sump, HP water pumps, LP water pumps, economiser ash water pumps etc.

BAHP (bottom ash high pressure) water pumps are used to extract bottom ash from both units intermittently and sequentially in case of jet pump system and continuously in case of SSC system. In case of jet pump system, BAHP pump supply water for jet pumps, BA hopper flushing, seal trough & gate housing flushing etc. In case of SSC system, BAHP



pumps supply water for quenching, BA trench jetting, seal trough flushing, gate cooling, BA sump agitation etc.

In case of jet pump system, BALP (bottom ash low pressure) pumps supply water for refractory cooling, BA hopper cooling water to maintain hopper water at 60 deg.C, BA hopper fill and make up, seal trough make up/fill, slurry sump hopper make up water etc.

In case of SSC system, BALP pumps supply water for refractory cooling, cooling water for upper trough of SSC to maintain water temp. at 60 deg.C, seal trough make up, cooling water to inspection windows, wash water to grinder, BA sump make up, ash slurry sump make up etc.

Fly ash HP water pumps (FAHP) supply water to wetting heads, air washers, F.A. slurry/trench jetting, combined ash slurry sump make up, combined ash slurry sump agitation etc.

Seal/cooling water pumps are provided for gland sealing of slurry pumps, vacuum pumps cooling of compressors and sealing water requirement of clinker grinders. Alternatively, plant DM water can be used in closed cycle for cooling purpose.

In order to conserve water used in wet ash disposal, an ash water recovery system is provided to recirculate the decanted water from the ash pond and re-using this water for ash handling purposes. BA hopper cooling water overflow can also be re-circulated after treating in settling tank and surge tank .

3.2.4 Ash Disposal System

Dry disposal

The dry fly ash from ESP hoppers is conveyed to intermediate surge hoppers by vacuum/pressure conveying, which are located as close to the ESP as possible. Fly ash collected in intermediate surge hoppers is pneumatically conveyed to storage silos in a separate area near the plant boundary, with independent access from where it is unloaded into the open/ closed trucks or in railway wagons.

Wet disposal

While bottom ash handling and disposal shall be in wet mode, wet disposal of fly ash is to be resorted during initial period of plant operation till 100% fly ash utilization is achieved or during emergency when dry disposal is not possible.

Fly ash and bottom ash slurry is led to common ash slurry sump. Pre-treatment plant clarifier sludge is also discharged into common ash slurry pit. This combined slurry is then pumped to the ash pond through ash slurry pipelines by centrifugal type low speed ash slurry pumps.

The ash slurry pumps may be required to be placed in series (maximum four) for meeting high head requirement while pumping to long distances and higher elevations. In case of excessively high head requirement of ash slurry pumping a booster station may also be required between ash slurry pump house and ash pond. Ash slurry is discharged in the ash



dyke at strategic locations to ensure even filling of ash pond using pipe garlanding around the dyke.

Alternatively, high concentration slurry disposal (HCSD) system is employed, which uses the slurry concentration between 55 % - 70 % depending on specific slurry rheology.

3.2.5 Ash Handling System Operation

The MOE&F notification dated 03.11.2009, stipulates for a 100% ash utilization within four years of commissioning for new plants and reduced land area (50 hectares for a 500MW unit using 45% ash coal) for emergency ash pond. The ash handling plant should therefore, adopt the following modes (option I & option II) of operation:

Option I

1. Fly ash disposal: Dry mode (normal continuous operation) and in wet slurry mode (initial operation period till 100% dry fly ash utilization is achieved and emergency operation when dry disposal is interrupted)
2. Bottom ash disposal: Wet or semi- wet mode

Option II

1. Fly ash disposal: Dry mode (normal continuous operation) and in HCSD mode (initial operation period till 100% dry fly ash utilization is achieved and emergency operation when dry disposal is interrupted)
2. Bottom ash disposal: Wet or semi - wet mode

3.2.6 Typical scope of work for 2x500 MW thermal power project is attached at Annexure 3A

Typical flow diagrams (as listed below) of ash handling system for 2 x 500 MW are enclosed :

1. Drawing no: CEA-TETD-AHP-001 (Typical flow diagrams for fly ash handling system - 2 x 500MW coal based thermal power plant (vacuum system))
2. Drawing no:CEA-TETD-AHP-002 (Typical flow diagrams for fly ash handling system- 2 x 500MW coal based thermal power plant (pressure system))
3. Drawing no:CEA-TETD-AHP-003 (Typical flow diagrams for bottom ash handling, ash disposal - 2 x 500MW coal based thermal power plant (submerged scrapper chain conveyor system))
4. Drawing no:CEA-TETD-AHP-004 (Typical flow diagrams for bottom ash handling, ash disposal - 2 x 500MW coal based thermal power plant (jet pump system))



3.3 DESIGN CRITERIA AND BROAD FEATURES

3.3.1 Capacity of ash handling system

a) *Bottom ash disposal system (water impounded hopper type)*

The water impounded hopper system employs a storage type of hopper and the ash is extracted on an intermittent basis by means of jet pumps.

The number of hours of storage of ash in the hopper is determined by calculating the hopper volume considering the following aspects:

- i) The maximum water level in the hopper under hot conditions shall be as per the recommendations of the boiler manufacturer.
- ii) The effective ash level shall be considered at least 300 mm below the maximum water level. However, this needs to be decided in consultation with boiler supplier to avoid water splashing on the furnace tubing.
- iii) The angle of inclination of hopper walls with horizontal shall be 45° (min.)
- iv) For the purposes of calculation of hopper volume, the bulk density of bottom ash shall be considered as 0.65 ton/m³.
- v) All the equipments (clinker grinders, jet pumps & piping) shall be located preferably above ground and accordingly the bottom of the hopper shall be kept 1.5m or more above ground.
- vi) 'Inkpot' shape of the hopper shall be discouraged to the extent possible.

The determination of volume with above criteria dictates the no. of times the hopper is to be emptied in one shift.

Whereas it shall be endeavored to maximize the storage capacity of B.A. hopper, the minimum acceptable storage capacity shall not be less than 5 hours.

If the capacity available is more than 8 hours then the hopper would be emptied once in a shift in 90 minutes period and if the volume available is less than 8 hours but more than 5 hours then the hopper would be emptied twice in a shift.

Each unit shall have two jet pumps working simultaneously, in case the shape of hopper is double V (generally for 500 MW units) and three jet pumps working simultaneously, in case the shape of hopper is triple V (generally for 600/660/800 MW units). The choice of having double 'V' type or triple 'V' type water impounding hoppers depends on the evacuation capacity per outlet of the hopper based on the available capacity of jet pumps (present maximum capacity of jet pumps: 105 tonnes per hour on dry ash basis).



b) *Bottom ash disposal system (submerged scrapper conveyor type)*

In case of continuous type bottom ash removal system employing submerged scrapper chain conveyors (SCC), the system shall be capable of removing bottom ash continuously at a normal rate equal to the bottom ash generated (when firing worst coal on BMCR basis), from furnace bottom of each unit. However, the continuous maximum operating capacity of SCC shall be 25% higher than the amount of BA generation rate, to take care of soot blowing, shutdown, breakdown etc.

The minimum operating depth of water in the upper water filled trough of the scraper conveyor shall be 2.0 metres.

c) *Dry Fly ash disposal system*

Fly ash system shall be designed to remove fly ash from each unit in maximum 6 hours per shift of 8 hours while firing worst coal. However system will operate continuously under normal running condition.

d) *Ash slurry disposal system*

- i) Ash slurry disposal rate from ash slurry sump to dyke shall be sum of bottom ash conveying rate and fly ash conveying rate as given below:

- Bottom ash conveying rates arrived at as per the criteria mentioned at Clause a) above if the water impounded hopper system alternative is adopted

OR

Normal bottom ash collection rates as at Clause b) if the submerged scrapper chain conveyor system alternative is adopted. During soot blowing conditions, the slurry concentration shall increase.

- The fly ash handling system shall be assumed to operate continuously and the fly ash collection rates shall be same as the rates considered for sizing pneumatic conveying system, for the purpose of sizing of the disposal system.
- ii) The slurry line velocities shall not exceed 2.8m/sec.
- iii) The value of 'C' factor to be considered for arriving at the pressure drop shall be 140.
- iv) In case HCSD system is used for ash slurry transportation, the following shall be taken into account:
- Range of concentration for ash slurry pumping shall be 55% to 70% by weight.
 - System design shall be based on 60% slurry concentration by weight.



- One common HCSD stream shall be provided as standby which can be used for de-blocking with water under choking conditions of disposal pipeline.
- The HCSD pump maximum discharge pressure shall consider the discharge pressure requirement during normal operating condition while discharging slurry at design concentration of 60% and a minimum 50% margin shall be provided in the pump discharge pressure as De-blocking pressure requirement over the normal discharge pressure while pumping at 60% concentration.
- The high concentration ash slurry disposal pump shall be positive displacement type.
- The HCSD pump shall have variable speed drive.
- HCSD pump operating range – 10% to 100% of rated flow.
- The HCSD pump electric motor shall have output rating corresponding to the maximum de-blocking pressure requirement along with motor kW margin of 20% (minimum).
- 1 no. mixing tank and 1 no. independent disposal pipeline shall be provided for each HCSD pump.
- Mixing tank effective volume between high level and low level shall be for 30 minutes of HCSD pump capacity at 60% concentration.
- Shut-down restart capability for pumping operation – 6 hrs to 12 hrs depending on slurry rheology.
- The high concentration slurry shall be disposed in disposal area such that no significant free water is released from the slurry.
- Ash pipe line velocity – 1.8 m/sec. maximum at 60% concentration.
- The HCSD disposal pipeline shall be made from seamless steel pipe having a minimum wall thickness as per Schedule 80. Bends shall have minimum - 3D radius made from seamless steel pipe of same thickness.

e) *Fly ash storage silos*

The storage silos shall have sixteen (16) hours storage capacity based on fly ash generation with design coal at 100% MCR.

f) *Ash water recovery system*

Recovery water collection arrangement from pond will be designed for collection of 70% water delivered through slurry pumping.

g) *Typical ash handling system capacities*

Typically for a 2 x 500 MW power stations the system capacities shall be worked out on per unit basis as under:



Standard Design Criteria/Guidelines for Balance of Plant of Thermal Power Project
2 x (500MW or above)

Section- 3 (Ash Handling Plant)

Unit Capacity	500.00	MW	
Heat Rate	2450.00	kCal/kWh	
PLF	100	%	
GCV of Worst Coal	3150.00	kCal/kg	
Specific coal requirement	0.78	kg/kWh	
Daily Coal Requirement	9333.33	Tons	
Daily Coal Requirement	388.89	TPH	
Peak daily coal requirement for BMCR flow	416.50	TPH	
Ash Percentage	46%		
Ash Generated per Unit	191.59	TPH	
ESP Ash	172.43	TPH	@90%
APH Ash	9.58	TPH	@5%
Chimney Ash	0.96	TPH	@0.5%
Total fly ash	182.97	TPH	
Evacuation Time per shift	6.00		
Fly ash system evacuation capacity per unit	243.96		
	say 240	TPH	
Furnace Bottom ash	47.9	TPH	@25%
Economiser ash	9.6	TPH	@5%

3.3.2 Design Requirements

3.3.2.1 Mechanical Equipment / Systems

General

- i. Ash collections at various points expressed as percentage of total ash generated when firing worst coal on BMCR basis.
 - a) Bottom ash collection 25%
 - b) Ash collection in economiser 5%
 - c) Fly ash collection in air pre heaters 5%
 - d) Fly ash collection in ESP 90%
 - e) Fly ash collection in chimney hopper 0.5%

- ii. Basis of various tanks capacities shall be as below
 - a) Common slurry pit (each compartment) : 5min
 - b) Ash water sump : 30min
 - c) Bottom ash over flow tank : 10 min
 - d) Drain sumps : 10min
 - e) Recovery water sump : 30min

- iii. Density of ash in kg/m³ shall be taken as follows.
 - 1) For volume consideration
 - a) Bottom Ash 650



- b) Fly Ash 750
- 2) For load consideration
- a) Bottom Ash 1600
- b) Fly Ash 1600
- 3) The particle density for ash conveying systems shall be taken as 2000 kg/m³.
- iv. Conventional lean slurry concentrations

The ash concentration (w/w) shall be as given below:

- a) For combined slurry disposal 28% max.
- b) For fly ash slurry disposal 30% max.
- c) For bottom ash slurry disposal 25% max.
- v. Design capacity for vacuum pumps & compressors shall have 10% margin. Slurry pumps shall have 10% margin over and above total friction head requirement. Water pumps shall be provided with 15% margin in capacity.

Standby arrangement for Ash handling system

Bottom Ash System	100% standby for clinker grinders, jet pumps with independent pipelines for each jet pump outlet or 100 % standby for submerged scrapper conveyor (SSC) and clinker grinders
Fly Ash System	100% standby for vacuum pumps (or conveying air compressors), collector tanks, wetting heads. 100% standby for blowers for intermediate surge hopper and storage silos, instrument air compressors, air locks/pump tanks. 50% standby for transport air compressors. Minimum one (1) number standby pneumatic conveying line for each unit.
Ash slurry disposal	One pump stream as operating standby and one pump stream as maintenance standby. Independent pipelines for each pump stream
Water system	100 % standby for BAHP pumps, BA overflow pumps, Seal water and sludge pumps. Minimum 50 % standby for BALP, FAHP and cooling water pumps.

Bottom Ash Hopper

- vi. The hopper shall be made from tested quality mild steel plates of thickness not less than 10 mm (IS:2062) and suitably stiffened with rolled steel sections. The top 1100 mm of



the hopper including seal trough shall be constructed of 6 mm thick SS : 316. In case of sea water application, the entire hopper including seal trough shall be 6 mm thick of SS:316. Hopper shall be lined with monolithic castable refractory of minimum thickness 230 mm.

Bottom Ash Water Impounded Hoppers Discharge Gates

- vii. Each gate shall be capable of discharging 100% (percent) of the contents of one hopper section, within the specified time. The gate size shall be minimum 900mm x 900mm. Electric drives for gate operation are not acceptable. The material of gates shall be as below:

Gates	Cast Iron IS:210, Gr.FG-260.
Gate wear liners	6 mm thick SS : 316
Housing wear plates/ Impingement Plates	25 mm thick Cast Iron IS: 210, Gr FG 260
Housing	10 mm thick (Min.) Mild steel IS :226 or IS: 2062

Clinker Grinders

- viii. The clinker grinder shall be single roll / double roll type and its speed shall not exceed 40 rpm and the grinder drive motor speed shall not exceed 1000 rpm. The clinker grinders shall be provided with a reversing mechanism to reverse the direction of the grinder rolls should an obstruction stall the grinder. The clinker grinder shall crush large clinkers to suitable size [normally to (-) 25 mm for transportation through pipeline. The material of construction shall be as under:

Grinder Chamber	Carbon Steel (IS:2062) ,10 mm thick.
Wear Plates	12-14% (percent) Mn. Austenitic steel plates to IS:276, 10 mm thick
Grinder Rolls & Teeth	Hadfield's Manganese steel (ASTM A128, 12-14% Mn) casting shop hardened to 300-BHN at all working surfaces and work hardened to 400 BHN at site.
Grinder shaft	Stainless Steel 304/EN-8.
Shaft sleeve	Hardened stainless steel 410/416
Clinker outlet chute	10mm thk mild steel (IS:2062) lined with wear resistant liners as above.

Sea water applications shall have suitable materials.



Jet Pumps

- ix. The Jet pumps shall be designed so that it will convey ash at the rated capacity with a minimum of 25 mm wear margin on the diameter of the throat. The material shall be wear resistant and proven type. Typically, the material shall be as per below:

Inlet Section, Throat and Discharge/Tail piece	Alloy Cast iron as per IS:4771 type 1 (a) minimum 4.5% (percent) Nickel with hardness of minimum 500 BHN.
Nozzle inlet	C.I. Grade FG-260 as per IS:210
Nozzle tip	Ceramic lined Stainless Steel /Tungsten carbide

Bottom Ash Hopper overflow Tank

- x. Each overflow tank shall have an effective storage capacity of minimum ten (10) minutes. For volumetric calculations the density of stored contents shall be taken as 1 t/m³ and for load calculations the density of stored contents shall be considered as 1.1 t/m³.
- xi. The tanks shall be constructed of tested quality mild steel plates for minimum 10 mm thickness. The tanks shall be complete with all make-up, drain, overflow and other associated piping and valves.

Submerged Scrapper Chain Conveyor

- xii. Scrapper chain conveyors shall be 2x100% (1 working + one standby) or 4x50% (2 working + 2 standby) for each boiler. The scrapper chain shall be Cr-Ni based alloy steel with minimum hardness of 750 HV (equivalent to 63 RC or 690 BHN). The upper surface of the chain shall be case hardened to a depth of minimum 3mm to offer abrasion resistance. The size of the chain shall be provided with a factor of safety of minimum five (5) over the required chain pull during startup condition with the upper trough being filled with ash up to maximum water level. In no case the dia of the chain shall be less than 26mm. The drive of SCC shall be provided with variable speed.

Vacuum Pumps

- xiii. The vacuum pump shall be of the low speed liquid ring type driven by an electric motor.
- xiv. The design shall also take into account the possibility of vacuum pumps sucking in flue gas containing SO₂ and SO₃ from the ash collection chutes.



Wetting Heads

- xv. Wetting head shall be constructed of alloy cast iron while the water nozzles shall be constructed of hardened stainless steel 400 series with minimum 500 BHN.

Intermediate Surge Hopper

- xvi. The capacity of the Intermediate Surge Hopper shall be adequate to store 30 minutes fly ash collection of a unit. It shall be complete with all other equipment needed for ash intake, ash discharge and fluidisation etc. The material of construction shall be 10 mm thick M.S. to IS:2062 with 20 mm thick abrasion resistant alloy C.I/ 10mm thick SS liners of 300-350 BHN hardness at sloping surfaces and outlet area.

Vent Filters/ Bag Filters – Pulse jet type

- xvii. Bag Filters shall be provided in vacuum conveying line above intermediate surge hoppers and vent filters with pulse jet system at silo top. These filters shall have adequate capacity to achieve 50 mg/Nm³ air quality at filter outlet. Vent fans shall be provided complete with drive motor and accessories. The material of bag shall be suitable for 140 °C continuous temperatures. Adequate “anti-static” protection will be taken (if required) in design to prevent any possibility of “dust explosion” within the silo/bag filter. The performance of the bag filter shall not get affected with 10% of the bags plugged.

Fluidizing Air Blowers

- xviii. 2x100% fluidizing blowers shall be provided for fluidizing ESP hoppers and intermediate fly ash silos with dedicated heating units to maintain the temperature of fly ash about 140°C for establishing free flow.

Air lock vessels and valves

- xix. Material of construction for air lock vessel shall be minimum 10mm thick MS plates to IS: 2062 and shall be designed as per ASME section VIII or IS: 2825 with a corrosion allowance of minimum 3 mm.
- xx. Ash intake/ ash discharge valves shall be dome type/ rotary segregating type/ cone type/ swing disc type. The size of ash intake/ash discharge valves shall be as per system requirements. Material of construction shall be as below:
- Body : Alloy cast iron with 250 BHN minimum hardness.
 - Dome/segregating slide/cone/disc: Minimum 10mm thick SS/alloy CI 300-350BHN.
 - Seat (as applicable) : Replaceable type alloy CI or SS smooth finished, hardened to 250 BHN minimum.
- xxi. Valves shall be provided with suitably located poking port/access plug/panel if applicable.



- xxii. All valves shall be subjected to cycle testing for at least 15 cycles on-off operation to ensure smooth operation.

Transport and Conveying Air Compressors

- xxiii. Compressors shall be screw type. At least 10% margin shall be provided on compressor capacity over and above the maximum flow requirement. 50 Degree C ambient and a RH of 100% shall be considered for design of capacity of compressors.

Instrument Air Compressors, Air Receivers, Air Drying Plants

- xxiv. 2x100% (percent) capacity instrument air compressors shall be provided for each unit.
- xxv. Each compressor shall be provided with an air receiver of ample size so that delivered air pressure is kept within $\pm 5\%$ (percent) of rated pressure without excessive start/stop operation in the working cycle. Air receivers shall be located convenient to compressor discharge. The receivers and associated fittings shall comply with BS:5169 and BS:1123 or other approved standards.
- xxvi. Air drying plants shall provide reliable, moisture free compressed air supply.

Vacuum and pressure conveying pipes for dry fly ash

- xxvii. Following materials shall be used for dry fly ash conveying:

Vacuum conveying:	Class-D cast iron pipes conforming to IS : 1536 or BS:1211
Pressure conveying system upto 3.5 bars	Class-D cast iron pipes conforming to IS : 1536 or BS:1211
Pressure conveying system > 3.5 bars	MS pipes to IS:3589 of 9.5 mm wall thickness or Class-D cast iron pipes conforming to IS : 1536 or BS:1211

BAHP, BALP and FAHP Water Pumps

- xxviii. The two units shall have in common 2x100% BAHP, 3x50% BALP, and 3x50% FAHP water pumps with adequate capacity and head. The pumps shall be of horizontal, centrifugal direct driven type. The HP water pumps shall be sized on the basis of the flow and head requirement of the ash handling system as required. The material for the BAHP, BALP and FAHP water pumps shall be as below:
- Casing – 2% Ni Cast iron to IS:210 Gr. FG 260.
 - Impellers – Stainless Steel to ASTM A351 Gr. CF8M / Bronze - Grade LTB1, IS:318.
 - Shaft - Stainless steel type 410 hardened /Carbon Steel EN-8 / Equivalent
 - Shaft Sleeves - Stainless steel type 316 / 410.
 - Bolts/Nuts - Steel ASTM A 193/194.



Ash Slurry Pumps

- xxix. The slurry pumps shall essentially be slow rpm pumps. The rotational speed of the impeller at design point shall not exceed 1000 rpm. These shall be designed to pump the slurry upto the ash pond taking into account the distance and ultimate height of the ash pond embankment. The first stage of slurry pumps shall have a variable speed drive.
- xxx. The ash disposal pumps shall be designed limiting the impeller tip speed to 28 to 30 m/sec.
- xxxi. The ash disposal pumps shall be constructed of materials that equal or exceed the corrosion-erosion resistance of the following materials:-

Casing (inner & Outer)	Outer casing shall be of cast steel to ASTM-A216 or spheroidal Graphite Ductile iron to ASTM-A536, 65-45-12 Inner casing (Volute liners) shall be of chrome nickel cast iron (composition to NI hard-IV) of 550 BHN OR 24% chromium cast iron of 550 BHN
Impeller/wear plate	Chrome nickle cast Iron (composition to NI-hard IV) of 550 BHN OR 24% chromium cast iron of 550 BHN
Shaft	Carbon steel to AISI K-1040/EN-8
Shaft sleeves	SS 410

Slurry Line Valves

- xxxii. Adequately sized motor operated or solenoid operated pneumatically actuated metal to metal seated knife edge gate valves, the valves shall strictly meet the testing requirements of MSS-SP 81 code for seat leakages. The material of construction shall be as under:

Body/Cover:	Cast iron FG-260 to IS:210(min. 10 mm thickness) with alloy C.I./S.S Deflection cone (minimum 400 BHN hardness) for knife edge gate valves OR Carbon steel to ASTM – A – 216 Gr WCB (0.3% carbon max.) for WCB for plug valves.
Gate/Plug	Stainless steel with min. 400 BHN Hardness on wear surface for knife edge gate valves OR Carbon steel to ASTM-A-216 Gr. WCB with hardness of 400-450 BHN suitably impregnated for low friction.
Stem	Stainless steel (SS-316) for knife edge gate valves OR IS:1875 Class C made out of ASTM-A-105 (forged carbon steel) and will be suitably impregnated for low friction.



Dry Fly Ash Storage Silo

- xxxiii. The main fly ash storage silos shall be of reinforced concrete/ steel construction with flat/ conical bottom.
- xxxiv. It shall have facilities for dry ash unloading into covered road tankers or covered wagons and conditioned fly ash in open road tankers with two blanked connections along with isolation valves shall also be provided in the silo for future. Silo arrangement shall be such that the free space between silo columns is adequate to allow movement of 2 nos. trucks side by side to be loaded simultaneously from any 2 of the 4 outlets as mentioned above.
- xxxv. The unloading conditioners and chutes individually, shall unload ash at a rate not less than amount of fly ash generated at BMCR conditions.
- xxxvi. The storage silo shall be designed to provide a clear headroom of 6 m for a road tanker to come under the silo and receive the ash from the retractable chutes. It may be noted that unloading system from Silo shall be suitable for both rail wagon unloading and closed tanker/open truck unloading.
- xxxvii. The dust loading from the outlet of the bag filters shall not exceed 50 mg per Nm³ under any operating condition with 10 per cent bags plugged.

Silo Fluidizing Air Blowers

- xxxviii. Each main fly ash silo shall be provided with adequately rated 2x100% silo fluidizing blowers with dedicated heating units for maintaining temperature of fly ash about 140⁰C for establishing free flow.

Materials for Water and Air piping

- xxxix. The material for instrument air pipe shall be GI.
 - xl. The material for conveying air pipes shall be MS.
 - xli. Water piping shall be MS ERW pipes heavy grade upto 150 NB confirming to IS:1239 and MS ERW pipes above 150 NB confirming to IS:3589 of thickness 9.4mm..

Slurry Pipes and fittings

- xlii. Slurry piping from bottom ash hopper to slurry sump: 20mm thick cast basalt lined MS pipe (MS shell 6mm thickness).
- xliii. Slurry piping from slurry sump to disposal area: 9.52 mm thick (minimum). MS pipes of min. 6 mm thick with 20mm thick cast basalt lining may be used for sea water applications.



- xliv. Fittings for slurry pipes: Ni-chrome alloy C.I. or eqvt. with minimum hardness 400 BHN. Integral wear back of minimum 20 mm thickness or 20 mm thick cast basalt lined MS fittings - (MS shell 6mm thick)

3.3.2.2 Electrical System

For design requirements of Electrical System, Section 8 of this document may be referred to.

3.3.2.3 Control and Instrumentation System

The control system for Ash Handling System shall either be Programmable Logic Controller (PLC) based or shall be implemented through micro-processor based distributed control system (DCS). For design requirements of Control & Instrumentation system, Section 8 of this document may be referred to.

3.3.2.4 Civil Works

For design requirements of Civil works, Section 9 of this document may be referred to.

3.3.2.5 Layout and Maintenance requirements

- i. While deciding the layout of buildings namely ash slurry pump house, ash water pump house, air compressor house, silo complex the following parameters shall be considered:
- a) Minimum clear working space around the equipment shall be 1200 mm.
 - In case of vertical suction / discharge pumps, the distance between edges of pedestals of adjacent pumps & the same shall be 1200 mm.
 - In case of horizontal/suction discharge pumps distance between outer of suction pipe of one pump & outer of discharge pipe of another pump shall be 1200 mm minimum.
 - Distance between inside face of column to edge of pump/pedestal shall be 1200 mm minimum.
 - b) Suction & discharge header shall preferably be routed inside the building.
 - c) In case of two (2) rows of pumps/equipment located in parallel, minimum distance between the equipment shall meet the following criteria.
 - Clear distance between edges of pedestals/motors of pump located parallel shall be 2000mm.
 - In case of space provided is acting as the handling space for the equipment by overhead crane the space shall be maximum size of equipment being handled



- plus the clearance of 500 mm minimum on either side with the stationary equipment.
- Withdrawal spaces of equipment.
- d) In case of provision of crane inside the building, provision of minimum 550 mm clear walkway at crane rail level on both the side of the building.
- e) Building height shall take care of the following parameters
- Head room for the piping/cabbling shall be 2500 mm (minimum).
 - In case of handling of the equipment one over the other, the clearance between moving & stationary equipment shall be 500 mm (minimum).
 - In case of handling of the equipment on the side of the other equipment, ground clearance of moving equipment shall be 2500 mm (minimum).
 - Head room of 2100 mm over crane rail level walkways. Pipes & cables shall be routed overground inside/outside the building.
- f) No pipe trenches are to be routed overground inside or outside the building. However, cable slits can be provided for routing of cables from the over head cable trays to the respective motor of the equipment cable slits shall be finished to surrounding floor level with adequate cushioning of sand.
- g) One maintenance bay of 6m (minimum) x the width of the building shall be provided in slurry pump house, air compressor house and ash water pump house.
- h) Two (2) nos. of rolling shutters of size 4000 x 4000 mm (min) shall be provided one at the entrance and the other at exit of maintenance bay. In case entrance & exit of maintenance bay is common i.e. on the same side, only one rolling shutter of size 4000 x 4000 can be provided.
- i) Valves shall be located such that they are accessible from the regular floor of the building, as far as possible. Valve operating platform's alongwith approach ladder/cage ladder shall be provided for the valves which are not accessible from the floor of the building.
- j) Each equipment room shall be provided with alternative exits in case of fire/accidents as per requirement of factories act and statutory bodies/insurance companies.
- k) Hoist maintenance platforms alongwith approach ladder shall be provided, preferably at the end of the building.
- l) Fresh air supply/exhaust air fans shall be located at a minimum height of 2500 m.
- m) It is preferable to raise the elevation of wetting unit / collector tower such that discharged slurry pipelines are routed through over head pipe trestle and all the slurry pumps are installed at ground level only. This is however site layout dependent.
- ii. The following criteria in addition to those specified above shall be followed for sizing the various buildings.



A) Ash slurry pump house

- a) Ash slurry pit shall have be two sump compartments with one common trough at the inlet with 2 nos. adequately sized manually operated / motorised plug gates. Each sump compartment shall be sized for five (5) minutes of storage capacity of total slurry flow between high & danger low level. Not more than two pump streams shall take suction from one sump. Independent sump for each slurry pumping stream may also be adopted. Hand railing shall be provided all around the sump top. Two (2) nos. access ladders 600 mm wide shall be provided to access bottom of the sump
- b) 1.5 M (clear) wide RCC passage way shall be provided along the length of pump house, after last pump in each stream.
- c) Two (2) nos. 1200 mm wide staircase shall be provided, one on either end of the pump house for entry into dry pit i.e. bay housing first stage pumps, for such layout where first stage pumps are located in a pit below ground level.
- d) Two nos. rolling shutters of 4 m x 4m (min) size shall be provided.
- e) Ash slurry sumps shall be clear of intermediate columns. Further the pump house shall also be provided with columns only at periphery without any intermediate columns.

B) Ash Water Pump House

- a) Sump shall be provided along the entire length of the building. Hand railing shall be provided all around the sump top.
- b) Ash water sump shall be clear of intermediate columns. Further the pump house shall also be provided with columns only at periphery without any intermediate columns.
- c) Two (2) nos. 1200 mm wide stair case shall be provided on either side of the sump, to reach on the top of the sump.
- d) Two (2) number access ladders 600 mm wide shall be provided to access bottom of the sump.

C) General

- a) Grating shall be provided to cover the complete sump for all sumps including sumps in the combined ash slurry pump house, ash water pump house, silo area and surge and setting tanks in bottom ash overflow treatment area. Further the grating platforms required in any of the buildings housing ash handling system equipments shall also be supplied including the structural steel supports.
- b) All the RCC trenches and drains shall be provided with grating. Wherever the depth of the trench increases to 2.5 M, the trench shall be converted into underground tunnel. Suitable manhole covers with access ladders at suitable intervals shall be provided. Further the trench in between the two ESPs as also in passageways in boiler and ESP area shall be provided with heavy duty precast covers for movement of heavy duty equipment.



- c) All the buildings shall be provided with columns only at periphery without any intermediate columns.
- d) Fly ash silos shall be located in a separate area near the plant boundary, with independent access.
- e) The vacuum pumps and conveying air compressors shall be kept as close to the ESP as possible to reduce energy requirement and better effectiveness of vacuum and compressed air used in pneumatic conveying.

3.4 PERFORMANCE REQUIREMENTS

3.4.1 Performance and Guarantee Tests

- a) Prior to conducting of PG test, the ash handling plant shall be on a trial operation for 14 days to establish full range operation of ash handling plant.
- b) The performance guarantee tests shall be conducted for three (3) days of operation of the boiler at 80% to 100% load. In case of any major breakdown in any of the equipment disrupting the operation of Ash Handling Plant, the breakdown period shall be added to the testing period of 3 days.
- c) The performance guarantee test shall be conducted to prove uninterrupted operation of ash handling plant of each unit separately as they are completed and all units simultaneously when they are completed. The ash handling plant shall be operated with its normal auxiliaries, (as applicable commensurate with the number of boiler units in operation) without using standby pumps or any other standby equipment.

3.4.2 Performance Guarantees

The parameters guaranteed shall have no tolerance value whatsoever. The equipment and systems offered shall be guaranteed to meet the following performance.

(a.) Bottom Ash Handling System

In case of intermittent type bottom ash removal system employing water impounded hopper and jet pumps, the system shall be guaranteed to meet the following performance:

- i) Continuous effective extraction, crushing and conveying of bottom ash generated during various modes of boiler operation to the ash slurry sump and the continuous effective pumping of combined slurry from this sump to the ash slurry dump area. The extraction of bottom ash shall be done as per frequency and collection rates specified as per clause 3.3.1.a).
- ii) Power consumption (kW) as measured at motor input terminals for all motors operating during continuous effective ash extraction rate as outlined in a (i) above.
- iii) Rated capacity at rated head of all pumps.



In case of continuous type bottom ash removal system employing submerged scrapper chain conveyors, the system shall be guaranteed to meet the following performances.

- i) Continuous effective discharge, crushing and sluicing of bottom ash generated during various modes of boiler operation to the bottom ash slurry sump and the continuous effective pumping of slurry from this sump to the main slurry sump in ash slurry pump house for onward effective pumping from main sump to the ash slurry dump area.
 - ii) Conveying Capacity of submerged scrapper chain conveyor:
 - (a) Continuous normal conveying capacity 50 T/hr or 25 T/hr (as the case may be) of the submerged scrapper chain conveyors with the linear speed of chain not exceeding 2.0 m/min. (guaranteed extraction rate).
 - (b) Dead start capability of submerged scrapper chain conveyor i.e. it shall be able to start and discharge the bottom ash with water filled trough full of bottom ash upto maximum water level.
 - iii) Power consumption (KW) as measured at motor input terminals for submerged scrapper chain conveyors, ash crushers and pumps operating at the guaranteed conveying rate.
 - iv) Rated capacity at rated head of all pumps
 - v) The continuous effective conveying and pumping as stated above shall be established by no stagnation of ash or slurry at any point in the complete system and with all interlocks, protections and sequential operation working satisfactorily.
- (b.) **Economiser and Air Pre-heater Ash Handling System**
- Continuous effective conveying of ash collected in economizer in wet mode and continuous effective conveying of ash collected in air preheater in wet or dry mode, as envisaged for the plant. The continuous effective conveying of ash as stated above shall be established by no stagnation of ash or slurry at any point in the complete system and with all interlocks, protections working satisfactorily.
- (c.) **Fly Ash Handling System**
- i) Continuous effective conveying of fly ash from all fly ash collection hoppers, in dry and wet form, i.e. ESP hoppers, generated during various modes of boiler operation upto collector tank/ intermediate surge hoppers, from intermediate surge hoppers to ash storage silo and from collector tank to the ash slurry sump and the continuous effective pumping of ash slurry from this sump to dyke area. The fly ash collected in each unit in every shift of eight (8) hours corresponding to maximum ash collection rates shall be extracted in six (6) hours.
 - ii) The continuous effective conveying and pumping as stated above shall be established by no stagnation of ash or slurry at any point in the complete system and with all interlocks, protections and sequential operation working satisfactorily.



- iii) Rated capacity at rated discharge pressure of each air compressor/blower/vacuum pump as applicable.
- iv) Power consumption (kW) of air compressors/blowers/vacuum pumps, as applicable, as measured at motor terminals when operating at the rated capacity and pressure as stated in c(3) above.
- v) The performance listed in (iii) & (iv) above shall be performed on test rig at the vendor's works using actual motor in case of HT drives. However, for LT drives, shop test motor may be used.

(d.) Ash water and Seal Water Pumps

- i) Rated capacity at rated head of each ash, seal and flushing water and other water pumps.
- ii) Power consumption (KW) of each ash, seal and flushing water pump and other pumps as measured at motor input terminals when operating at the rated capacity and head as stated in d (i) above.
- iii) The performance listed in (i) & (ii) above shall be performed on test rig at the vendor's works using actual motor in case of HT drives. However, for LT drives, shop test motor may be used.

(e.) Ash slurry Disposal Pumps

- i) Rated capacity at rated head of each ash slurry disposal pump.
- ii) Power consumption (kW) of each ash slurry disposal pump as measured at motor input terminals when operating at the rated capacity and head as stated in (e)(i) above. The power consumption figure shall be corrected to take into account ash slurry as the pumping medium.
- iii) The performance listed in (i) & (ii) above shall be performed on test rig at the vendor's works using actual motor in case of HT drives. However, for LT drives, shop test motor may be used.

(f) Power consumption

- i) The actual power consumption for the complete ash handling plant of two (2) units shall be worked out by using the following formula:

$$P = \sum(p \times n \times f)$$

P = Total power consumption.

p = Power consumption of the Individual drives listed below, at motor input terminals without any negative tolerance during PG test (at shop or site as the case may be)

n = No. of drives in operation

f = Weightage factor for the various drives as listed below



List of weightage factors* for various drives.

S. No.	Drive	Weightage Factor
1.	Bottom clinker grinder	0.25 for jet pump system & 1.0 for submerged scrapper conveyor system
2.	Bottom Ash H.P. Water Pumps	0.25 for jet pump system & 1.0 for submerged scrapper chain conveyor system
3	Bottom ash L.P. Ash Water Pumps	1.0
4.	Fly ash water pumps	1.0
5.	Bottom Ash Slurry Transportation pumps	1.0
6.	Submerged scrapper chain conveyor	1.0
7.	(i) Fly ash conveying air compressors with air drying plant (ADP)	1.0
	(ii) Fly ash conveying vacuum pumps	1.0
	(iii) Transport air compressor with air drying plant	0.5
8.	BA hopper cooling water over flow water pumps	1.0
9.	Ash slurry disposal pumps	1.0
10.	Seal/cooling water pumps	1.0
11.	Instrument air compressor with air drying plant	1.0
12.	Economiser/ economizer bypass ash water pump (If Applicable)	1.0

* The weightage factors given in the table above shall be guided by the hours of operation of each equipment. For example, if the bottom ash clinker grinder operates 1 hour per 4 hours, the weightage factor shall be considered as 0.25.



- ii) Using the above computation method, if the actual power consumption exceeds the guaranteed power consumption, liquidated damages shall be payable.

3.5 CODES AND STANDARDS

The design, manufacture, inspection and testing of the Ash Handling System shall comply with all the currently applicable statues, regulations and safety codes in the locality where the equipment is to be installed. The equipment shall confirm to the latest edition of the following standards & codes. Other internationally acceptable standards/codes, which ensure equal or higher performance, shall also be accepted.

Air Compressors, vacuum pump, Air Receivers, Air Drying Plants

BS-1571 (Part I&II). Acceptance test for positive displacement compressors and exhausters

IS : 6206 Guide for selection, installation and maintenance of air compressors, plants with operating pressures upto 10 bars

Code PTC-9 Displacement compressors, vacuum pumps and blowers

IS: 5727 Glossary of terms relating to compressor and exhausters.

IS : 5456 Code of practice for testing of positive displacement type air compressors and exhausters.

BS : 726 Compressor performance test.

IS : 3401 Silica Gel

ISO : 1217 Displacement Compressors-Acceptance tests

Pipes

IS : 1536 or BS:1211 Centrifugally cast (spun) iron pressure pipes for water, gas and sewage

IS:3589 Steel Pipes for Water and Sewage (168.3 to 2 540 mm Outside Diameter) – Specification

IS:1239 MS tubes and tubular for sizes upto 150 NB

Pumps

IS 1520 Horizontal centrifugal pumps for clear, cold fresh water.

IS 5120 Technical requirements for rotodynamic special purpose pumps

IS 5639 Pumps handling chemicals & corrosive liquids

IS 5659 Pumps for process water.

IS 6536 Pumps for handling volatile liquids.

API 610 Centrifugal pumps for general refinery service.

Standards of Hydraulic Institute of U.S.A.



ANNEXURE 3A

TYPICAL SCOPE OF WORKS FOR BALANCE OF PLANT OF THERMAL POWER PROJECT (2X500MW) : ASH HANDLING PLANT

3A.1.0 SCOPE OF WORK

The scope of ash handling plant typically covers the design, engineering, manufacture, inspection and testing at manufacturer's works, supply, packing and delivery at project site, unloading, storage and in plant transportation at site, erection, supervision, pre-commissioning, testing, successful commissioning, performance testing and handing over of ash handling plant of the thermal power project. Scope of work shall include all mechanical, electrical, C&I, accessories, civil, structural and architectural works to make the system complete.

Typical scope of work for 2x500 MW thermal power project includes:

3A.2.0 SCOPE OF MECHANICAL WORKS

The scope of work comprises turnkey supply, erection and commissioning of complete mechanical works of ash handling system for two (2) nos. boilers of 500 MW nominal rating and their associated electrostatic precipitators. The scope of work also includes supply and erection of dry fly ash storage silos for ash utilization purposes.

3A.2.1 The scope of work shall include the design, engineering, manufacture, shop fabrication, assembly, testing and inspection at manufacturer's works, type testing wherever applicable, packing, ocean shipment, marine insurance, custom clearance, port clearance and handling, inland transportation, inland transit insurance, delivery at site, unloading, handling, storage and in plant transportation at site, complete services of erection including erection supervision and site testing, inspection, all associated civil, structural and architectural works, insurance during, storage, erection and commissioning, performance testing and handing over to the Owner, of Ash handling system.

3A.2.2 The equipment and materials to be supplied shall form a fully comprehensive ash handling system. Any items though not specifically mentioned but which are required to make the plant complete in all respects for its safe, efficient, reliable and trouble free operation shall also be taken to be included, and the same shall be supplied and erected.

3A.2.3 The work consists of mechanical and electrical work and equipment, all associated civil, structural and architectural works, Control and Instrumentation equipment, mechanical services and pipe work and electrical services associated with this ash handling system, the principal features of this system being:

- (f.) Wet ash conveying system for ash collected in the boiler furnaces, economizer/economizer bypass duct and air pre heater ash hoppers including treatment system of bottom ash hopper overflow water.



- (g.) Dry fly ash conveying system for the ash collected in electrostatic precipitators collection hoppers.
- (h.) Dry fly ash transportation and storage system which includes dry ash storage silos.
- (i.) Combined fly ash and bottom ash slurry disposal system.
- (j.) Ash water supply system.
- (k.) Pendant controlled overhead traveling cranes to handle the equipment in ash water pump house, ash slurry pump house, compressor house etc. as specified complete with runway rails with necessary rail clamps, bolts, splice bars and end stops for each of the runway.

3A.2.4 Bottom Ash Handling System

Bottom ash handling system starts from the boiler furnace bottom to the disposal of ash slurry in the sump of combined ash slurry pump house, consisting of: -

- (a.) In case of intermittent type bottom ash handling system employing W-type water impounded hoppers and jet pumps, the plant shall include, at least, the following basic elements.
 1. Two (2) numbers water impounded bottom ash hoppers of structural steel complete with hydraulically operated discharge gates, refractory cooling arrangement, hopper overflow, water seal boxes, sluicing headers with nozzles, seal trough with overflow connection, refractory lining, access doors, observation and inspection glass windows, poke holes, supporting steel structures, platforms, stairs and all accessories as specified and as required.
 2. Eight (8) numbers clinker grinders complete with drive motors, rails, fluid coupling, gear reducers and accessories as specified as required.
 3. Eight (8) numbers jet pumps along with discharge gate housing, using flushing and drain connection, etc. as specified and required.
 4. Eight (8) lengths of bottom ash slurry transportation pipe of 6mm thick MS pipe having 20 mm thick cast basalt lining (one (1) no. independent pipe line for each Jet pump) complete with basalt lined pipe bends, fixtures, elbows, gaskets, nuts, bolts, structural steel supports and other accessories as specified and as required, from the outlet of jet pumps to the ash slurry sump in the ash slurry pump house.
 5. All make up, overflow, drain and other piping, valves and accessories, including hangers, pipe supports etc. as required and necessary to complete the bottom ash handling system.



- (b.) In case of continuous type bottom ash handling system employing dry type bottom ash hopper cum transition chutes and sub-merged scrapper chain conveyors, the plant shall include at least, the following basic elements.
1. Two (2) numbers dry type bottom ash hopper of structural steel, each hopper complete with hydraulically/electrically operated hopper isolation gates (minimum 1000mm x 1000 mm) with provision for manual operation, seal troughs with overflow connection, refractory lining, access doors, inspection glass windows, poke holes, quenching nozzles, supporting steel structures, platforms, stairs and accessories as specified and as required.
 2. Four (4) nos. of 100% capacity (one (1) no. working + one (1) no. standby for each unit) or Eight (8) nos. of 50% capacity (two (2) nos. working + two (2) nos. standby for each unit) submerged scrapper chain conveyors, complete with hydraulic drive with gear reduction unit (if necessary) of suitable design, as specified and as required. Standby scrapper conveyor shall be installed adjacent to the working scrapper conveyor units. The standby scrapper conveyor units shall not be connected to boiler and the same shall be brought under the boiler bottom, whenever the working scrapper conveyor unit is to be taken out for maintenance. The Scrapper units shall be provided with rails, wheels and suitable motorized self propulsion arrangement to facilitate their removal from under the boiler furnace and its replacement with the standby scrapper conveyor unit.
 3. Four (4) nos. or eight (8) nos. clinker grinders complete with drive motors, fluid couplings, gear reducers and accessories as specified and as required.
 4. Rails for grinder and water filled trough assembly.
 5. All make-up, overflow and drain piping with necessary valves and accessories including hangers and supports as required and as necessary to complete the bottom ash handling system.
 6. Bottom ash slurry transportation pumping system starting from the bottom ash slurry sump to the main slurry sump in ash slurry pump house consisting of :
 - i. Six (6) streams of horizontal bottom ash slurry transportation pumps and motor sets, variable speed hydraulic coupling complete with all the accessories of drive and mounting as specified (Three (3) nos. for each unit, out of which one will be working, one will act as normal standby and other stream will act as maintenance standby for each unit)
 - ii. Four (4) lengths of bottom ash slurry transportation pipe of 6mm thick MS pipe having 20 mm thick cast basalt lining complete with bends, fixtures, elbows, gaskets, nuts, bolts, structural steel supports and other accessories as specified and as required from the bottom ash slurry transportation pump house(s) to the ash slurry sump in the Ash Slurry Pump house.
 - iii. Twelve (12) nos. solenoid operated pneumatically actuated knife edge gate valve at the suction and discharge of bottom ash slurry transportation pumps.



7. Cast iron liners for lining the slurry trench and alloy cast iron liner for lining the sump.
8. All jetting nozzles for the trenches and agitating nozzles for slurry sump as specified and as required.
9. Four (4) numbers vertical sump drainage pumps (slurry duty) with motors complete with piping, valves, fittings, supports, inserts, sleeves etc.
10. Two (2) mono rail hoist (one (1) for each unit) for BA slurry pump handling, complete with runway rails, necessary rail clamps, bolts, splice bars and stops for the runway.

3A.2.5 Common for Bottom Ash Handling

- (i) One (1) number flushing equipment below each economizer /economizer bypass duct, primary and secondary air pre heater hoppers, complete with flushing nozzles, expansion joints, vertical pipe connections, gaskets, slurry discharge and overflow pipes and necessary fixing clamps and structural steel supports as specified and as required.
- (ii) One (1) number hopper isolation valve assembly below each economizer/economizer bypass duct, primary and secondary air pre heater hoppers as specified complete with hopper connecting flanges, gaskets, nuts, bolts etc.
- (iii) MS disposal pipes for transfer of economizer / economizer bypass duct hoppers and air pre heater hoppers ash slurry from flushing apparatus to economizer /APH slurry trench complete with pipe bends, fixtures, elbows, gasket, supporting steel structure etc.
- (iv) Cast iron liners for lining the slurry trenches.
- (v) All instrument air piping to the various valves and instruments complete with fittings, valves, pressure reducing station, filters, flanges, gaskets, nuts and bolts, hangers, supports, etc, as specified as required.

3A.2.6 Dry Fly Ash Conveying System

Scope under this portion for dry fly ash conveying system starts from electrostatic precipitator ash collection hoppers outlet onwards and consist of :-

- (a.) **For Vacuum Conveying System**
 - (i) One (1) no. material handling valve/feed valve at the outlet of each ESP hopper. One (1) no. chute isolation valve at the outlet of each ESP hopper. Expansion joints wherever required shall also be provided.
 - (ii) Eight (8) nos. Mechanical vacuum pumps along with drive and accessories for each unit. Out of Eight (8) nos., four (4) nos. shall be working & four (4) nos. shall be dedicated standby for each unit. The



valves at the suction of vacuum pumps shall be butterfly type having rubber seating arrangement.

- (iii) Dry fly ash conveying cast iron pipes from ESP hopper outlet onwards up to intermediate surge hoppers/collector tanks complete with valves, specialties, bends, pneumatic actuators, structural steel supports, platforms, etc.
- (iv) Four (4) nos. fly ash surge-cum-collection intermediate surge hoppers each complete with supporting steel structures, platforms, stairs, aeration system, primary collector, secondary collector along with bag filter etc. or target box along with bag filter etc. for each unit.
- (v) Eight (8) nos. collector tanks each complete with wetting heads, air-washers, seal boxes supporting structure, platforms etc. for each unit.
- (vi) Monorail hoists for handling vacuum pumps and intermediate surge hopper aeration blowers complete with runway rails, necessary rail clamps, bolts, splice bars and stops for the runway.

(b.) **For Pressure Conveying System**

- (i) One (1) no. material handling valve/feed valve at the outlet of each ESP hopper. One (1) no. chute isolation valve at the outlet of each ESP hopper. Expansion joints wherever required shall also be provided.
- (ii) One (1) no. air lock/pump tank below each ESP hopper.
- (iii) Four(4) nos. air compressors along with drive and accessories for each unit. Out of four (4) nos., two (2) nos. shall be working and two (2) no. shall be standby. Each compressor shall be provided with a dedicated refrigerant type air dryer and air receiver.
- (iv) Dry fly ash piping (as given in 3.3.2.1 xxvii) from ESP hopper outlet onwards up to intermediate surge hoppers complete with valves, specialties, bends, pneumatic actuators, structural steel supports, platforms, etc.
- (v) Four (4) nos. fly ash intermediate surge hoppers each complete with supporting steel structures, platforms, stairs aeration system, primary collector & secondary collector along with bag filter or target box along with bag filter etc. for each unit.
- (vi) Twenty four (24) nos. feeders (three nos. per intermediate surge hopper) for dry ash and Twenty four (24) nos. wetting units along with supporting steel structures, platform etc. below intermediate surge hoppers in each unit for converting ash into slurry. Out of twenty four (24) nos., sixteen (16) nos. shall be working and eight (8) nos. shall be standby



3A.2.7 Common for vacuum and pressure Conveying system

- (i) All interconnecting compressed air/exhaust pipelines complete with valves and fittings and supporting steel structure.
- (ii) M.S. Disposal pipes for transfer of slurry from collector tank to fly ash slurry trench with supporting structures. Fly ash slurry trench shall be provided below collector tanks to transfer fly ash slurry from collector tanks to slurry sump in the combined ash slurry pump house as specified and as required.
- (iii) Cast iron liners for lining the slurry trench up to ash slurry pump house.
- (iv) All nuts, bolts and jointing materials at flanged termination points.
- (v) Mechanical ventilation (supply/exhaust fans) for different areas in vacuum/extraction compressor house and air conditioning of main control room housing DDCMIS based main control desk.
- (vi) One (1) no. pendant controlled electrically operated overhead traveling crane for each conveying air compressor house as specified complete with runway rails, necessary rail clamps, bolts, splice bars and stops for each of the runway.
- (vii) Two (2) x 100% instrument air compressors for each unit i.e. one (1) working and one (1) standby, along with its dedicated air drying plants, air receivers complete with motors, valves, pads and pipelines along with supporting steel structures to meet the complete requirement of ash handling plant such as actuation of material handling, segregation valves ; various water and airline valves, slurry valves; bag filter cleaning etc.
- (viii) Two (2) x 100% capacity aeration blowers per unit for aeration upto intermediate surge hoppers, wetting head/collector tank tower during dry/wet mode of operation, each complete with dedicated heaters, valves, pipelines including supporting steel structure, insulation, silencer, filters and all other accessories as specified and as required.
- (ix) Suitable ventilation and lighting system shall be provided for tunnel section of slurry trench.

3A.2.8 Wet Fly Ash Slurry System

This system shall consist of :

- (i) Eight (8) [four (4) working and four (4) stand-by] wetting heads
- (ii) Eight (8) [four (4) working and four (4) stand-by] collector tanks
- (iii) Eight (8) [four (4) working and four (4) stand-by] air washers.
- (iv) One (1) ash slurry line from each collector tank to the common ash slurry sump.



3A.2.9 Dry Fly Ash Transportation and Storage System

Scope under this portion for dry fly ash transportation and storage system starts from the outlet of intermediate surge hoppers and consists of:

- (a.) Eight (8) nos. of pump tanks/air locks for each unit, two each at the outlet of each intermediate surge hoppers, for transportation of dry fly ash to storage silos. Out of two (2) nos. pump tank/air lock at the outlet of each hopper, one will be working and one will be standby.
- (b.) Three (3) numbers (2 working + 1 stand by) transport air compressors for each unit along with silencer, filter, drive motor, after cooler along with all other accessories and supporting structures, platforms etc. as specified and as required.
- (c.) Three (3) numbers (2 working + 1 stand by) refrigerant type air dryer for each unit along with accessories as specified and as required.
- (d.) Three (3) numbers (2 working + 1 stand by) air receivers for each unit along with safety relief valve, automatic drain trap and other accessories as specified and required.
- (e.) Six (6) (4 working + 2 standby) lengths of pipes (material as per cl. 3.3.2.1 xxvii) for both units for fly ash conveying from intermediate surge hoppers to storage silos, including pipe rack, trestles, platforms, access stairs and other associated supporting steel structure and other accessories as required.
- (f.) Four (4) nos. dry ash storage structural steel or RCC silos with systems for road and rail loading of dry fly ash and complete with an aeration system, dust separators and all other accessories as required and as specified. The silos shall be complete with all fittings, accessories and supporting steel structures, access staircases, platforms, as required for safe and reliable operation and maintenance of dry fly ash storage system.
- (g.) Aeration plant consisting of silo aeration blowers (one for each silo + one common standby) each complete with dedicated heaters, valves, pads and pipelines including supporting steel structures, insulation, silencer, filter and all other accessories for aeration of silos.
- (h.) One (1) no. air receiver along with safety relief valve, automatic drain trap and other accessories complete with supporting steel structures to meet the complete requirement of ash storage silo such as actuation of silo ash inlet valves, segregation valves ; various water and airline valves, slurry valves ; bag filter cleaning etc.
- (i.) Target box and bag filter assembly along with pulse jetting arrangement, fan units etc. and other accessories.
- (j.) Four (4) nos. slide plate type isolation valves below each storage silos and six (6) nos. silo inlet valves as specified.
- (k.) Four (4) numbers of rotary drum type hydro-mix conditioner units along with drive motor, rotary feeder, one (1) number for each silo, along with associated water piping and valves, for unloading the conditioned fly ash into trucks.
- (l.) Five (5) nos. ash conditioner pumps (1 for each unloader + 1 common standby) for conditioned ash unloaders along with drives and controls as required and specified.
- (m.) Four (4) number of dry fly ash unloaders (one for each dry fly ash storage silo) along with rotary feeders, telescopic chutes and other accessories as specified and as required.



- (n.) All necessary hydraulic or pneumatic actuators.
- (o.) All interconnecting compressed air pipelines complete with valves, fittings, pipe rack and supporting steel structure.
- (p.) 2 x 100% wash water pumps along with drive motor and accessories in silo area along with dedicated hose pipe.
- (q.) 2 x 100% vertical sump drainage pumps along with drive motor and accessories in silo area to pump the accumulated ash water to the combined ash slurry disposal pump house sump including piping along with necessary valves, fittings, supports, etc. as specified as required.
- (r.) One(1) number pendant controlled overhead traveling crane each in transport air compressor house and silo area utility building to handle the equipment in the transport air compressor house and silo area utility building pump & blower room, as specified complete with run way rails, necessary rail clamps, bolts, splice bars and end stops for each of the runway.
- (s.) All nuts, bolts and jointing materials at flanged termination points.
- (t.) Mechanical ventilation (supply/exhaust fans) for different areas in utility building.

3A.2.10 Ash Slurry Disposal System

Scope under this portion for ash disposal system starts from ash slurry sump in the combined ash slurry pump house and consists of :

In the combined Ash Slurry pump house

- (i) Four (4) streams of horizontal ash slurry disposal pumps complete with drive motors, variable speed hydraulic couplings, for first stage pumps and fixed belt drive arrangements for subsequent stages, base plates, foundation bolts, inserts, embedments and accessories as specified and as required.
- (ii) Four (4) lengths each of required length as per plant layout and garlanding around ash pond, of ash slurry disposal pipelines (excluding the length of bends & fittings from the ash slurry pump house to the ash dyke including the lines around the ash dyke and extensions into the dyke at a number of discharge points complete with basalt lined bends, specialties, fittings, fixtures, pipe couplings, gaskets, nuts, bolts, clamps, embedments, structural steel supports for piping system and other accessories.
- (iii) Complete ash slurry piping along with bends, supports along with bolts, nuts, clamps etc. inside the ash slurry pump house. All the piping inside the pump house shall be basalt lined.
- (iv) Eight (8) nos. adequately sized motor operated or solenoid operated & pneumatically actuated metal to metal seated knife edge gate valve/100% tight shut off rubber lined knife edge gate valves/plug valves shall be provided at the suction and discharge of combined ash slurry disposal pumps.
- (v) Four (4) nos. slurry sump compartment isolation valves.



- (vi) Eight (8) nos. of manually operated plate valves at the slurry disposal pipelines outlets in the dyke area as specified and as required.
- (vii) Two (2) nos. vertical sump drainage pumps with motors complete with piping, valves, fittings, supports, inserts, sleeves etc.
- (viii) Alloy Cast iron liners (as specified) for lining the ash slurry sumps.
- (ix) One (1) no. pendant controlled overhead traveling crane to handle the equipment in ash slurry pump house, as specified complete with runway rails with necessary rail clamps, bolts, splice bars and end stops for each of the runway.
- (x) Mechanical ventilation (supply exhaust fans) for different areas in ash slurry pump house and switchgear rooms.

3A.2.11 Ash Water Pumps, Water Piping and Accessories

- (a.) All types of ash water pumps namely bottom ash LP water, bottom ash HP water, fly ash HP water, flushing water pumps etc. complete with drive motors, base plates, foundation bolts, inserts, embedment and accessories as specified and as required. Complete ash water pipe lines, valves, fittings, pipe rack, structural steel supports for piping system and other accessories as specified and as required. The ash water pumps namely bottom ash LP water, bottom ash HP water, fly ash HP water, Flushing water pumps are to be located in Ash water pump house.
- (b.) Seal/cooling/other water pumps and motors complete with all the accessories of drive and mounting as specified and as required.

3A.2.12 Bottom ash over flow water system

- (i) One (1) number bottom ash over flow water storage tank for each unit, including structural steel supports.
- (ii) Minimum one (1) number settling tank and minimum one (1) number surge tank common for both units or per unit including its structural steel supports, platforms, staircases and all accessories.
- (iii) Two (2) number bottom ash over flow water pumps (one (1) working and one (1) standby) for each unit complete with drive motors, variable speed hydraulic coupling and other accessories as specified and required for pumping BA hopper/SSC upper trough cooling water overflow from Bottom ash overflow water storage tank/sump to settling tank.
- (iv) Bottom ash overflow water pipes from BA hopper to BA overflow water storage tank in case of jet pump system or to BA overflow water sump in BA slurry pump house in case of SCC system, from BA overflow water tank/sump to suction of BA overflow water pumps, from discharge of BA overflow water pump to settling tanks complete with valves, fittings, structural steel supports etc. Overflow transfer pipes to transfer clear water from surge tank to over ground sump of ash water pump house, by gravity flow.



- (v) Two (2) nos. sludge pumps, to remove sludge from settling & surge tank to sump of combined ash slurry pump house.
- (vi) Any treatment facility required to ensure that bottom ash over flow water total suspended solids is restricted to 100 ppm.

3A.3.0 ELECTRICAL SYSTEM

Two no. feeders shall be provided from 3.3kV station switchboards for Ash Handling Plant. Further, distribution of power supply at 415V voltage level and all other required electrical equipment for putting ash handling plant into successful operation shall be in the scope of work of AHP supplier. The 415V supply shall be arranged through 3.3/0.433kV LT auxiliary transformers.

Separate arrangement shall be made for providing power supply to ash water recovery pumps switchgear.

Typically, following electrical equipments shall be included :

- i) 3.3/0.433kV auxiliary transformers
- ii) 3.3kV and 415V switchgears
- iii) HT and LT busducts
- iv) Power and control cables including incoming cables from 3.3 kV station switchboard.
- v) Cable laying alongwith cabling accessories, cable trays and termination/ jointing kits of cables, and fire sealing
- vi) HT and LT motors
- vii) 220V DC system comprising of battery banks, chargers and DC distribution boards (if required)
- viii) Complete illumination system for internal and external lighting of associated plant and building
- ix) Complete grounding and lightning protections and its interconnection with nearest earth mat
- x) Emergency stop push button for all HT and LT motors



3A.4.0 CONTROL & INSTRUMENTATION SYSTEM (FOR PLC BASED SYSTEM)

- i) Microprocessor based programmable logic control (PLC) system for operation, control and monitoring of the entire ash handling plant from the ash handling system control room located near ash slurry pump house. One number operator work station and one number programmer's work station shall be provided common for both the units. It shall be possible to monitor the ash handling plant from the main DCS in the Unit Control Room through soft link.
- ii) PLC based control system, one for each unit, for control of various drives in bottom ash area or remote I/O can be provided depending on distance/location. These systems shall also be controllable from main ash handling control room.
- iii) PLC based silo control panel along with mimic for control of various drives in silo area. These systems shall also be controllable from main ash handling control room.
- iv) Micro PLC or Relay based local control panel for ash water recovery system pumps located in ash pond area.
- v) Necessary field instruments viz. level switches for hoppers/sumps/tanks, pressure/vacuum gauges, d.p. gauges, pressure/vacuum switches, temperature sensors etc.

3A.5.0 SCOPE OF CIVIL WORKS

The works to be performed under this package consists of design, engineering, construction, leveling, grading, providing and supplying all labour, materials, consumables, construction equipment, temporary works, temporary storage sheds, temporary site offices, constructional plants, fuel supply, tools and plant, scaffolding, supplies, transportation, all incidental items not shown or specified but reasonably implied or as necessary for successful completion of the works, including Contractor's supervision and in strict accordance with the drawings and specifications, including revisions and amendments thereto, as may be required during the execution of work.

3A.5.1. The complete works under this scope is referred to as Civil, structural and architectural works. Buildings including pump houses, MCC / switchgear rooms, sumps / tanks, transformer and other equipment foundations, pipe supporting structures & trestles/ thrust blocks, including foundations / pedestals / trestles / thrust blocks / hoppers, silos / bins, drains / trenches, area drainage, plants and systems, facilities, etc. as per system requirement, as specified elsewhere in this specification. The scope of civil/architectural works is defined hereunder for clarity. However, all civil/architectural works required to complete the ash handling system shall be included, even if the scope is not explicitly defined hereunder:

1. Combined ash slurry pump house along with related sumps.
2. Ash water pump house along with related sumps.
3. Air compressor house



Standard Design Criteria/Guidelines for Balance of Plant of Thermal Power Project
2 x (500MW or above)

Section- 3 (Ash Handling Plant)

4. Vacuum pump house & blower sheds.
5. Switchgear/control room/RIO rooms
6. Bottom ash transportation pump house alongwith related sumps (if applicable)
7. Supporting structure and foundations for bottom ash hopper, Intermediate surge hopper & collector tank and supporting structure and foundation for settling tank and surge tank, transformers and other misc. foundations.
8. Pipe racks along with foundations.
9. F.A transportation pipe trestles and foundations. Grating shall be provided for the entire length of pipe trestles.
10. B.A. slurry pipe pedestals.
11. Bridges/ Culverts for roads / pipe crossings/nallah/boundary wall etc.
12. Supporting structure for Dry Ash Silos alongwith foundations.
13. Silos including utility Building, office and switchgear rooms including paving, fencing, sentry house, gate, drainage etc. for silo area.
14. Supply and laying earthing mat all around the periphery of buildings, structures, and outdoor equipments,
15. Access roads to all buildings/facilities of AHP including construction and maintenance of temporary access roads for approach to the building/facilities for construction/erection activities.
16. Cable trenches, cable slits as required.
17. Transformer foundations with required cable slits , soak pit, fire wall, fencing & gates.
18. HT/LT switchgear buildings for ash handling system.
19. Ash slurry pipe pedestals and thrust blocks/ culverts including garlanding of ash dyke.
20. Survey for all areas under the scope including the ash pipe corridor (inside and outside the plant boundary) and development of layout of pipes.
21. Any culverts/ road crossings , if required based on or site conditions , the same shall be provided including all statutory clearance from concerned authorities for crossing his pipe/trestles over road / rail / culverts / nallah etc.



22. Maintenance road along ash pipe corridor. Wherever the maintenance road approaches cart roads, bridges etc. the longitudinal slope shall not be steeper than 1 : 20.
- 3A.5.2 The nature of works shall generally involve earthwork in excavation including controlled blasting and very deep underground excavation, extensive de-watering, shoring and strutting, sheet piling, back filling around completed structures and plinth protection, area paving, disposal of surplus excavated materials, piling, concreting, including reinforcement and form work, brick work, fabrication and erection of structural / miscellaneous steel works, inserts, architectural items and finishes, such as plastering, painting, flooring, doors, windows and ventilators, glass and glazing, rolling shutters etc., permanently colour coated profiled steel sheeting, anchor bolts, R. C. C. trenches with covers, laying and testing of water pipes, sanitation, water supply, drainage, damp proofing, water proofing and other ancillary items.
- 3A.5.3 The works shall have to be carried out both below and above ground level and shall be involving, basements, equipment foundations including grounding, slabs, beams, columns, footings, rafts, walls, steel frames, brick walls, stairs, trenches, pits, access roads, culverts, trestles, finishes, complete architectural aspects, drainage, sanitation, water supply (from terminal points to various buildings) and all other civil, architectural and structural works associated with the Ash Handling System works.
- 3A.5.4 Scope of the bidder shall also include supply and laying of 40 mm Dia MS rods as earthing mat, placed at a distance of 1.0M away and at depths between 0.60M and 1.00M all around the periphery of buildings, structures, and outdoor equipments. Risers of 40 mm Dia MS Rods and connecting to the above Earthing mat shall also be supplied and laid in position by the Contractor. Risers shall be laid upto a height of 300 mm above the local Ground level, at each of the columns of the buildings on outside of the buildings, and minimum 2 (Two) numbers for structures and outdoor equipment. The contractor scope shall also include supplying and laying of necessary number of 3.0 M deep vertical 40 mm Dia MS Rods Earthing electrodes and connecting them to the Earthing mat and the supplying and laying of 40 mm Dia MS Rods for connecting the Contractor's earthing mat with the Owner's earthing mat separately at two locations.
- (i) Cable trenches, cable slits as required for contractor's and owner's equipment installed in the plant and buildings under contractor's scope.
 - (ii) Insert plates / support beams as required for cable tray supporting arrangement and supporting channels in cable trenches below owner's switchgears/distribution board/panels.
 - (iii) Transformer foundations with required cable slits , soak pit, fire wall, fencing & gates



Instruments, materials, access to works etc. to the Engineer, for checking the correctness of the civil works.

Conceptual arrangement of civil works supported by calculations along with tender bids. Later on, detailed construction drawings and design calculations for all civil works for static as well as dynamic analysis (wherever essential) shall be submitted for approval prior to undertaking construction work.

3A.5.5 Construction Water

Arrangement for construction water of required quality. All borings, pipe lines, pumps, water tankers, underground and over ground storage tank, etc. whatsoever required for taking the water from the underground source to the site of work shall be provided / erected / constructed / maintained by the contractor at his own cost.

3A.5.6 Concreting

For the concreting works covered in the package, provision for batching plant of suitable capacity (depending upon the concreting requirements of work schedule), with printout facility, with transit mixers etc.



**STANDARD DESIGN CRITERIA/GUIDELINES FOR BALANCE OF PLANT OF
THERMAL POWER PROJECT 2x (500MW OR ABOVE)
SECTION-4 : FUEL OIL HANDLING SYSTEM**

4.1 INTRODUCTION

The fuel oil handling and storage system in a thermal power station covers unloading of the fuel oil, its storage and transfer to the day oil tanks.

Heavy Fuel oil (FO/LSHS/HPS) are generally used for the initial start up of the boiler and upto a load of 30% MCR. Fuel oil is also used for coal flame stabilization upto 40-50% MCR of the steam generator. In addition to above, light diesel oil (LDO) system, of 7.5% MCR capacity, is also provided to start the unit from cold condition when steam is not available for HFO heating. Light Diesel Oil (LDO) is also used for auxiliary boiler (if envisaged).

The fuel oil may be received in a power station by rail tankers or by road tankers or by ships for coastal plants depending on the logistics. Based on the kind of tankers received the unloading facilities are planned.

4.2 SYSTEM DESCRIPTION

The Fuel Oil Handling system of a power station essentially consists of the following:

4.2.1 Fuel oil unloading system

Heavy Fuel oil (HFO/LSHS/HPS) is generally unloaded by rail tankers. Till recently, oil rake consisted of 80 wagons (TOH/TORX type) of 22.3 kL each. Currently rakes consisting of 48 wagons (BTPN type) of about 58 kL each are also being received. Unloading system involves heating of high viscosity fuels such as furnace oil, LSHS & HPS. The heating is normally done by steam tapped off from the auxiliary steam header. The unloading of oil rake is done in about 8 hours duration (wagon placement, heating & pumping). Suitable unloading headers, about 700 meter long covering entire length of the rake, along the railway tracks are envisaged for quick unloading. This process involves use of unloading pumps for transferring the fuel oil to the storage tanks.

In cases where coal transportation is not by rail, HFO unloading by road is preferred to eliminate the need of laying a railway track and associated marshalling facilities.

The unloading of LDO is done by road only.



4.2.2 Fuel oil storage and transfer to day tanks

The heavy fuel oil is stored in the storage tanks. These tanks are heated to maintain a suitable temperature by supplying steam through floor coil heaters. Heavy fuel oil tanks are also provided with suction heaters with steam as the heating source to heat the oil before sending it to transfer pumps.

The fuel oil unloaded into main storage tanks is transferred to the day oil tanks for sending it to oil pressurizing station from where it is sent to the burners, as and when required. The oil is transferred from main oil tank to day oil tank using the transfer pumps. During this process the fuel is freed from mechanical impurities by means of filters. The provision of day tank may not be required where fuel oil tanks are located close to boilers.

4.2.3 LDO storage and transfer to day tanks

The light diesel oil is stored in the storage tanks. LDO is further transferred to the day oil tanks for sending it to oil pressurizing station from where it is sent to the burners, as and when required. The oil is transferred from main oil tank to day oil tank using the transfer pumps. During this process the fuel is freed from mechanical impurities by means of filters. The provision of day tank may not be required where LDO tanks are located close to boilers. The LDO day tank is also provided for auxiliary boiler, if envisaged.

4.2.4 Steam and Condensate system

The heating steam required for floor heater and suction heater in HFO/LSHS/HPS storage tanks, HFO/LSHS/HPS unloading headers, piping and pumps is supplied at about 16 kg/cm² (a) at saturated condition from auxiliary steam header. Steam pressure is reduced to 4 kg/cm² (a) through a pressure reducing station, located near the fuel oil tank farm area, and distributed to the following heating applications:

- a) HFO/LSHS/HPS unloading header and piping
- b) HFO/LSHS/HPS railway wagons.
- c) HFO/LSHS/HPS unloading and transfer pumps and valves.
- d) HFO/LSHS/HPS storage tank floor heaters and suction heaters.
- e) HFO/LSHS/HPS unloading and transfer piping upto the day tank.
- f) Drain oil tank at main tank farm area.

4.2.5 Drain oil system

Clean oil spillage from unloading and transfer pumps in pump house is collected in a drain oil tank. This drain oil tank is located in the unloading pump house area. Drain oil pumps transfer the drained oil to either of the HFO/LSHS/HPS storage tanks. The drain oil tank is insulated and provided with steam coil heater to maintain the temperature for flow-ability inside the tank as required for those of HFO/LSHS/HPS storage tanks. Dirty oil spillage/ floor wash from unloading area and unloading/transfer pump house is collected in an oily sump.



4.2.6 Typical scope of work for 2x500 MW thermal power project is attached at Annexure 4A

Typical flow diagrams (as listed below) of fuel oil handling system for 2 x 500 MW are enclosed :

1. Drawing no: CEA-TETD-FO-001 (Typical flow diagram – Fuel Oil unloading, Storage and Handling (HFO) for 2x500 MW coal based Thermal power plant)
2. Drawing no: CEA-TETD-FO-002 (Typical flow diagram – Fuel Oil unloading, Storage and Handling (LDO) for 2x500 MW coal based Thermal power plant)

4.3 DESIGN CRITERIA AND BROAD FEATURES

4.3.1 Capacity of Fuel Oil Handling System and Major Equipment

- i) The following shall be considered while sizing the plant:
 - a) Heavy fuel oil unloading system shall handle one full rake of HFO/LSHS/HPS at a time. The unloading time shall be 8 hours (wagon placement, heating and pumping).
 - b) LDO unloading system shall handle 8 road tankers (max) at a time. The capacity of each tanker is 9.9m^3 . The unloading time shall be 4 hours (pumping & tanker placement).
 - c) Capacity of HFO/ LSHS/ HPS storage tanks shall be maximum of the following:
 - To store one full rake of wagons
 - 2.0 ml/kWh of HFO/LSHS/HPS for one months' requirement.
 - Minimum no. of tanks shall be two of capacity 2000 kl each
 - d) For LDO storage, minimum two tanks of 500 kl each shall be provided.



Standard Design Criteria/Guidelines for Balance of Plant of Thermal Power Project
2 x (500MW or above)

Section- 4 (Fuel Oil Handling System)

ii) Typically for a 2 x 500 MW power station the system capacities are given below:

SI No	Equipment	No. of equipment	Typical rated capacity of each equipment for 2x500 MW plant
1	HFO/ LSHS/ HPS Unloading Pump	5	100 m ³ /hr
2	LDO Unloading Pump (for road tanker)	2	50m ³ /hr
3	HFO/ LSHS/ HPS Transfer Pump (if required)	2	25m ³ /hr
4	LDO Transfer Pump (if required)	2	25m ³ /hr
5	LDO Transfer Pump for auxiliary boiler day tank (if required)	2	25m ³ /hr
6	HFO/ LSHS/ HPS Tanks	2	2000 kl
7	LDO Tank	2	500 kl
8	HFO/ LSHS/ HPS Day Tank (if required)	2	100 kl
9	LDO Day Tank (if required)	2	100 kl
10	LDO Day tank for Auxiliary boiler (if required)	1	100 kl
11	Sump pumps in Unloading pump house	1 (W)+1 (S)	10 m ³ /hr
12	Sump pumps in Oil water separator	1 (W)+1 (S)	10 m ³ /hr
13	Drain oil pumps	1 (W)+1 (S)	5m ³ /hr



4.3.2 Design Requirements

4.3.2.1 Mechanical Equipment / Systems

General

i. Typical Fuel Oil Characteristics

A. Light Diesel Oil (IS:1460-1974)

Sulfur	1.8%
Ash	0.02%
Relative density at 15°C	0.86 – 0.90
Pour Point (°C max.)	18
Kinematic viscosity at 38°C	15.7 centistokes
Water (Volume percent)	0.10
Gross Calorific Value (Kcal/kg, avg)	10,600
Flash point (°C min)	66

B. Heavy fuel Oil

Sl.No.	Characteristics	Heavy Furnace oil Grade IS-1593-1992	Low sulphur Heavy stock (LSHS) IS-11489-1985	Heavy Petroleum stock (HPS) IS-11489-1985
1.	Total sulphur content	4.5% Max.	1.0% Max.	4.5% Max.
2.	Gross calorific value (kcal/kg)	10280 (Typical)	of the order of 11,000	of the order of 10,000
3.	Flash point (Min)	66 deg C	66 deg C	72 deg C
4.	Water content by volume (max)	1.0%	1.0%	1.0%
5.	Sediment by weight (max)	0.25%	0.25%	0.25%
6.	Asphaltene content by weight (max)	2.5%	2.5%	2.5%
7.	Kinematic viscosity in centistokes at (max)	370 50 deg C	100 100 deg C	100 100 deg C
8.	Ash content by weight (max)	0.1%	0.1%	0.1%
9.	Acidity (inorganic)	Nil	Nil	Nil
10.	Pour point (max)	Source specific	Source specific	Source specific
11.	Sodium content	-	-	100 ppm
12.	Vanadium content	25 ppm	25ppm	25ppm



- ii. The unloading system shall be compatible with the latest designs of fuel oil wagons as indicated by RDSO.
- iii. In case due to layout constraint for placing of 650 meter long rake for unloading is not possible then the rake can be unloaded by splitting in two parts and the unloading header shall then be located in between the two tracks designated for unloading of oil rake.
- iv. In case of multiple tanks for fuel storage, tank transfer lines with NRV (non return valve) shall be provided using the unloading pumps.
- v. Dyke size shall be as per OISD-118 guide lines.
- vi. The temperature to be maintained for handling the oil shall be 10 deg. C above its pour point except for HFO which shall be handled at 50 deg. C.
- vii. 100% capacity of the pressure reducing station shall correspond to the maximum steam requirement under the worst (lowest temperature) ambient condition for the following conditions put together:
 - a) Unloading of one full rake of railway wagons.
 - b) One heavy oil storage tank in heating mode
 - c) One heavy oil storage tank in 'Maintain' temperature mode.
 - d) One suction heater in operation.
- viii. Steam condition after pressure reducing station shall be 4 kg/cm².
- ix. The system layout should meet the requirements of Indian Explosive Acts and approval in this regard shall be taken from Chief Controller of Explosives.

Pumps

- x. HFO/LSHS/HPS unloading pumps shall be of steam jacketed, positive displacement twin-screw type.
- xi. LDO unloading pumps and LDO transfer pumps shall be of positive displacement twin-screw type.
- xii. Drain oil pumps shall be of vertical centrifugal type.
- xiii. The pumps shall be capable of operation in parallel.
- xiv. Material of construction for major components will preferably be as below:
 - a. Pump casing: Cast iron grade IS 210 FG 260
 - b. Screws: 13% Chrome Steel
 - c. Rotors: AISI 431 or equivalent



- d. Shaft: Stainless steel
- e. Shaft seal: 30% Chrome steel mechanical seal

Fuel oil tanks

- xv. Fuel oil storage and day tanks shall be of Cone roof, vertical cylindrical, atmospheric pressure welded steel tanks, conforming to IS:2062 Gr.B or approved equal welded construction designed, fabricated and installed in accordance with IS:803. The tanks shall have sloping bottom 1 in 100 towards an adequately sized sump inside the tank to enable complete draining of the contents. Sufficient number of plugged holes shall be provided in the bottom plate of the tanks for bottom testing as per IS:803.

HFO & LDO tanks shall be provided with spiral staircase conforming to the relevant standards. The tanks shall be provided with level indicators, level switches, level transmitters and other instruments to make the system complete. Proper earthing shall be provided for these tanks.

- xvi. Conical roof with a slope of not less than 1 in 16 to ensure drainage of rain water.
- xvii. All shell course plates shall be accurately bent at required radius. Care shall be taken during bending to prevent plate skewing. For butt-weld joints, edges shall be prepared which shall be uniform and smooth throughout.
- xviii. Shell plates in each course width shall be so arranged that all vertical joints are staggered having a minimum of 600 mm stagger.
- xix. HFO/LSHS/HPS tanks shall be provided with floor coil heater and suction heaters. The tanks shall be insulated with minimum 40 mm thick mineral fibre blocks for personnel protection and heat conservation purposes

Strainers

- xx. For oil strainers, the open area ratio (i.e. straining area to the inlet area ratio) shall be 6:1
- xxi. The strainer shall have screen of stainless steel (AISI-304) construction with wire diameter of about 0.01 inch. and open area of about 50%. Strainer screen in unloading line shall be of 40 mesh & that in pressurising side shall be of 80 mesh.
- xxii. Strainer body shall be made of mild steel. No cast iron component shall be used in strainers for F.O. system.

Insulation and cladding

- xxiii. Insulation materials shall be inhibited and of a low halogen content Insulation materials shall contain no asbestos.



- xxiv. All heavy fuel oil, steam & condensate piping and heavy fuel oil tanks shall be insulated with lightly resin bonded mineral wool insulation. There shall be full insulation on tank except the roof top.
- xxv. Equipment and piping operating at elevated temperatures shall be insulated with rock wool mattress conforming to IS:8183 and have a density of 100 kg/m³.
- xxvi. Thickness of aluminum lagging shall be 20 SWG (0.911 mm) for piping and all equipment having outside diameter over 450 mm and above. Thickness of lagging shall be 22 SWG (0.711 mm) for piping having outside diameter including insulation less than 450 mm. Emissivity of cladding material shall be considered as 0.2.

4.3.2.2 Electrical System

For design requirements of Electrical System, Section -8 of this document may be referred to.

4.3.2.3 Control and Instrumentation System

For design requirements of Control and Instrumentation System, Section -8 of this document may be referred to.

4.3.2.4 Civil Works

For design requirements of Civil works, Section 9 of this document may be referred to.

4.3.2.5 Layout and Maintenance requirements

- i. While deciding the layout of buildings namely Fuel Oil Pump House building the Bidder shall consider the following parameters.
 - a) Minimum clear working space around the equipment shall be 1200 mm
 - b) In case of space provided is acting as the handling space for the equipment by overhead crane the space shall be maximum size of equipment being handled plus the clearance of 500 mm minimum on either side with the stationary equipment.
 - c) Withdrawal spaces of equipment.
- ii. One maintenance bay of 6m x the width of the building shall be provided.



4.4 PERFORMANCE REQUIREMENTS

Performance Guarantee Tests shall include:

- i) Full load power measurement of motor for various pumps
- ii) Capacity of the HFO unloading & transfer pumps
- iii) Capacity of the LDO unloading (road and rail) & transfer pumps
- iv) Capacity of the Drain oil pumps
- v) Demonstration of steam system parameters

4.5 CODES AND STANDARDS

The design, manufacture, inspection and testing of the Fuel Oil Handling System shall comply with all the currently applicable statutes, regulations and safety codes in the locality where the equipment is to be installed. The equipment shall confirm to the latest edition of the following standards & codes. Other internationally acceptable standards/codes, which ensure equal or higher performance, shall also be accepted.

OISD 118	Layouts for Oil and Gas Installations including tank farm for storage of crude / products.
IS 1593	Code for Heavy fuel Oil (HFO)
IS 1460	Code for light Diesel Oil (LDO)
IS 817	Code of practice for training & testing of metal arc welders.
IS 823	Code of procedure for manual metal arc welding of mild steel
API 620	Recommended rules for design and construction of large welded low pressure storage tanks
API 650	Welded steel tank for oil storage ASME Boiler & Pressure Vessel (B & PV) Code : Section VIII, Division I, Pressure Vessel. ASME Boiler & Pressure Vessel (B & PV) Code : Section IX, Welding & Brazing qualification.
API 12D	Large welded production tanks
IS 803	Code of practice for design, fabrication and erection of vertical mild steel cylindrical welded oil storage tank
IS 816	Code of practice for use of metal arc welding for general construction in mild steel.
IS 4503	Code for design & manufacture of Heater
ANSI B31.1	Design of power piping system
API 600	Code for design & construction of gate valve for sizes 50 NB or above
API 602	Code for design & construction of gate valve for sizes below 50 NB
API 598	Code for testing of gate valve
BS 1873	Code for design & testing of globe valve
BS 1863	Code for design & testing of check valve
BS 5351	Code for design & testing of ball valve
API 599	Code for design & testing of plug valve



Standard Design Criteria/Guidelines for Balance of Plant of Thermal Power Project
2 x (500MW or above)

Section- 4 (Fuel Oil Handling System)

IS 8183 Group 4	Specification for Bonded Mineral Wools
IS 9842 Group 3	Specification for Preformed Fibrous Pipe Insulation
IS 277	Specification for Galvanised Steel Sheet
IS 7413	Code of practice for the Application and Finishing of Thermal Insulating Materials at temperatures between 40 Deg.C and 700 Deg.C



ANNEXURE 4A

TYPICAL SCOPE OF WORKS FOR BALANCE OF PLANT OF THERMAL POWER PROJECT (2x500MW): FUEL OIL HANDLING SYSTEM

4A.1.1 SCOPE OF WORK

The scope of fuel oil handling system typically covers the design, engineering, manufacture, supply, assembly and testing at manufacturer's works, inspection, packing, forwarding, delivery FOR site and handling with storage at site (i.e. taking delivery of materials from carriers, transportation to site), fabrication (as needed), erection, trial run, testing and commissioning including painting protection of fuel oil handling system.

The statutory approval for fuel oil unloading, transfer and storage system from Chief Controller of Explosives shall be obtained by the bidder.

Typical scope of work for 2x500 MW thermal power project includes:

4A.1.2 Mechanical

- i) One (1) no. 400 NB (min.) heavy fuel oil unloading manifold, 686 meter length, complete with eighty (80) stand pipes with flexible hoses of 8 m length, with tank heating arrangement.
- ii) One (1) no. 200 NB LDO unloading manifold completed with eight (8) stand pipes with flexible hoses of 8 M length for connecting to road tankers.
- iii) Five (5) nos. 100 m³ per hour capacity, 4 kg/cm² (g)* discharge pressure, AC driven horizontal twin screw type steam jacketed heavy fuel oil unloading pump sets.
- iv) Two (2) nos. 50 m³ per hour capacity, 4 kg/cm² (g)* discharge pressure, AC driven horizontal twin screw type LDO unloading pump sets for unloading road tankers.
- v) Two (2) nos. 25 m³ per hour capacity and 4 kg/cm²(g)* horizontal twin screw type pumpset for transferring HFO from storage tank to day tank, if required.
- vi) Two (2) nos. 25 m³ per hour capacity, 4 kg/cm²(g)* horizontal twin screw type pumpsets for transferring LDO from storage tank to day tank, if required.
- vii) Two (2) nos. 25 m³ per hour capacity, 4 kg/cm²(g)* horizontal twin screw type pumpsets for transferring LDO from storage tank to day tank for auxiliary boiler.



- viii) Simplex type strainers (one for each oil pump) each having a capacity equal to that of the pump with isolating valves, drain valves, vent valves with goose neck piping and other accessories.
- ix) Two (2) Nos. sump pumps of capacity 10 m³/hr complete with all accessories of drive and mounting in FO Unloading pump house.
- x) Two (2) nos. drain oil pumps of capacity 5 m³/hr
- xi) Two (2) nos. 2000 kl capacity vertical cylindrical heavy fuel oil storage tanks with accessories.
- xii) Two (2) nos. 100 kl capacity vertical cylindrical HFO day tanks with all accessories (if envisaged).
- xiii) Two (2) nos. 500 kl capacity vertical cylindrical light diesel oil storage tank with accessories.
- xiv) Two (2) nos. 100 kl capacity vertical cylindrical LDO day tanks with all accessories located in the day tank farm area. (if envisaged).
- xv) One (1) no. 100 kl capacity vertical cylindrical LDO day tank with all accessories located in the day tank farm area for Auxiliary boiler for storage of LDO. The tank shall be located in the vicinity of the auxiliary boiler. (if envisaged).
- xvi) One (1) nos. pressure reducing station for reducing steam pressure to 4 kg/cm² (a).
- xvii) One (1) no. oil water separator along with two (2) Nos. sump pumps of capacity 10 m³/hr complete with all accessories. Necessary skimmer pipe, valves etc. shall be provided to separate oil from water.
- xviii) One (1) no. drain oil tank of 10 m³ for main tank area, and One (1) no. drain oil tank of 2 m³ for day tank farm area.
- xix) One (1) no. condensate tank of suitable capacity for main tank area and one no. for day tank farm area.
- xx) All piping and valves for fuel oil and LDO

* The pressure of 4kg/cm² is for guidance purpose only. The actual pressure may vary as per layout requirement.

4A.1.3 Electrical System/ Equipment

Two no. feeders shall be provided from 415V Station Switchboard for Fuel oil system to feed LT loads of entire fuel oil facilities for unloading, storage and forwarding. All 415V switchgears shall be located in fuel oil building switchgear room. Typically, following electrical equipment shall be included:



- i) 415V switchgears
- ii) Power and control cables
- iii) Cable laying alongwith cabling accessories, cable trays and termination/ jointing kits of cables, fire sealing and installation of equipments
- iv) LT motors
- v) Complete illumination system for internal and external lighting of associated plant and building
- vi) Complete grounding and lightning protections and its interconnection with nearest earth mat
- vii) Emergency stop push button for all LT motors

4A.1.4 Instrumentation & Control System

- i) Micro-PLC or relay based local control panel with push buttons etc. shall be provided for operation, control and annunciation of various drives for fuel oil handling facilities in fuel oil pump house. It shall be possible to monitor the fuel oil tank level from the main DCS in the Unit Control Room through soft link in case micro-PLC is used.
- ii) Instrumentation and control cables including cables laying and termination
- iii) Power supply system for C&I system
- iv) Instrumentation as required for the system.

4A.1.5 Civil Works

- i) The civil works to be performed shall cover providing all labour, materials, construction equipment, tools and plant, scaffolding, supplies, transportation, all incidental items necessary for successful completion of the work. The work shall involve earthwork in excavation, extensive de-watering, shoring and strutting, sheet piling, back filling around completed structures and plinth protection, area paving, disposal of surplus excavated materials, piling, concreting including reinforcement and form work, brick work, fabrication and erection of structural / miscellaneous steel works, inserts, architectural items & finishes such as plastering, painting, flooring, doors, windows & ventilators, glass and glazing, rolling shutters etc., permanently colour coated profiled steel sheeting, anchor bolts, R. C. C. trenches with covers, laying and testing of water pipes, sanitation, water supply, drainage, damp proofing, water proofing and other ancillary items.



- ii) All buildings shall be complete with all electrical, civil, structural, architectural works, cable trenches, fire safety walls, foundation, earth mat, fencing, earthing for transformers. All cables, duct banks, trenches, cable trestles shall be complete with associated civil/ structural work and necessary civil foundations. Buildings to be provided shall include the following :
 - a) Fuel Oil Pump House
 - b) Fuel Oil Tanks and dykes around it
 - c) Paving required in the FO area
- v) Scope shall also include supply and laying earthing mat all around the periphery of buildings, structures, and outdoor equipments, as per the approved drawings.
- vii) Access roads to all buildings/facilities of Fuel oil handling facilities including construction and maintenance of temporary access roads for approach to the building/facilities for construction/erection activities.



**STANDARD DESIGN CRITERIA/GUIDELINES FOR BALANCE OF PLANT FOR
THERMAL POWER PROJECT 2x (500MW OR ABOVE)
SECTION-5: WATER TREATMENT PLANT**

5.1 INTRODUCTION

- i) In a coal fired thermal power plant, water is required for various applications such as condenser cooling, ash disposal, heat cycle make up, equipment cooling, service water, potable applications and other miscellaneous applications. Raw water available from river, canal etc. is required to be treated to suit the particular application. Various types of treated water used in a coal fired power stations are:
 - a) Clarified water as cooling tower make-up and service water
 - b) Demineralised water for heat cycle make-up, equipment cooling system make-up, condensate polishing plant regeneration etc.
 - c) Filtered & disinfected water for potable water requirement.
- ii) The water treatment scheme to be adopted for production of above types of treated water depends on the source & quality of raw water. Mainly surface water (river, canals, lakes etc.) and seawater are the primary sources of raw water for coal fired thermal power plants. In some specific case treated sewage water or high TDS water may also be used as source raw water for the plant. Since raw water quality varies in quantum of suspended solids, organic matter, turbidity, hardness, dissolved salts, silica, colour & odour etc., the treatment scheme is designed and adopted keeping in view the plant requirements and the environmental norms stipulated by MOEF/CPCB and the local pollution control authorities.
- iii) Design of plant water system is based on the best possible economy of water and least possible pollution of the water source. This can be achieved by:
 - a) Increasing the cycle of concentration (C.O.C.) for circulating water keeping in view the raw water quality and water requirement for ash handling plant and other low grade application requirements. Cooling tower blow down is used to meet the above said requirements so that waste water being drained outside the plant boundary is minimal. Typically, C.O.C. of 5 is selected for circulating water.
 - b) Recycling of liquid effluent recovered from waste sludge of clarification plant (through centrifuges/ belt press filters) and filter backwash back to clarifiers/ raw water inlet thereby reducing the net consumptive water requirement of the plant.



Standard Design Criteria/Guidelines for Balance of Plant for Thermal Power
Project 2 X (500W or above)

Section- 5 (Water Treatment Plant)

- c) Dry/ HCSD fly ash handling system and recycling of ash pond decanted water for bottom ash handling.
- d) Segregation of waste based on oily & non-oily waste waters and treating them through oil separators, clarification etc. for use in low grade applications or recycling.
- iv) Typical scope of work for 2 x 500MW coal based thermal power plant is indicated at Annexure 5A.
- v) Drawing no. CEA-TETD-AS-01 (two sheets) indicating typical plant water balance diagram for 2 x 500MW coal based thermal power plant for dry/HCSD modes of fly ash handling and wet mode for bottom ash handling is enclosed.
- vi) Drawing no. CEA-TETD-AS-02 titled 'Typical flow diagram for PT Plant for 2 x 500MW coal based thermal power plant is enclosed.
- vii) Drawing no. CEA-TETD-AS-03 titled 'Typical flow diagram for DM Plant for 2 x 500MW coal based thermal power plant is enclosed.

5.2 SYSTEM DESCRIPTION

5.2.1 Raw Water Reservoir and Pump House

- i) The raw water from river, canal etc. is brought up to plant raw water reservoir located within the plant boundary. Reservoir is open type in two compartments. Capacity of reservoir is selected based on the reliability of raw water source such that storage can meet the plant water requirement during period of non-availability of water from the source.
- ii) Raw water from plant reservoir is supplied to pre-treatment plant by raw water pumps. Emergency water requirement for ash handling plant, when running in wet mode, is also supplied from discharge of raw water pumps.

5.2.2 Pre-Treatment (PT) Plant

- i) The pre-treatment plant produces clarified water for meeting the requirement of clarified water applications of the power plant viz. cooling tower makeup, service water and input water for producing potable and DM water.
- ii) For surface waters, typical pre-treatment scheme involves raw water chlorination, aeration through cascade aerators and clarification through conventional gravity clarifiers or reactor type clarifiers.
- iii) In case raw water contains colloidal silica, provision of separate reactor clarifier is made for producing input water for DM plant & potable water. Further, in case raw water contains high level of colloidal silica along with high hardness levels,



Standard Design Criteria/Guidelines for Balance of Plant for Thermal Power Project 2 X (500W or above)

Section- 5 (Water Treatment Plant)

provision of ultrafiltration, which separates particles on the basis of their molecular sizes, may also be considered in the pre-treatment scheme.

- iv) Typical PT plant for 2x500 MW capacity consists of one number aerator cum stilling chamber (common for both clarifiers), two nos. reactor type clarifiers, clarified water tank and pump house. Water from aerator flows by gravity up to the clarified water storage tank through inlet channels (one for each clarifier) and clarifiers. Clarified water from clarified water storage tank is pumped through horizontal/ vertical pumps, installed in the clarified water pump house, for cooling tower make-up, DM plant, potable water plant, service water system tank and other miscellaneous use such as APH washing, power water for raw water chlorination, Air conditioning & ventilation system make up etc. The provision for supply of CT make up by gravity flow from clarifiers can also be considered, if feasible. In case clarified water is to be used for fire fighting the storage of clarified water for firefighting may either be in a separate storage tank or a dead storage is provided in clarified water storage tank. Accordingly, the fire water horizontal pumps may be housed in a separate pump house or otherwise be installed in clarified water pump house.
- v) A common two storied chemical house is provided for handling and storage of chemicals for pre-treatment plant such as lime, alum, polyelectrolyte coagulant aid and for housing dosing equipments such as tanks, pumps etc. Chemicals are stored on the ground floor whereas chemical dosing equipment is installed on the first floor except for FeCl_3 dosing system (if applicable) which shall be located at ground floor.
- One number overhead storage tank is provided on the top of chemical house to provide storage of filtered water to be used for preparation of the chemicals, flushing of equipment etc. This tank is filled from the discharge of DM plant pressure filters.
- vi) In case of coastal power stations, sea water is used for cooling of condenser and secondary cooling of heat exchanger either in once through mode or employing sea water cooling tower. Surface water from alternative source or sea water is treated to produce input water for potable water; service water and DM make up water. Typical pre- treatment scheme for sea water involves chlorination, clarification, double filtration by gravity or pressure filters (to achieve desired silt density index necessary for safety of downstream reverse osmosis plant membranes) and one stage or two stage reverse osmosis as per application requirement.

5.2.3

Filtration System

Clarified water is filtered for providing input to DM plant and for use as potable water. This filtration may be done in gravity filters (common for potable and DM water) or in separate pressure filters.



5.2.4 Chlorination System

During various stages of treatment, water is chlorinated to inhibit organic growth in the water retaining structures/ equipment such as clarifiers, storage tanks, cooling tower sumps, channels, condenser tubes & piping etc. and for disinfection of potable water. Chlorine dosing, by chlorine gas cylinders, is extensively used in thermal power plants for this purpose. However, for coastal plants electro chlorination is also an economical option.

Keeping in view the ability of ozone to kill virus along with disinfection, ozone dosing can also be considered for potable water treatment as an alternate to chlorine dosing. Further, hypochlorite (NaOCl) dosing can also be used for potable water disinfection. Additional treatment may be required for potable water depending upon quality of source raw water.

5.2.5 DM Plant

- i) DM Plant is meant to supply demineralised water for power cycle/ condensate make-up, make-up for equipment auxiliary cooling system, CPU regeneration, HP/LP dosing system etc. Conventional demineralising plant (DM), i.e. process of removing the mineral salts from water by ion-exchange method, consisting of cation, anion and mixed bed polisher, is used for production of demineralised water from filtered water with total dissolved salts (TDS) level of up to 500 ppm. Depending upon the concentration of various ions in water, weak cation & weak anion exchangers are introduced in DM streams. For surface waters having TDS>500ppm RO plant can be considered in the scheme for generation of DM water. Typical scheme for production of DM water with RO is Filtration-RO-MB or Filtration-RO-DM. For production of demineralised water from sea water (in case of non-availability of sweet water source for coastal plants), having TDS in the range of 35,000-45,000 ppm a two stage RO plant followed by mixed bed exchanger is employed.
- ii) Typically, 3 x 50% DM streams are provided for 2 x 500 MW plant and output water from all the DM streams is stored in the DM Water storage tanks. Condensate make-up pumps and boiler fill pumps supply DM water for various power cycle consumptions of the plant.

5.2.6 Waste Water Treatment System

All the wastewater generated at various facilities of the plant is segregated at the source of generation and is subjected to treatment according to their type and characteristic. A basin termed “Central Monitoring Basin” or CMB is provided for equalization of all effluents - treated or otherwise. Part of treated water collected in the CMB is pumped for coal dust suppression system, plantation etc. Balance water is disposed off as per the applicable guidelines of pollution control authorities. Method of handling different types of wastes generated is given below:



Standard Design Criteria/Guidelines for Balance of Plant for Thermal Power
Project 2 X (500W or above)

Section- 5 (Water Treatment Plant)

Waste	Treatment	Disposal
PT plant clarifier sludge	Sludge is collected in a sump and pumped to thickener. Solid waste is removed by centrifuges/ belt press filter.	Clear water is led to inlet of clarifier. Solid waste is disposed by dumpers to land fill.
Pressure sand filter back wash waste	Nil	Sent directly to the common inlet chamber of raw water pumps/ clarifier inlet for its recycling.
Side stream filter back wash waste	Nil	Taken to ash slurry sump
DM plant regeneration waste	Neutralized in a dedicated neutralizing pit near DM plant building	Neutralized regeneration effluent pumped to CMB
Condensate polishing unit regeneration waste	Collected & neutralized in a common neutralization pit	Neutralised effluent pumped to CMB
Boiler blow down (BBD)	Nil	Collected in BBD collection pits, one for each boiler, and pumped to CW sump
Cooling tower blow down (CTBD).	Nil	Part to be used up for ash handling system and balance CTBD to be sent to the CMB
Plant service waste water	To be treated by oil water separator, lamella or conventional/ reactor clarifier.	The treated water from clarifier to be transferred to CMB.
Coal pile area run offs	Run off to be channelised to twin settling pond.	Clear overflow from the settling pond to be pumped to the CMB. A bye-pass weir to be provided for bypassing clear water to the nearby storm drain during rainfall.
Fuel oil storage and handling area effluent	Oily effluent to be pumped to oil water separator (OWS).	Treated effluent to be pumped to the CMB.

5.3

DESIGN BASIS

- i) The design basis given hereunder is based on the following assumptions:
- a) Plant Capacity : Two (2) units of 500MW each
 - b) Raw water source : Canal



Standard Design Criteria/Guidelines for Balance of Plant for Thermal Power
Project 2 X (500W or above)

Section- 5 (Water Treatment Plant)

- c) Mode of Fly Ash Handling : Dry
d) Mode of Bottom Ash Handling : Wet
e) Cycle of concentration : Five (5)

ii) Typical raw water analysis considered for canal water is as under:

S. No.	Constituents	Concentration
i)	PH	8.2
ii)	Conductivity, micro mhos/cm	450
iii)	TDS	315
iv)	Turbidity, NTU	20-500
v)	Calcium hardness as CaCO ₃ ppm	110
vi)	Magnesium hardness as CaCO ₃ ppm	95
vii)	Sodium as CaCO ₃ ppm	100
viii)	Potassium as CaCO ₃ ppm	10
ix)	Total cations as CaCO ₃ ppm	315
x)	P-Alkalinity as CaCO ₃ ppm	Nil
xi)	M-Alkalinity as CaCO ₃ ppm	250
xii)	Chloride as CaCO ₃ ppm	30
xiii)	Bicarbonates as CaCO ₃ ppm	250
xiv)	Sulphate as CaCO ₃ ppm	25
xv)	Nitrate as CaCO ₃ ppm	5
xvi)	Floride as CaCO ₃ ppm	5
xvii)	Total Anions as CaCO ₃ ppm	315
xviii)	Dissolved silica, mg/l as SiO ₂	8

A suggested performa for detailed raw water analysis to be carried out for source water is enclosed as Annexure- 5B.



Standard Design Criteria/Guidelines for Balance of Plant for Thermal Power
Project 2 X (500W or above)

Section- 5 (Water Treatment Plant)

- iv) Typical consumptive requirement at COC of 5 for 2 x 500 MW thermal project is as under:

S. No.	Description	Requirement, m ³ /h
1	Cooling tower make up	2550*
2	DM water	85
3	Potable water	52
4	Service water	200
5	Reservoir evaporation	30 ^s
6	Loss in sludge etc.	2
7	Bottom ash system make up	90 [#]
	Total	2899 say 3000

* Includes 20 m³/h as boiler blow down.

^s for reservoir surface area corresponding to 10 days plant requirement with water depth as 8 m.

[#] Cooling tower blow down is used for bottom ash handling, hence not considered.

Notes:

1. The raw water requirement shall be maximum upto 3600 m³/h if fly ash is disposed in wet slurry form without recovery of ash pond water. After recovery of ash pond water commences, raw water drawal of 3000 m³/h shall be adequate for plant operation with ash disposal in wet mode. It is expected that ash water recirculation system of the plant shall become functional after within one year of plant operation. As such, plant consumptive water requirement shall be maximum upto 3600 m³/h during first year of plant operation and 3000 m³/h during subsequent period. However, if HCSD system is used for disposal of fly ash instead of wet slurry system, available blow down water shall be adequate for disposal of fly ash and bottom ash, and plant consumptive water shall be 3000 m³/h right from beginning of plant operation.
2. The above plant water requirements are for normal sources of raw water with COC of 5 for CW system. In case, treated sewage water or high TDS water is used as source raw water or plant is required to be provided with FGD plant, the plant water requirement could be higher and needs to be worked out on case to case basis. In some cases, it may be possible to increase COC of CW system above 5.0 based on quality of raw water and feasibility of cooling water treatment. In such case, plant consumptive water would reduce as per reduction in CT blow down water.
3. In case waste water from CMB is treated using RO plant, the requirement of plant input water shall get reduced as per recovery of permeate water from RO plant and scheme for utilization of RO reject and other plant waste waters.



Standard Design Criteria/Guidelines for Balance of Plant for Thermal Power
Project 2 X (500W or above)

Section- 5 (Water Treatment Plant)

- iv) Clarification plant shall be designed for 120% of the total calculated consumptive water requirement. The aerator surface flow rate shall not be less than $0.03 \text{ m}^2/\text{m}^3/\text{hr}$. The velocity of water through the stilling chamber shall be low enough in the range between 0.05 to 0.08 m/sec and residence time shall be minimum 60 seconds to avoid any turbulence of the incoming water.

The overall area of clarifier shall be based on an average flow velocity not more than $3 \text{ m}^3/\text{m}^2/\text{hr}$. The unit shall be designed with a minimum retention time of 90 minutes. Design of the sludge removal system should be such as to reduce loss of water during sludge blow off within 3% of rated flow.

Provision shall be made for measurement of colloidal silica at the inlet & outlet of clarification plant.

- v) Various chemical dosing equipment in the pre-treatment plant shall be designed for the following minimum dosing rates:
- a) Alum as $\text{Al}_2(\text{SO}_4)_2$: 50 ppm
 - b) Lime as $\text{Ca}(\text{OH})_2$: 30 ppm
 - c) Coagulant aid : 2 ppm
- vi) A minimum free board of 300 mm shall be provided in all the water retaining structures of PT Plant (such as stilling chamber, clarified water distribution chamber, clarified water storage tank, overhead filtered water tank, sludge sump etc.) above the maximum water level / overflow level as the case may be.
- vii) Raw water & potable water chlorination plant shall be designed at a dosage level of 5 ppm & 2 ppm respectively. Actual chlorine dosing during plant operation shall be decided based on maintaining residual chlorine level of 0.5 ppm.
- viii) DM plant shall be sized to meet the heat cycle makeup at the rate of 3% of the boiler MCR, makeup water for closed cycle ECW system, CPU regeneration & any other requirement envisaged. Cation & anion exchangers shall be designed for 20 hours of operation cycle followed by 4 hours regeneration period in a day of 24 hours. Mixed Bed shall be regenerated after minimum 140 hours of operation.
- ix) Typical figures of water treatment plant for 2 x 500MW are as under:

S.No	Equipment/ Facility	Configuration/ Capacity
1	Raw water reservoir	$8,64,000 \text{ m}^3$ (10 days)
2	Raw water pumps	4 x $2000 \text{ m}^3/\text{h}$
3	Aerator	$3000 \text{ m}^3/\text{h}$
4	Carifier	2 x $1800 \text{ m}^3/\text{h}$
5	Clarified water storage tank	1500 m^3
6	CT make up pumps	3 x $1400 \text{ m}^3/\text{h}$
7	DM plant feed pumps	3 x $45 \text{ m}^3/\text{h}$
8	Service water pumps	2 x $220 \text{ m}^3/\text{h}$



Standard Design Criteria/Guidelines for Balance of Plant for Thermal Power
Project 2 X (500W or above)

Section- 5 (Water Treatment Plant)

9	Potable water pumps	2 x 60 m ³ /h
10	DM water storage tank	3 x 1000 m ³
11	Raw Water chlorination plant	2 x 15 kg/hr
12	Potable water chlorination plant	2 x 100 gm/h
13	Potable water filters	2 x 52 m ³ /h
14	Lamella clarifier/ tube settler	2 x 30 m ³ /h
15	Thickener	2 x 100 m ³ /h
16	Centrifuge	4 x 25 m ³ /h

5.4 LAYOUT REQUIREMENTS

- i) Layout for water pre-treatment plant shall be designed in such a way that all facilities (e.g. aerators cum stilling chambers, inlet channels, clarifiers, clarified water storage tanks, filter water storage tank, chemical house first floor, etc.) are interconnected by at least 1 meter wide walkway at appropriate elevations with hand railing one meter high on both sides.
- ii) Operating platforms shall be provided for all the structures such as aerator cum stilling chamber, clarifier, sludge chamber etc. along with hand railing.
- iii) Chemical storage shall be on the ground floor & chemical preparation & dosing equipment shall be located on first floor of chemical house except for FeCl₃ dosing system (if applicable) which shall be located at ground floor. The chemical house shall have sufficient unloading space, wide corridors for movement of staff & chemicals, etc.
- iv) Raw water chlorination equipment (chlorinators, evaporator, chlorine ton containers etc.) will be located indoor in a RCC building adjacent to chemical house. However, if the layout permits, raw water chlorine dosing equipment may be located in the CW chlorination building.
- v) Potable water chlorination equipment (chlorinators, chlorine containers etc.) shall be located within Demineralization plant building.
- vi) Pressure filters, activated carbon filters, Ion exchange units and Regeneration equipments shall be located in DM plant building. The height of DM plant vessel area building shall not be less than 8 meters.
- vii) The layout of all equipment and accessories shall be developed in a way to facilitate easy accessibility and maintenance of all equipment.
- viii) Various Systems/ equipments/ structures/ buildings shall be designed in such a way that they are approachable from main roads by means of access roads/ pathways.



Standard Design Criteria/Guidelines for Balance of Plant for Thermal Power
Project 2 X (500W or above)

Section- 5 (Water Treatment Plant)

- ix) Proper access for maintenance of equipment shall be provided as per system requirements. All tank and sumps shall be provided with access rungs and dewatering pits.
- x) Adequate provision of space for maintenance of equipments shall be kept in all the areas/facilities/ buildings.

5.5 BROAD TECHNICAL FEATURES

5.5.1 Mechanical

i) *Raw water reservoir & pump house*

Raw water reservoir of RCC construction in twin compartments shall be provided with free board of one meter shall be provided above the maximum water level. Walk way around the reservoir (minimum 1.2m wide) and one meter high hand railing through out the periphery & partition wall shall also be provided. Reservoir shall be suitably lined with HDPE film to avoid any seepage from bottom & from walls.

ii) *Aerator & stilling chamber*

The aerator shall be of stepped design and shall allow water to flow downward after spreading over inclined thin sheets and the turbulence is secured by allowing the water to pass through a series of steps and baffles.

The aerator riser shall not be more than 250mm & tread shall not be less than 400mm. Required exposure time is provided by adequate number of steps in the aerator.

iii) *Clarifier*

Clarifiers shall be of sludge recirculation type with integral variable recirculation arrangement to internally re-circulate sludge at adjustable rate to produce clarified water of consistent effluent quality at seasonal varying hydraulic load and turbidity. Clarifiers shall be provided with radial launders. Provision for bypass of water from inlet of the clarifier(s) to clarified water storage tank shall be provided.

Bridge type rake arm and suitable equipment (turbine/ impeller) shall be provided for internal sludge recirculation. Sludge removal system design shall consist of central sludge sump with rotating pickets and back flush arrangement for proper control of sludge accumulation at the bottom.

All structural/ support material shall be of steel construction and suitably braced to provide rigidity. Clear width of the bridge shall not be less than 1200 mm. Each of the clarifier shall be provided with a gate at the outlet for isolation of any of the clarifier for maintenance.



Standard Design Criteria/Guidelines for Balance of Plant for Thermal Power
Project 2 X (500W or above)

Section- 5 (Water Treatment Plant)

iv) *Chemical preparation and dosing equipment*

Quick lime shall be dissolved in the slaking tanks and the resultant slurry (about 10% W/V) from the slaking tanks shall be transferred to the lime solution dosing tanks by lime slurry transfer pumps.

Lime slaking/ preparation tanks (minimum two numbers) shall be sized for total 24 hours requirement of lime dosing for all clarifiers and provided with 2 x 100% lime slurry transfer pumps.

Each clarifier shall be provided with one (1) number each of lime, alum and polyelectrolyte solution dosing tanks. Each dosing tank shall be sized for 8 hour operation plus 25% margin. One (1) tank shall be provided as common standby for each type of chemical. Chemical solutions shall be dosed by dosing pumps. One working dosing pump for each clarifier with one standby dosing pump shall be provided for each type of chemical.

MOC for slaking/ preparation and dosing tanks shall be RCC/ MSRL. All slaking/ preparation/ dosing tanks shall be provided with charging platform and SS316 dissolving basket. Slow speed SS agitators shall be provided for each tank.

v) *Sludge/ backwash/ drain disposal system of PT plant*

Sludge from clarifiers shall be taken to twin compartment RCC construction sludge pit. The capacity of each compartment should be designed to hold the total sludge blow off from all the clarifiers at one time with 20% margin plus continuous drained water coming from telescopic arrangement. or 400m³, whichever is higher. Desludging of clarifier will be done once in a shift of 8 hours.

Sludge disposal system shall be designed to empty the 8 hour collection of sludge in 4 hours.

Each section of the sump shall be provided with agitation by air agitation system consisting of 2 x 100% air blowers.

vi) *Potable water plant*

Potable water plant shall be designed to produce desired quality of drinking water for both plant & colony. Any other treatment if essentially required to make the filtered water as potable water of acceptable quality shall also be provided. Filtered water from the filters shall be duly chlorinated, by PT chlorination plant, to achieve the desired concentration of chlorine in potable water.

For colony, the potable water supply line shall be laid up to a suitable point outside the plant boundary with suitable interface (flanged end valve connection) by the bidder. Onward supply of potable water to colony shall be in the scope of owner.



Standard Design Criteria/Guidelines for Balance of Plant for Thermal Power
Project 2 X (500W or above)

Section- 5 (Water Treatment Plant)

Vertical pressure sand filters incorporating dual filter media of quartz sand and anthracite shall be provided for production of filtered water. The filters shall be lined with rubber/ epoxy from inside. The pressure filters shall be of welded mild steel construction as per IS: 2825 designed for maximum working pressure and capable of withstanding a hydrostatic test pressure of 1.5 times the design pressure.

The normal flow rate through the filters shall not be more than $10 \text{ m}^3/\text{hr}/\text{m}^2$. A minimum 50% free board shall be provided over the filtering bed depth. The minimum bed depth of filtering media, excluding the support material, shall be 1200 mm, of which 700 mm shall comprise of quartz sand and 500 mm of anthracite.

Back washing of pressure filters shall be done once in 24 hours on line. Filter backwash shall be taken to common inlet chamber of raw water pumps. Loss of head gauge shall be provided locally on the filters. The back-washing rate shall be between $25\text{-}30 \text{ m}^3/\text{hr}/\text{m}^2$ of bed area. The flow rate of air shall be $50 \text{ m}^3/\text{hr}/\text{m}^2$ of filter bed area.

vii) *Raw & Potable water chlorination plant*

In raw water chlorination system, chlorine will be dosed in stilling chamber of pre- treatment plant to remove organic matter present in raw water. Raw water for chlorination booster pumps will be supplied from the clarified water storage tank. For potable water chlorination system, chlorine will be dosed in filtered water at the outlet header of pressure sand filters. The water to the booster pumps will be supplied from the discharge header of pressure sand filters.

(For Technical features & other relevant details of equipment refer Section-6)

viii) *DM Plant*

The analysis of the filtered water to be adopted for design of DM plant shall consider the chemical dosing in the PT plant. The plant shall be designed for continuous and simultaneous operation of all the streams.

a) *Activated Carbon Filter*

The flow velocity shall not exceed 15 m/hr. The bed depth, excluding support material, shall be minimum 1200 mm and at least 75% free board shall be provided over the bed depth. The inlet distribution system shall be header lateral type. The vessels shall be lined internally with suitable anti-corrosive lining or coating to prevent corrosion.

Back washing of activated carbon filters should be done once in 24 hours using filtered water. Backwash waste water shall be taken to common inlet chamber of raw water pumps of PT plant.



Standard Design Criteria/Guidelines for Balance of Plant for Thermal Power
Project 2 X (500W or above)

Section- 5 (Water Treatment Plant)

b) Ion exchange units

The Ion exchange units shall be vertical, rubber lined welded plate steel construction and fabricated as per IS: 2825 or equivalent. The vessels shall be rubber lined to a thickness of 4.5mm.

The cross sectional areas for cation & anion vessels shall be determined for a maximum flow rate of $30\text{m}^3/\text{hr}/\text{m}^2$. The cross sectional areas for mixed bed vessels shall be determined for a maximum flow rate of $45\text{m}^3/\text{hr}/\text{m}^2$. At least 100% free board shall be provided for all ion exchange vessels. The resin bed depth for cation, anion and mixed bed vessels shall not be less than 1.0 meter. Deration factor of minimum ten (10) % shall be considered in resin exchange capacities for the design of all ion exchange vessels.

c) Ion exchange resins

i) Cation exchanger resins

High capacity, strongly acidic, sulphonated polystyrene, macroporous cation exchange resins in bead form shall be supplied for strong cation exchange unit.

ii) Anion exchanger resins

Strongly basic, isoporous/ macroporous, type- I in OH form, regenerated with caustic soda shall be supplied for strong base anion unit.

iii) The attrition loss of the cation resins shall be guaranteed not to exceed 3% per year for the first three years of operation, whereas for anion resins attrition loss shall not be more than 5% per year during first three years.

d) Cation regeneration

Cation resin shall be regenerated by hydrochloric acid (30-33% M/V technical grade IS: 265 or equal).

i) The capacity of each acid unloading/ transfer pumps pump shall be at least $10\text{ m}^3/\text{hr}$ with minimum 15mwc head.

ii) Bulk acid storage tanks of carbon steel as per IS 2062, shall be provided. The tank shall be of rubber lined mild steel construction. The outlets from both the tanks shall be bussed together. The tanks shall be provided with double isolating valves at the outlet.



Standard Design Criteria/Guidelines for Balance of Plant for Thermal Power
Project 2 X (500W or above)

Section- 5 (Water Treatment Plant)

- c) The capacity of acid measuring tank shall be sufficient to hold total quantity of 30 % HCl required for at least one regeneration with adequate margin of minimum 25%. The tanks shall be of MSRL construction.
- d) Cation regeneration pumps shall draw suction from degassed water storage tanks.

e) Anion regeneration

The anion exchange resins shall be regenerated with sodium hydroxide (48% w/v rayon grade in lye form as per (IS: 252) solution of suitable strength.

The equipment configuration and materials to be provided for receiving & unloading of alkali and anion regeneration shall be similar to that envisaged for cation regeneration. Power water pumps to be provided for anion units shall draw water from DM water storage tanks.

f) Degasser Tower and Tank

The degasser tower shall be of MSRL construction, forced draft type and shall be equipped with motor driven blowers. The degassed water storage tank shall be of epoxy coated RCC/ MSRL with effective storage capacity sufficient to hold one hour downstream water flow plus regeneration water requirement for one stream.

The outlet from the tower will be through a PVC air seal tube going to the bottom of the degassed water storage tank of RCC.

g) Drain Neutralisation System

- i) The neutralising pit shall be of RCC construction in twin compartment. Minimum effective storage volume of each pit shall be sufficient to store all waste water from one cation, anion and mixed bed unit with 50% margin. Provision of baffles shall be made to mix the wastes by recirculation and acid/alkali dosing.
- iii) The capacity of waste recirculation and disposal pumps shall be selected as per the requirement of emptying one neutralising pit in maximum three hour.
- iv) The capacity of each acid/ alkali measuring tank shall be sufficient to hold acid/alkali for one neutralisation with 30% margin.



Standard Design Criteria/Guidelines for Balance of Plant for Thermal Power
Project 2 X (500W or above)

Section- 5 (Water Treatment Plant)

- ix) Lamella Clarifier/Tube Settler
- a) The tube settler/ lamella Clarifier of RCC shall be designed with minimum side water depth of 3 m. The overall area of unit shall be based on an average flow velocity not more than $5 \text{ m}^3/\text{hr}/\text{m}^2$.
 - b) Unit shall be circular/rectangular with distinct tube / plate separation zones, sludge thickener zone, clear water zone and oil skimming zone. The tube settler/ Lamella Clarifiers shall be counter flow or cross flow type. Walkway (bridge) and platform to approach all the internals shall be provided. Clear width of the bridge shall not be less than 1200 mm. Clarifier shall be provided with one RCC flash mixer and flocculation Chamber at its upstream. Chemical shall be added to the water in the flash mixer.
 - c) The length of the tubes/plates shall not be less than 1.5 m. The cross sectional area of each tube shall be such that the effective hydraulic diameter is minimum 80 mm. In case of plate type separator the distance between the successive plates shall be 50 mm (min). The material of tube pack shall be UV inhibited virgin PVC or GRP (glass reinforced plastic).
 - d) The tube/ plates shall be easily accessible for the cleaning purpose. The tube pack/ plates shall be placed inside the separator such that these may be individually removed for maintenance even when separator is operating.

x) *Chemical Dosing Pumps*

The pumps shall be of simplex type, positive displacement, plunger design and driven by electric motor through suitable speed reduction unit. The stroke shall be continuously adjustable to given capacity variation in 0-100% range. Adjustment of capacity shall be done manually and during operation of the pump. The adjusted capacity should be read directly from the dial of the setting thimbles.

xi) *Vertical (wet Pit) Pumps*

Pumps shall be of vertical shaft, single/ multi-stage, submerged suction, turbine / mixed flow type design. The pumps shall be rated to run at 1500 rpm. However, for specific case of pump to be selected for low capacity and high head, rated speed may be taken as 3000 rpm (synchronous). Shut off head of the pump shall be in the range of 115% to 130% of rated head. Pumps shall be designed for continuous (normal) operation and as well as for intermittent operation. Margin of 10% on pump flow and 10% margin on frictional head shall be provided over the design requirement.

The MOC of vertical pumps shall not be inferior to the following:

Suction bell/ casing/ bowl	:	2%NiCl;IS:210Gr FG 260
Impeller	:	ASTM A351 CF8M
Impeller shaft, pump & line shaft, shaft coupling, shaft sleeves	:	SS- ASTM- A 276- Gr.410



Standard Design Criteria/Guidelines for Balance of Plant for Thermal Power
Project 2 X (500W or above)

Section- 5 (Water Treatment Plant)

xii) *Horizontal Centrifugal Pumps*

Horizontal centrifugal pumps shall conform to Indian Standard specification IS: 5120, 9137, 5639, 5659 or 10981 (latest revision). They shall be made of materials suitable to handle the fluids specified. However, DM water supply & regeneration pumps shall be of stainless steel construction.

The pumps shall be rated to run at 1500 rpm. However, for specific case of pump to be selected for low capacity and high head, rated speed may be taken as 3000 rpm (synchronous). Shut off head of the pump shall be in the range of 115% to 130% of rated head. Margin of 10% on pump flow and 10% margin on frictional head shall be provided over the design requirement.

The MOC for horizontal pumps shall not be inferior to the following:

Casing/ bowl	:	2%NiCl;IS:210Gr FG 260
Impeller & wear rings	:	SS -316
Shaft, shaft sleeves	:	SS-410
Shaft sealing arrangement	:	Mechanical seal

xii) *Pressure Vessels and Storage Tanks*

a) General Design Criteria

- i) Pressure vessels shall be designed as per IS 2825 or equivalent. All pressure vessels shall be designed and tested to withstand 1.5 times the design pressure.
- ii) Design of all vertical cylindrical atmospheric storage tanks containing water, acid, alkali and other chemicals shall conform to IS: 803. Design of all horizontal cylindrical atmospheric storage tank containing water, acid, alkali and other chemicals shall conform to BSEN-12285 Part-II.
- iii) All vessels/tanks without inside rubber lining shall have a corrosion allowance of minimum 2 mm and mill allowance (minimum 0.3 mm) for shell and dished ends. Thinning allowance of 2 mm (minimum) shall be considered for dished end.
- iv) The design of Demineralised water storage tanks (Vertical type) shall conform to IS: 803. Supporting frame where required shall be in accordance with IS: 800. The tank shall be "Non-pressure" fixed roof type, centrally supported with atmospheric vents.
- v) All the atmospheric tanks shall have sufficient free board above the "Level High"/"Normal Level" as the case may be. The overflow level shall be kept at least 20 cm or 10% of vessel height above the "Level High"/"Normal Level" for all the tanks except for the DM tanks for which a minimum height of 300 mm shall be provided over the "High



Standard Design Criteria/Guidelines for Balance of Plant for Thermal Power
Project 2 X (500W or above)

Section- 5 (Water Treatment Plant)

Level". Further, a minimum 100 mm free board shall be provided above the top of overflow level to the top of the tank. Wall thickness of atmospheric tanks shall not be less than 6 mm.

b) Special Accessories for Vessels /Storage Tanks

Water seal shall be provided for the overflow line of DM and degassed water storage tanks (for DM System). The vent and overflow lines of alkali preparation/ measuring/ day tanks and vent line of DM storage tanks shall be provided with Carbon-di-oxide absorber of proven design to prevent contamination from atmospheric air. The vent and overflow lines of acid measuring tanks shall be provided with fume absorber using suitable packing material, such as pall rings/ rasching rings.

c) Protective Linings, Painting etc.

Rubber lined vessels shall be provided with natural rubber lining of total thickness not less than 4.5 mm. Surface hardness of rubber lining shall be 65 +/- 5 deg. A (shore).

xiii) *Piping*

Piping shall be adequately designed and Material of construction shall be suitable to the service intended.

5.5.2 Electrical System

For design requirements of Electrical System, Section VII of this document may be referred to.

5.5.3 Control and Instrumentation System

For design requirements of Control & Instrumentation System, Section VIII of this document may be referred to.

5.5.4 Civil Works

For design requirements of Civil Works, Section 9 of this document may be referred to.

5.6 PERFORMANCE GUARANTEES

i) *Pre-treatment plant*

Water quality at clarifier outlet at rated capacity shall be:

- | | | |
|--------------|---|----------|
| a) Turbidity | : | < 10 NTU |
| b) pH | : | 7.0- 7.5 |



Standard Design Criteria/Guidelines for Balance of Plant for Thermal Power
Project 2 X (500W or above)

Section- 5 (Water Treatment Plant)

- iv) Tube settler/Lamella clarifier
 - a) Outlet turbidity : <10 NTU
 - b) Oil content : < 5 mg/l
- v) CMB outlet (in case waste water is discharged outside the plant boundary)
 - a) Suspended solids : 100 mg/l (max.)
 - b) pH : 5.5 to 9.0
 - c) Temperature : Shall not exceed 5°C above the receiving water temperature.
 - c) Oil and grease : < 10 mg/l

Further, the plant effluent quality shall comply with the stipulations of MoEF/CPCB & local pollution control authorities.

5.7 PERFORMANCE AND GUARANTEE TESTS

- i) The following tests will be conducted at the manufacturer's works:
 - a) Hydrostatic tests for all pump casing, pressure vessels, pipes, valves and fittings.
 - b) Integrity of lining of vessels and equipment by 'Spark testing'.
 - c) Water fill test of all tanks.
 - d) Performance testing of the pumps & blowers.
 - e) Testing of control panels & M.C.C.
- ii) The following tests and checks shall be made at site in the presence of the purchaser:
 - a) Satisfactory operation of each equipment.
 - b) Net continuous output over a period of 3 days for the plants covered under plant water system.
 - c) In case of DM plant test shall cover minimum two regenerations.
 - c) Tests required for establishing the guaranteed performance and chemical consumption (for DM plant).

5.8 Codes & Standards

All materials, equipment and safety regulations shall comply with applicable provisions of the latest edition of relevant Indian Standards and other applicable codes/ standards. The following Indian standards (latest edition) shall be applicable to this specification unless otherwise specified:



Standard Design Criteria/Guidelines for Balance of Plant for Thermal Power
Project 2 X (500W or above)

Section- 5 (Water Treatment Plant)

- | | |
|-----------|--|
| IS : 458 | - Concrete pipes (with and without reinforcement). |
| IS : 554 | - Pipe thread for pressure tight joints. |
| IS : 778 | - Gunmetal gate, globe and check valves for general purpose. |
| IS : 783 | - Code of practice for laying RCC pipes. |
| IS : 803 | - Code of practice for design, fabrication and erection of Vertical Mild Steel cylindrical welded oil storage tanks. |
| IS : 816 | - Code of practice for use of metal arc welding for general construction in mild steel. |
| IS : 817 | - Code of practice for training and testing of metal arc welders. |
| IS : 822 | - Code of procedure for inspection of welds. |
| IS : 1239 | - Mild steel tubes and fittings - Part I & II. |
| IS : 1363 | - Black hexagonal bolts, nuts and locknuts (dia 6 to 39 mm) and black hexagon screws (dia to 24 mm). |
| IS : 1364 | - Precision and semi-precision hexagon bolts, screws, nuts and lock nuts. |
| IS : 1367 | - Technical supply conditions for threaded fasteners. |
| IS : 1435 | - Specification for Platform Weighing Machines |
| IS : 1536 | - Centrifugally cast (spun) iron pipes for water, gas and sewage. |
| IS : 1537 | - Vertically cast iron pressure pipe for water, gas and sewage. |
| IS : 1538 | - Cast iron fittings for pressure pipes for water, gas and sewage. |
| IS : 1703 | - Ball valves (horizontal) plunger type including floats for water supply purposes. |
| IS: 1710 | - Vertical Turbine Pumps for clear cold fresh water. |
| IS : 2002 | - Steel plates for pressure vessels for intermediate and High temperature service including boilers. |
| IS : 2062 | - Specification for weldable structural steel. |
| IS : 2379 | - Colour for the identification of pipe line. |
| IS : 2685 | - Code of practice for erection, installation, and maintenance of sluice valves. |
| IS : 2712 | - Gaskets. |
| IS : 2825 | - Code of unfired pressure vessels. |
| IS : 3006 | - Acid resistant SWG Pipe. |
| IS : 3042 | - Single faced sluice gates (200 to 1200 mm). |
| IS : 3114 | - Code of practice for CI Pipes. |
| IS : 3133 | - Manhole and inspection opening for chemical equipment. |
| IS : 3589 | - Electrically welded steel pipes for Water gas & sewage (200 to 2000 mm). |
| IS : 3952 | - Cast Iron butterfly valves for general purposes. |
| IS : 4038 | - Foot valve for water works purposes. |
| IS : 4049 | - Specification for formed ends for tanks and pressure vessels. |



Standard Design Criteria/Guidelines for Balance of Plant for Thermal Power
Project 2 X (500W or above)

Section- 5 (Water Treatment Plant)

IS : 4682	- Code of practice for lining of vessels and equipment for chemical processes Rubber Lining.
IS : 4736	- Hot dip zinc coating on steel tubes.
IS : 4984	- High density polyethylene pipes.
IS : 4985	- Unplasticised PVC Pipes.
IS : 5120	- Technical requirements of rotodynamic special purpose pumps
IS : 5312	- Swing check type reflux (non-return) valve Part-I.
IS : 5639	- Pumps Handling Chemicals & corrosion liquids.
IS : 5659	- Pumps for process water
IS : 8034	- Submersible pumps for clear cold fresh water
IS : 10221	- Code of practice for coating and wrapping of underground mild steel pipelines.
IS : 10981	- Horizontal Centrifugal Pumps for clear cold fresh water.
IS : 14846	- Sluice valves for water purpose.
ASTM- A 106	- Gr. C Seamless carbon steel pipe.
ASTM- 53	- Seamless carbon steel.
AWWA-C-504	- Rubber seated butterfly valve.
AWWA M11	- Steel Pipe – A Guide for design and installation.
ANSI:B - 16.5	- Steel pipe flanges and flanged fittings.
ANSI:B - 31.1	- Power Piping code
HIS	- Hydraulic Institute Standards U.S.A.



Standard Design Criteria/Guidelines for Balance of Plant for Thermal Power
Project 2 X (500W or above)

Section- 5 (Water Treatment Plant)

ANNEXURE-5A

5A.0 SCOPE OF WORK

Typical scope of supply of Water Treatment System for 2 x 500MW thermal power plant is described as follows:

5A.1 Mechanical

5A.1.1 *Raw water pump house*

- a) Four (4) number vertical wet pit type raw water pumps complete with motor & accessories with three (2 working + 1 standby) for pre-treatment plant raw water supply and one for emergency ash handling plant water supply.
- b) Discharge piping up to aerator and ash handling system along with isolation valves, non-return valves and RE joints etc. at discharge of each pump.
- c) Removable protective screens, sluice gate(s) for each chamber.

5A.1.2 *Pre-Treatment Plant*

- a) Set of control valve with upstream and downstream isolation valve and a motorized bypass control valve at the inlet to aerator
- b) One (1) number aerator cum stilling chamber of RCC construction with inlet channels to individual clarifiers along with isolation gates.
- c) One (1) number flow measuring element (parshall flume) of RCC Construction in inlet channel of each clarifier.
- d) Two (2) x 60% reactor type clarifiers of RCC construction, along with associated equipment and drives.
- e) One (1) number complete sludge handling system consisting of one number RCC sludge pit (2 sections) of minimum capacity 400 m³, sludge bleeding arrangement (manual & timer operated), sludge piping from clarifiers up to the pit, associated valves etc., three (3) x 50% sludge disposal pumps with drives and associated valves, piping etc. up to thickener, emergency sludge disposal piping from sludge disposal pumps up to bottom ash slurry pit, two(2) x 100% air blowers of oil free type, its drives and associated accessories, piping from blowers to each section of the sludge pit for air scouring of sludge. Sludge disposal pump shall be of vertical and non-clog type and its capacity shall correspond to emptying the 8 hour collection of sludge in 4 hour period.
- f) Two storey chemical house of RCC construction for chemical handling, weighing, preparation & dosing system for each type of chemical and



Standard Design Criteria/Guidelines for Balance of Plant for Thermal Power
Project 2 X (500W or above)

Section- 5 (Water Treatment Plant)

storage for one month requirement of each chemical to be dosed in pre-treatment section.

- g) Two (2) no lime slaking tanks and 2 x 100% lime transfer pumps. Four (2) number (2W+1S) chemical dosing tanks for each type of chemical (lime alum, polyelectrolyte) to be dosed in clarifier. Four (3) number (2W+1S) chemical dosing pumps for each type of chemical.
- g) One no. partly underground twin compartment clarified water storage tank of RCC construction for half an hour capacity of plant (two hours in case CT make up is supplied by gravity from clarifier) clarified water requirement at full load.
- h) Underground type clarified water pump house of RCC with following pumps complete with motor, accessories, suction and delivery piping up to final delivery point, non-return valves & isolation valves at the discharge, discharge header etc:
 - i) 3 x 50% CT make up pumps
 - ii) 3 x 50% DM plant feed pumps
 - iii) 2 x 100% service water pumps
 - iv) 2 x 100% potable water pumps
 - v) 2 x 100% chlorination plant power water supply pumps
 - vi) 2 x 50% APH wash pumps
 - vii) 2x100% capacity dewatering pumps
 - ix) Any other pumps/equipment envisaged
- i) Overhead filter water storage tank of RCC, of capacity minimum 5m³, for supplying water for chemical preparation located on top of chemical house with water supply line associated valves, piping, fittings etc.

5A.1.3

DM plant

- a) Three (3) x 50 % streams of DM plant. Each stream shall consist of:
 - i) Pressure filter with accessories
 - ii) Activated carbon filter with accessories
 - iii) Cation exchanger with accessories
 - v) Degasser system consisting of degasser tower, 2 x 100% degasser blower with drive & accessories, degassed water storage tank, degassed water transfer pump with drive & accessories.
 - vi) Anion exchanger with accessories
 - vii) Mixed bed exchanger with accessories
- b) Regeneration equipment for cation, anion & mixed bed units including:
 - i) Chemical preparation/ measuring tanks- 2 x 100% for cation (acid) and 2x100% for anion (alkali), and 2x100% each of acid and alkali for mixed bed regeneration.



Standard Design Criteria/Guidelines for Balance of Plant for Thermal Power
Project 2 X (500W or above)

Section- 5 (Water Treatment Plant)

- ii) Regeneration pumps (2 x 100% degassed water & 2 x 100% DM water) with drive & accessories.
 - iii) MB Regeneration blowers (2 x 100%) with drive & accessories.
 - iv) Ejectors/ dosing pumps.
- c) Four (4) number power cycle DM make-up pumps, 2 x 100% for each unit complete with drive motor, accessories and piping up to the main plant terminal point.
- d) Two (2) x 100% boiler fill pumps complete with drive motor, accessories and piping up to the main plant terminal point.
- e) Acid receiving, unloading, storage facility including storage tanks for one month (minimum 50 m³) requirement consisting of 2 x 50% bulk acid storage tanks and 2x 100% unloading pumps with hoses.
- f) Alkali receiving, unloading, storage facility including storage tanks (minimum 20 m³) consisting of 2 x 50% bulk alkali storage tanks and 2 x 100% unloading pumps with hoses.
- g) Three (3) number DM water storage tanks for total of 24 hours of DM water requirement of the plant at full load operation.
- h) Drain neutralisation system including twin compartment RCC neutralising pit, sumps & trenches, priming chambers, two (2) x 100 % disposal pumps with drive, accessories and MSRL piping up to CMB, alkali & acid measuring tanks (2 x 100% each) etc.
- i) Overhead filtered water storage tank of RCC of adequate capacity for supplying water for fume absorbers & safety shower of DM plant.

5A.1.4 *Potable and Service Water System*

- a) Potable water plant comprising of 2 x 100% pressure filters, 2 x 100% air blowers, potable water storage tanks (2 x 50 m³) of RCC and distribution piping through out the plant. Any other treatment if essentially required to make the filtered water as potable water of acceptable quality shall also be provided.
- b) Piping, including valves & fittings up to the inlet chamber of raw water pumps for disposal of filter backwash waste water.
- c) Overhead service water tanks (2 x 100 m³) of RCC and distribution piping through out the plant.



Standard Design Criteria/Guidelines for Balance of Plant for Thermal Power
Project 2 X (500W or above)

Section- 5 (Water Treatment Plant)

5A.1.5 *Chlorination Plant*

1. Number of streams for raw water chlorination: 2 x 100%.
2. Number of streams for potable water chlorination: 2 x 100%.
3. The following equipment shall be provided for each chlorination stream of raw/potable water chlorination as applicable:
 - a) Chlorine containers
 - i. Raw water chlorination: 900 kg capacity- 4 nos. or for one month requirement, whichever is higher.
 - ii. Potable water chlorination: 65 kg capacity- 3 nos. or for one month requirement, whichever is higher.
 - b) Chlorine gas strainer- 2 x 100% per stream
 - c) Evaporator (for raw water chlorinator)-One for each stream
 - d) Pressure regulating valve- one per stream
 - e) Chlorinator- one per stream
 - f) Suction strainer for chlorinator water booster pump-one for each pump
 - g) Chlorinator water booster pump with piping-One for each stream
 - h) Flexible connector pipes
 - i) Liquid chlorine (for raw water chlorination) & gas pipelines,
 - j) Residual chlorine analyser, leak detection and safety equipment, chlorine absorption system etc.

5A.1.6 *Waste water treatment plant*

- a) Sludge treatment system
 - i) Two (2) x 50% sludge thickeners of adequate capacity
 - ii) Overflow channel of RCC construction from thickener to inlet of PT clarifier.
 - iii) 3 x 50% thickened sludge transfer pumps along with drives & accessories.
 - iv) 2 x 100% dewatering polyelectrolyte dosing tanks & 2 x 100% dosing pumps.
 - v) 4 Nos. centrifuges (3W +1S) of SS316 construction along with drives & accessories.
 - vi) 4 no. closed dumper trucks, each of 9T capacity.
- b) Boiler Blow Down
 - i) Two (2) number Boiler Blow Down (BBD) collection sumps of RCC, one for each unit.
 - ii) 2 x 100% BBD transfer pumps (for each sump), its drives, associated piping, valves etc. up to CMB.
- c) Plant service water waste
 - i) One (1) number RCC waste service water (2 sections) sump for collection of waste service water by tapping waste water main plant drains and required connection from the plant drain up to the sump.
 - ii) 2 x 100% plant service waste water transfer pumps, its drives, associated piping, valves etc.



Standard Design Criteria/Guidelines for Balance of Plant for Thermal Power
Project 2 X (500W or above)

Section- 5 (Water Treatment Plant)

- iii) One (1) number oil separator.
 - iv) One (1) number tube settler/ lamella clarifier of RCC construction along with RCC flash mixer.
 - v) Sludge pipeline (Cast Iron) with associated valves from the tube settlers/ lamella clarifiers up to the sludge pit of clarifiers of PT plant by gravity flow/ pumping.
- d) Coal pile area run offs
- i) Two (2) no. inlet connection channel from the Coal Stockyard area drains upto the Coal Slurry Settling Pond (CSSP) to transfer waste water laden with coal dust to the CSSP.
 - ii) Two (2) numbers of CSSP of RCC construction along with by-pass weir to be provided for bypassing clear water to the nearby storm drain during rainfall.
 - iii) One no. RCC (twin section) decanted water sump for collection of overflow water.
 - iv) Two (2) numbers (1W+1S) coal decanted water pumps along with its drives, associated piping, valves etc.
 - v) Two (2) numbers portable submersible type pumps for draining the water from the CSSP, with hose pipes etc.
 - vi) Bypass arrangement before settling pond & after overflow collection sump during rainfall.
- e) Central monitoring basin (CMB) of RCC construction (2 sections) and capacity 1000 m³ or four hours (whichever is higher).
- f) 2 x 100% final effluent disposal pumps & overflow system for final disposal of treated water from CMB along with its drives, associated piping , valves etc. up to the coal dust suppression system, plantation, dry fly ash collection system etc.
- 5A.1.7 Resins, filter media, degasser tower packing etc. for all types of vessels covered under the specification.
- 5A.1.8 Safety shower & eye wash facility for DM plant chemical area (storage & regeneration) & chlorination plant.
- 5A.1.9 Concrete filling of all pressure vessels & ion exchange units, if required.
- 5A.1.10 Service/ instrument air distribution piping for entire plant water system.
- 5A.1.11 All integral and interconnecting piping, globe valves, diaphragms valves, gate valves, control valves and all types of pipe supports, flanges, nuts, bolts and gaskets, cable racks, pipe/ cable bridges and clamping arrangements required for entire water treatment plant system covered in scope of work.



Standard Design Criteria/Guidelines for Balance of Plant for Thermal Power
Project 2 X (500W or above)

Section- 5 (Water Treatment Plant)

- 5A.1.12 Material handling equipment such electrically operated monorail hoist, chain pulley blocks etc. for pump houses (including sludge pumps), centrifuge building, thickened sludge pumps & chemical houses for operation and maintenance of the equipment.
- 5A.1.13 Air conditioning of control room and ventilation of various buildings covered under the scope of work.
- 5A.1.14 Supply of all types of chemicals, greases, lubricants etc. Suitable standard lubricants as available in India shall be supplied.
- 5A.1.15 One set of necessary tools and tackles required for operation and maintenance of the plant.
- 5A.1.16 Adequate number of weighing scales as required.

5A.2 Civil works

- i) The civil works shall include to cover providing all labour, materials, construction equipment, tools and plant, scaffolding, supplies, transportation, all incidental items necessary for successful completion of the work. The work shall involve earthwork in excavation, de-watering, shoring and strutting, sheet piling, back filling around completed structures and plinth protection, area paving, disposal of surplus excavated materials, piling, concreting including reinforcement and form work, brick work, culverts, CW ducts, fabrication and erection of structural / miscellaneous steel works, inserts, architectural items & finishes such as plastering, painting, flooring, acid/alkali proof lining, doors, windows & ventilators, glass and glazing, rolling shutters etc., permanently colour coated profiled steel sheeting, anchor bolts, R.C.C. trenches with covers, laying and testing of water pipes, sanitation, water supply, drainage, damp proofing, water proofing and other ancillary items.
- ii) All buildings shall be complete with all electrical, civil, structural, architectural works, cable trenches, fire safety walls, foundation, earth mat, fencing, earthing for transformers. All cables, duct banks, trenches, cable trestles shall be complete with associated civil/ structural work and necessary civil foundations. Buildings/ facilities to be provided shall include raw water reservoir, raw water pump house, aerator, stilling chamber, inlet/outlet channels, clarifiers, chemical house, sludge sump, sludge pump house, clarified water storage tank, clarified water pump house, DM plant building, degassed water storage tanks, DM water pump house, neutralizing pit, potable water tanks, service water tanks & chlorination plants building including ton container storage, waste water treatment plant sumps/ tanks, central monitoring basin, thickener, centrifuge house etc.
- iii) Scope shall also include supply and laying earthing mat all around the periphery of buildings, structures, and outdoor equipments, as per the approved drawings.



Standard Design Criteria/Guidelines for Balance of Plant for Thermal Power
Project 2 X (500W or above)

Section- 5 (Water Treatment Plant)

- iv) Access roads to all buildings/facilities including construction and maintenance of temporary access roads for approach to the building/ facilities for construction/ erection activities.

5A.3 Electrical works

- i) There shall be one no. 415V switchgears located each in Raw water pump house and DM plant building. Power supply to raw water pumps and fire water pumps shall be provided from Raw water pump house switchgear and supply to other areas viz. Pretreatment, Clarified water, Chlorination plant, DM water etc. shall be provided from DM plant switchgear.
- ii) Power supply to various drives and equipments of lamella and CMB disposal pumps shall also be arranged from DM plant switchgear. However, power supply to various collection sumps covered under waste water treatment plant shall be arranged from nearby switchgear/ MCC, as these are generally distinctly located.
- iii) Two no. Incoming power supply feeders of 2x100% capacity for each of the above switchgear shall be provided from 415V Station Switchboard separately. Further, distribution of power supply for putting water treatment system into successful operation shall be in the scope of work of supplier. Separate DC supply feeders shall also be provided at main plant DC board. Typically, following electrical equipments shall be included:
- a) 415V Switchgears
 - b) Power and Control Cables
 - c) Cable laying along with cabling accessories, Cable trays and termination/ jointing kits of cables, and fire sealing
 - d) Motors
 - e) DC distribution boards (if required)
 - f) Complete illumination system for internal and external lighting of associated plant and building
 - g) Complete grounding and lightning protections and its interconnection with nearest earth mat
 - h) Emergency stop push button for all motors

5A.4 C& I works

A totally integrated instrumentation and control system covering the total functional requirements of sequential control, interlock, protection, monitoring, alarm, data logging, fault analysis etc. to ensure operability, maintainability and reliability with latest state of art shall be provided for water treatment plant. The control system shall either be Programmable Logic Controller (PLC) based or shall be implemented through micro-processor based distributed control system (DCS). Remote I/O cabinets shall be provided wherever required depending upon distance/ location. Typical equipment required for PLC based system shall comprise of the following:



Standard Design Criteria/Guidelines for Balance of Plant for Thermal Power
Project 2 X (500W or above)

Section- 5 (Water Treatment Plant)

- i) PLC based control system for water treatment plant (WTP) located in DM plant control room consisting of Operating Work Stations (OWS), PLC panels, I/O racks, along with its power supply arrangement etc. for the control of entire WTP plant comprising of (a) raw water system, (b) pre-treatment plant, (c) DM plant and (d) waste water disposal system. It shall be possible to monitor the WTP from the main DCS through soft link.
- ii) Local control facility for operation and control of various drives in clarifier in pre treatment plant (i.e. rake mechanism drive motor, flocculator agitator motors, sludge motor etc.) located on each clarifier bridge.
- iii) Micro PLC or relay based local control panel for chlorination system in chlorination system control room with status in DM plant control room.
- iv) Instrumentation and control cables including cables laying and termination.
- v) Power supply system for C&I system including redundant UPS system, batteries, charges etc.
- vi) The necessary instrumentation viz. flow, pH, conductivity indicator/transmitter, silica analyser and recording devices along with all necessary, level switches, pressure gauges etc shall be provided for complete water treatment plant.



Standard Design Criteria/Guidelines for Balance of Plant for Thermal Power
Project 2 X (500W or above)

Section- 5 (Water Treatment Plant)

Annexure-5B

PROFORMA FOR RAW WATER ANALYSIS

Name of the Project _____ Source of Raw Water _____

Place of sampling _____ Date of Sampling _____

Depth of water source _____

Sl. No.	Constituents	Unit	Analysis
1.	2.	3.	4.
A.	(i) Calcium	mg/ lt. as CaCO ₃	
	(ii) Magnesium	- do -	
	(iii) Sodium	- do -	
	(iv) Potassium	- do -	
	(v) Iron	- do -	
	(vi) Manganese	- do -	
	(vii) Others	- do -	
	Total Cations	- do -	
B.	(i) Carbonates	- do -	
	(ii) Bi-carbonates	- do -	
	(iii) Chlorides	- do -	
	(iv) Sulphates	- do -	
	(v) Hydroxides	- do -	
	(vi) Reactive Silica	mg/ lt. as SiO ₂	
	(vii) Nitrate/Nitrite	mg/ lt. as CaCO ₃	
	(viii) Fluorides	- do -	
	(ix) Others	- do -	
	Total Anions	mg/lt. as CaCO ₃	



Standard Design Criteria/Guidelines for Balance of Plant for Thermal Power
Project 2 X (500W or above)

Section- 5 (Water Treatment Plant)

Sl. No.	Constituents	Unit	Analysis
1.	2.	3.	4.
C. (i)	Temperature	$^{\circ}\text{C}$	
(ii)	pH at 25°C		
(iii)	Turbidity	NTU	
(iv)	Colour	Cobalt scale	
(v)	Odour		
(vi)	Total suspended solids	mg/ lt.	
(vii)	Total dissolved solids	mg/lt.	
(viii)	Conductivity at 25°C	Micromhos/cm	
(ix)	P-Alkalinity	mg/ lt. as CaCO_3	
(x)	M-Alkalinity	- do -	
(xi)	Temporary hardness	- do -	
(xii)	Permanent hardness	- do -	
(xiii)	Total hardness	- do -	
(xiv)	Colloidal Silica (Non-reactive)	mg/ lt. as SiO_2	
(xv)	Dissolved oxygen	mg/lt.	
(xvi)	Bio-chemical oxygen demand(BOD)	- do -	
(xvii)	Chemical oxygen demand (COD)	mg/lt.	
(xviii)	Bacterial count	MPN/100 ml.	
(xix)	Silt content	mg/lt.	



**STANDARD DESIGN CRITERIA/GUIDELINES FOR BALANCE OF PLANT FOR
THERMAL POWER PROJECT 2x (500MW OR ABOVE)
SECTION-6: CIRCULATING WATER SYSTEM**

6.1 INTRODUCTION

- i) Circulating water system is provided for supplying water to the condenser for condensing the LP turbine exhaust steam. It is also used for secondary cooling of boiler and turbine auxiliaries.
- ii) The circulating water system may be of once through type or closed cycle recirculating type using cooling tower. Once through condenser cooling system is used for direct cooling of the condenser when cooling water is available in abundance such as sea water for coastal power stations. Closed cycle condenser cooling system using cooling towers is employed when plant water is drawn from fresh water sources such as river, canal, lake, and reservoir. As per MOE&F's stipulation dated 2.1.1999, the power plants installed after 1.6.1999 and based on fresh water sources to meet their water requirement are not permitted for adoption of once through condenser cooling system keeping in view thermal pollution aspects of the source water body. As such, all inland power plants have to adopt the cooling towers. Sea water based cooling towers are also adopted at coastal sites depending upon techno-economic considerations.
- iii) Two types of cooling towers are adopted - mechanical induced draft type or natural draft type depending upon techno-economics involving capital cost and operating expenses and consideration of site specific issues. In general, mechanical induced draft tower are preferred for power plants located near the pit head as operating expenses are low on account of lower cost of power generation at the pit head, and natural draft tower are preferred for the power plants located at load centers (far off from pit head) as these do not involve any rotating equipment, thus saving on costly power.
- iv) Air flow rate through NDCT depends upon density difference between ambient air and relatively hot & humid light air inside the tower. For sites with considerable duration of high summer ambient temperatures coupled with low relative humidity values adequate density difference would not be available for proper design and operational performance of NDCT. For such sites, IDCT should be preferred over NDCT.
- v) In case of once through system, desilting arrangement and traveling water screens of appropriate mesh size are provided at the intake section to prevent debris and biological species in source water from entering to cooling water and plant water systems. In case of sea water based cooling water system, debris filters of appropriate mesh size shall be provided at upstream section of condenser for further removing debris from the cooling water and thus reducing fouling of condenser tubes.



Standard Design Criteria/Guidelines for Balance of Plant for Thermal Power
Project 2 X (500MW or above)

Section- 6 (Circulating Water System)

- vi) Typical scope of work for 2 x 500MW coal based thermal power plant is indicated at Annexure 6A.
- vii) Drawing no. CEA-TETD-AS-04 titled 'Typical flow diagram for CW system for 2 x 500MW coal based thermal power plant is enclosed.

6.2 SYSTEM DESCRIPTION

6.2.1 Circulating Water Pumps

- i) For majority of the plants, the CW system envisaged is recirculation type system using clarified water with cooling towers. CW pumps supply cold water from cooling towers into intake ducts/ pipe headers to pass it through the condensers and plate heat exchangers of auxiliary cooling system. Hot water from the condensers/plate heat exchangers (PHE) is taken to the cooling towers through discharge ducts/ pipe headers.
- ii) CW pumps are normally of vertical wet pit type. However, for sea water applications, CW pumps of both vertical wet pit type and concrete volute type are used.
- iii) The discharge of CW pumps for one unit is connected to a common pipe header (separate for each unit). Circulating water from CW pump house is supplied to the plant condensers located in the main plant building and from outlet of the condensers to the cooling towers of individual unit. Cooling water for PHEs is tapped from upstream of the condenser and return hot water piping is connected back to the downstream of the respective condenser. Separate set of pumps (ACW pumps, to be installed in CW pump house), may also be provided to supply cooling water for PHEs. Cold water from the cooling towers flows under gravity to the CW pump house through an open cold water channel.
- iv) Each unit is provided with independent intake and discharge steel lined duct for circulating water. The CW pump house shall be provided with trash rack and stop logs. The water level in the CW pump house fore-bay/sump shall be regulated/ controlled by means of butterfly valve in the CW makeup line.

6.2.2 Cooling Towers

As mentioned earlier, two types of cooling towers are adopted - mechanical induced draft type or natural draft type.

The mechanical induced draft type cooling tower is of single or double inlet, cross flow or counter flow type with the fans located on top of the tower. The natural draft type cooling tower is of counter flow or cross flow type with draft for air flow through the packing provided by buoyancy effect of hot and humid air inside the tower shell as compared to outside ambient air. Packing can be of



splash type or film type. However, due to ambient air having high levels of dust, splash type film is preferred for both types of towers.

6.2.3 CW Make- up and Treatment System

- i) Circulating water quality in terms of desired COC is maintained by effecting blow down from hot water side of CW system and used in low grade applications such as ash handling system, coal dust suppression & gardening etc. Water loss due to evaporation, drift & blow down is replenished by make-up water supplied by CW make-up water pumps installed in the clarified water pump house.
- ii) For preventing the microbiological growth in the CW system, chlorine dosing is provided. Shock dosing of chlorine is carried out in the fore bay of CW pump house. Apart from chlorine dosing in the circulating water, dosing of sulphuric acid, scale inhibitor, corrosion inhibitor and biocide inhibitor as required is done for the control of scale formation, corrosion and organic fouling in the CW & ACW system.
- iii) Side stream (SS) filters are provided in clarified water based closed cycle cooling water system to reduce the turbidity in circulating water on account of suspended solids in make up water and atmospheric dust ingress through cooling tower. The SS filters shall treat a fraction of circulating water, of the order of 2% of CW flow.

6.3 Sea Water Cooling

Coastal thermal power station using sea water for condenser cooling have both the options i.e. once through cooling or closed cycle cooling using cooling towers. Selection of type of system is based on the thermal pollution effect on sea water and techno-economics based on the distance of power station from the coast and cost of pumping sea water.

Because of high salt concentration, cooling tower drift and salt contamination in the environment are considerations for cooling towers with sea-water makeup. The drift will contain very high (up to 55,000 ppm) concentration of total dissolved solids, hence a sea water cooling tower should not be located close to sensitive equipment to minimize corrosion effect. To avoid long distance drift of high concentration salt water, it is recommended that the distribution system be designed for low-pressure spray nozzles, which will reduce the quantity of water droplets impinging on the drift eliminators. Drift rate is limited to 0.02 to 0.05 percent of the circulation water flow rate.

A typical sea-water cooling tower operates at cycle of concentration ranging from 1.3 to 1.5 and size of cooling tower is 5 to 10 percent larger than a similar capacity fresh-water system. This is because sea water, having high salt concentration, lowers the water's vapor pressure and reduces the evaporative



Standard Design Criteria/Guidelines for Balance of Plant for Thermal Power Project 2 X (500MW or above)

Section- 6 (Circulating Water System)

cooling rate by 5 to 8 percent (depending on salt concentration). Approach temperatures used for design of towers must consider the effect salt water has on tower performance. For instance, if a 5 deg approach temperature is considered for fresh water based cooling tower, 6 degree approach would be acceptable for a sea water system.

Keeping in view the discharge water temperature limitations for coastal power plants, cooling tower blow down is effected from the colder side of CW circuit i.e. from the discharge header of CW pumps. The blow down is partially used for ash handling and remaining blow down is discharged back to sea.

For construction of sea water based cooling towers organic corrosion inhibitor (MCI Type) is mixed in concrete above water zone. A 2mm thick 100% solid polyurethane coating is applied on all concrete & steel members in water zone and hot water basin to protect the surface from the effect of sea water. Distribution piping of PVC performs well in salt water service.

The fan blades may be of glass reinforced polyester or epoxy coated aluminum. Gear reducers, bearing housings and fan hubs may be made of cast iron provided they are protected with a heavy coating of epoxy enamel. Mechanical equipment supports and welded steel fan hubs should also be protected with a heavy coating of epoxy enamel. Since stainless steel resists salt water very well in areas which are highly aerated, drive shafts and fasteners in the mechanical equipment should be made with type 316 stainless steel.

6.4 DESIGN CRITERIA

6.4.1 Capacities for a typical 1000MW unit (2 x 500MW) are as follows:

S.No	Equipment	Numbers	Capacity
1	CW pumps	5 (4 working +1 standby) for two units	32,200 m ³ /h each
2	Cooling tower	IDCT - 4 (2 for each unit) OR	30,000 m ³ /h each with cooling range of 9.5 deg C
		NDCT - 2 (1 for each unit)	60,000 m ³ /h each with cooling range of 9.5 deg C
3	Chlorination plant	4 streams (3 working +1 standby) for two units	200 kg/h each
4	Side stream filters	7 (6 working + 1 standby) for each unit	200 m ³ /h each



6.4.2 CW Pumps

The CW pumps shall be provided on unit basis. The standby pumps shall be provided common to more than one unit depending upon total number of CW pumps.

CW pumps shall be of vertical wet pit type, non pull out type, mixed flow design with single stage impeller suitable for continuous heavy duty application. These pumps shall be directly driven by a constant speed squirrel cage induction motor.

i) *Rated discharge*

- a) The capacity of the CW pump(s) shall be as per cooling water requirement of the condenser and secondary cooling water requirement of plate type heat exchangers. The requirement of power water for CW chlorination and flow to side stream filters, as applicable, shall also be considered while arriving at CW pump capacity. If separate set of auxiliary cooling water pumps are provided for heat exchangers, the capacity of CW pumps shall get reduced accordingly. For design of CW pumps, the requirement of cooling water for the condenser shall be taken corresponding to operation of the unit at VWO (valve wide operation) condition with design condenser pressure and 3% cycle make up.
- b) For arriving at the rated capacity of CW pump, five (5) % margin shall be provided on flow capacity as per (a) above.

ii) *Total head*

Total head of the CW pump shall be calculated as a sum of the following:

- a) Static lift from minimum water level in CW sump to the highest point of cooling tower hot water distribution system.
- b) Discharge velocity head
- c) Friction drop in the entire CW system with minimum 10% margin.
- d) The bowl head of the pump shall be calculated by adding the losses through the pump column, discharge elbow and entry losses at suction to the total head of the pump as calculated above.
- e) The selected head of CW pump shall provide for adequate margin so that pumps are capable of supplying equipment design flow at 47.5 Hz frequency of power supply.



6.4.3 Cooling Tower

- i) The cooling tower(s) shall be designed for a flow rate corresponding to maximum cooling water requirement of the condenser and auxiliary cooling water system.
- ii) The design range of the cooling tower shall be equal to design temperature rise across the condenser plus one deg. C for IDCT and shall be equal to design temperature rise across the condenser for NDCT.
- iii) The design wet bulb temperature of the cooling tower shall correspond to the ambient wet bulb temperature which is not exceeded by more than 5% of the time during four (4) summer months in an average year plus recirculation allowance (applicable for IDCT only). The recirculation allowance as per Cooling Tower Institute (CTI) code shall be considered
- iv) For natural draft cooling tower, the design relative humidity shall be appropriately selected based on annual variation of relative humidity in combination with annual variation of wet bulb temperature.
- v) The design approach to the design wet bulb temperature for arriving at the design cold water temperature shall generally not exceed 5 deg C for mechanical induced draft cooling tower and 6 deg C for natural draft cooling tower.

6.4.4 Side stream filtration

Side stream filters shall be designed to filter about 2% of the total CW & ACW flow. The filters shall be designed for maximum flow velocity of $10\text{m}^3/\text{h}/\text{m}^2$.

6.4.5 Chlorination

Shock dosing of chlorine shall be done in the forebay for half an hour per shift for a shift of 8 hours. Dosing rate of 5 ppm shall be considered for design of CW chlorination plant.

6.5 DESIGN REQUIREMENTS AND BROAD FEATURES

6.5.1 Mechanical Equipment / Systems

6.5.1.1 CW Pumps

- i) *Pump speed & cavitations*

The suction specific speed available (i.e. specific speed calculated with available NPSH) shall not be greater than 8500 US units at minimum water level. Pump speed shall be based on the suction specific speed available. The design, construction and speed of the pumps shall be such as to minimize cavitations and ensure a long and trouble free service. The suction specific speed required (i.e. specific speed calculated with NPSH required) of the pump shall not exceed



Standard Design Criteria/Guidelines for Balance of Plant for Thermal Power
Project 2 X (500MW or above)

Section- 6 (Circulating Water System)

12000 US units. Net positive suction head required (NPSHR) shall be less than Net positive suction head available (NPSHA) during all operating conditions including run out condition.

ii) *Pump characteristics*

- a) The pump shall have stable head capacity characteristics continuously rising towards shut off conditions.
- b) All the pumps shall be identical to one another and shall have identical characteristic curves and shall be capable of running in parallel continuously without any restriction.
- c) The pumps shall operate satisfactorily single or in parallel without cavitations or any deleterious effects, undue vibration or noise at all water levels from minimum to maximum.
- d) The rated duty point for circulating water pumps shall preferably be within 2 to 3% of best efficiency point.

iii) *Critical speed*

The operating speed of the pump shall not be too close to the first critical speed, i.e.

N should be less than $0.8 N_{C1}$ or greater than $1.3 N_{C1}$

Where

$$\begin{aligned} N &= \text{Operating speed} \\ N_{C1} &= \text{First critical speed} \end{aligned}$$

First critical speed should be more than reverse run away speed.

iv) *Pump sump*

Sump design for the CW pump house shall meet the requirements of Hydraulic institute Standards (HIS), USA.

v) **Hydraulic transient study**

Hydraulic transient analysis shall be carried out for the complete CW system to decide the following:

- a) Pump discharge valve closing sequence and rate of closure for pump stopping and pump tripping conditions.
- b) Number, size and location of air release valves.
- c) Condenser inlet and outlet valve closure rate.
- d) Pump discharge valve opening sequence and rate of opening during pump start-up condition.



Standard Design Criteria/Guidelines for Balance of Plant for Thermal Power
Project 2 X (500MW or above)

Section- 6 (Circulating Water System)

vi) *Hydrostatic test for CW pump*

The pump bowl, column and discharge head assembly shall be capable of withstanding a hydrostatic test pressure equal to twice the bowl discharge pressure at rated capacity or 1.5 times the shut off head, whichever is greater.

vii) *Model test of CW pumps*

For the specific speed of the offered pumps, the bidder should have carried out the model study. The specific speed of the model tested should lie within $\pm 5\%$ of the specific speed of the pump offered.

In case model test has already been not conducted, a model test for the offered CW pump shall be conducted to predict the performance of the prototype. Model test shall be conducted in vertical position and shall include the cavitations test. The model pump head should be the same as the head of the prototype pump, and should be run at such a speed that the specific speed is the same as that of the prototype.

6.5.1.2 **Cooling tower**

i) *Arrangement and Spacing of IDCT*

The axis of the mechanical induced draft cooling tower shall be oriented along the summer wind direction. Adequate clear space shall be provided on both the air inlet sides of the cooling tower as per requirements of the relevant codes. For installation of more than one cooling tower, the arrangement and minimum distance between two adjacent cooling towers shall be as per recommendations of CTI Code of USA.

ii) *Spare Cells for Mechanical Draft Tower*

The number of spare cells per tower shall be one number in case of double air inlet cells and shall be two nos. in case of single air inlet cells. All the cells including spare cell (s) shall be identical in shape, size and capacity.

iii) *Cooling tower structure*

The RCC structures of the cooling tower including structures either in contact with falling water or moisture/ water vapor shall be designed as uncracked and as stipulated in IS :11504-1985. The platforms, staircases, walkways etc. shall be designed as per IS: 456 and IS: 800.

iv) *Cooling tower basin*

a) The basin shall be designed for a water depth of at least 1.0m from minimum water level with free board of at least 0.50 m above maximum water level. The basin and cold water discharge channel shall be capable of handling 120% of the design flow without any overflow. The basin outlet shall be sized for a water velocity not exceeding 1.0 m/sec at minimum water level.



Standard Design Criteria/Guidelines for Balance of Plant for Thermal Power
Project 2 X (500MW or above)

Section- 6 (Circulating Water System)

- b) The Cold water basin including sump, partition wall, sludge pits, cold water channel, stop log gate, and hot water basin shall be designed considering water upto full level in the basin and no water on other side. The permissible leakage from stop log gate shall not exceed the stipulations of relevant IS codes or 15 litres per meter run of the contact whichever is lower.
- c) For NDCT tower, the basin shall be divided into two equal parts by water tight RCC partition for the purpose of cleaning and maintenance. The basin floor shall have slope of minimum one in 120 from centre towards the drain sump in the cooling tower. From the drain sump, water shall flow into an external sludge sump of adequate capacity. Arrangement for drainage of water/ sludge from the sump shall be provided.
- d) Cold water outlet shall be provided with a removable flow measuring weir, a trash rack and a steel stop log gate. Suitable handling arrangement with a monorail and a chain operated hoist will be provided.
- v) *Packing/ fill*
 - a) The splash type packing shall be of either pre-stressed concrete, PVC or PP type. The packing/ fill material shall be easily installable and shall promote a high rate of heat transfer consistent with low resistance to air flow. The packing shall provide for easy and free access of air to its all parts, and maintain uniform water and air distribution throughout the packing/ fill volume. The packing/ fill material shall be highly resistant to deterioration and shall be fire retardant.
 - b) The splash bars shall be horizontal and adequately supported to prevent sagging and damage. The water shall be uniformly distributed over the splash bars and no channelling should occur in any part of the tower.
 - c) The PVC material shall be ultraviolet ray stabilized using titanium dioxide. Only virgin PVC material shall be used and finished fills shall be white or light cream in colour.
- vi) *Drift eliminators*

The drift eliminators shall be designed to keep the drift loss to a minimum and the same shall not exceed 0.05% of total water in circulation. The drift loss shall be kept to a minimum by providing proper number of air flow direction changes across the eliminators.
- vii) *Induced draft fan*
 - a) Induced draft fans shall be of axial/ propeller type having aerofoil section blades with provision of pitch adjustment upto ± 5 deg. from the normal setting. The blades shall provide uniform velocity from hub to tip with low noise and vibration.
 - b) The number of blades shall not exceed twelve (12) and the blade tip velocity shall not exceed 65 m/sec.



Standard Design Criteria/Guidelines for Balance of Plant for Thermal Power
Project 2 X (500MW or above)

Section- 6 (Circulating Water System)

- c) All the rotating parts of fans shall be statically and dynamically balanced as per ISO 1940, Gr- 6.3.
 - d) The fan characteristic curves shall be developed based on model study of geometrically similar fan in a wind tunnel test.
 - e) The fan shall be designed with adequate margins so as to meet the rated performance at speed corresponding to 47.5 Hz frequency of power supply.
- viii) *Reduction gear box*
- a) The reduction gear box shall be heavy duty type suitable for installation in outdoor and humid environment. The gear drive shall be enclosed type and shall operate in oil bath. The gear shall be of spiral bevel or worm type and the reduction may be accomplished either in single stage or multistage.
 - b) The design rating of the gear box shall be arrived at after considering a minimum service factor of 2.0 and thermal derating effects at 50 deg. C. The piping for oil level gauge/dipstick and thermometer shall facilitate draining and refilling of oil from outside the stack.
 - c) The gear boxes shall utilize non-hygroscopic oil for lubrication and its temperature shall be kept within the recommended limits during all operating conditions. The guaranteed life of reduction gear unit shall not be less than one (1) lakh hours.
 - d) Each fan unit shall be fitted with a low oil level and high vibration cut out switches which may be preferably mounted on the gear box.
- ix) To protect the CT fan motor from cooling tower drift etc., suitable canopy shall be provided.

6.5.1.3 **Natural Draft Cooling Tower**

i) *Arrangement and Spacing of NDCT*

For natural draft cooling towers, the clear distance between two adjacent cooling towers at still level shall be kept at least half the diameter of the tower at basin sill level as provided in IS:11504-1975.

ii) *Specific Requirements of NDCT*

- a) Four (4) nos. aviation warning lights (GEO ZH 750 aviation neon low intensity or equivalent) shall be provided at the top each cooling tower, spaced 90 degree apart and shall meet the recommendations of ICAQ and Director General of Civil Aviation, India. The Aviation warning lighting system shall also conform to the latest Indian Standard IS: 4998. The photoelectric light detectors installed for monitoring the north sky shall cause the control unit to energise the aviation lighting system when the north sky



Standard Design Criteria/Guidelines for Balance of Plant for Thermal Power
Project 2 X (500MW or above)

Section- 6 (Circulating Water System)

illumination on the vertical surface decreases below 35 candela and de-energised when the same increases beyond 58 candela.

- b) The following loads shall be considered for the design of cooling towers:
- Dead Load
 - Wind load as per IS:875-1987 (latest)
 - Earthquake forces as per IS:1893 latest (corresponding to Zone iii)
 - Loads due to temperature effects: The temperature difference between the inside and the outside faces of the cooling tower shall be considered as per thermic design but not less than 10 deg. C. Further, a temperature variation of 50 deg. C shall be considered for each face on account of sun's radiation.
 - Constructional loads
 - Loads due to foundation settlement, if any
 - Any other load likely to act on cooling tower
 - Loads due to aerodynamic effect

The combination of different loads for design purposes shall be in accordance with IS: 875-1987 (latest).

- c) The inclination of the raker columns shall closely match with the meridional slope at the base of the integral shell so that the load transfer to foundation takes place predominantly as axial force in the columns. The basin wall shall be integral with the thickened pedestals under the raker columns and shall be designed as uncracked section as per IS:3370.
- d) The tower shall be designed as per IS: 11504-1985. The shell shall be designed as a uncracked section and the permissible tensile stresses in concrete as given in IS: 456-1978 shall not be exceeded. The pile foundations (cast in situ driven piles) shall be used for the cooling tower and shall be designed in accordance with IS : 2911 (Part I/Sec 1 II and III-1979).

6.5.1.4 *Design of CW Ducts*

i) *CW Duct*

CW duct from CW Pump house up to condensers and from condenser to cooling towers shall be steel pipe encased in reinforced cement concrete. The steel pipes shall be encased in concrete of grade minimum 20 and minimum thickness of concrete shall be 300 mm all-round up to 2200 mm dia pipe and 500mm all-round for higher dia pipes. The minimum thickness of steel pipe shall be as follows including corrosion allowance of 5mm.

- For pipes up to 2200mm dia - 12mm.
- For pipes above 2200mm dia upto 3200 mm dia - 14 mm.
- For pipes greater than 3200 mm dia - 16 mm.



Standard Design Criteria/Guidelines for Balance of Plant for Thermal Power
Project 2 X (500MW or above)

Section- 6 (Circulating Water System)

ii) *Air release valve*

The air release valves shall be provided on CW pump discharge and CW ducts/ piping. These valves shall be of double air kinetic type to function as automatic air-release-cum-vacuum breaker valve(s) with their number and size as per hydraulic transient study.

6.5.1.5 *CW Chlorination plant*

i) The chlorination plant shall be complete with ton containers, evaporators, expansion chambers, gas filters, chlorinators, ejectors, booster pumps, chlorine liquid and gas pipelines, fittings, valves, mechanical exhaust system for 35 air changes per hour, and all necessary instruments, interlocks & protections etc.

ii) The complete installation shall meet the requirements of Chief Controller of Explosives, Nagpur, India and the statutory regulations prevalent in India. Layout and design etc. of the chlorination system shall be got approved from the Chief Controller of Explosive, by the bidder before commencement of work.

iii) *Ton Containers*

Filled chlorine ton-containers, capacity not less than 900 kg, shall be provided to store chlorine in liquid vapour phase. Each Chlorine Ton-Container will be mounted on two (2) nos. metallic bracket type Roller Supports. These brackets will be mounted on civil foundation and all necessary anchor bolts, inserts, nuts etc. Automatic switchover system shall be provided with manifolds, valves, instruments & fittings. Material of construction shall conform to ASTM -A-285 Gr.C.

The chlorine ton containers and auxiliary tonner valves shall be of approved design by the Chief Controller of Explosives. The number of tonne containers to be provided shall be for fifteen (15) days requirement of chlorine dosing for the plant.

iv) *Evaporator*

Electrically heated constant temperature water bath type evaporator shall be provided to vaporise liquid chlorine into gas form for further feeding into the chlorinator. Vaporizer body for evaporator shall be Seamless steel tubes as per ASTM-A-106 Gr. B and Flanges of IS: 2002 Gr. B Plates.

v) *Chlorinators*

Chlorinator shall be of vacuum solution feed type. Chlorinator Cabinet will be fibreglass, self colored, resistant to corrosion by chlorine gas and chlorinated water solution. The chlorinator shall be complete with vacuum regulation valve (automatic), automatic pressure and vacuum relief valve, chlorine feed rate adjuster, adjustable throat ejector with ball check valve, vacuum trimmer and drain relief valve, ejector power water supply system, pressure vacuum and flow rate gauges etc.



Standard Design Criteria/Guidelines for Balance of Plant for Thermal Power
Project 2 X (500MW or above)

Section- 6 (Circulating Water System)

Chlorine gas strainer, 2 x 100% (for each chlorinator), shall be provided. MOC shall be Carbon steel and filter media shall be spun fibre glass wool.

Motive water for the chlorination plant shall be tapped from the CW pumps discharge header and its pressure shall be boosted by 3 x 50% capacity centrifugal pumps as per requirement of the chlorinators. Suction strainers, Bourdon Gauge with diaphragm seal type, shall be provided for each pump.

vi) *Chlorine Leak detection and safety equipment*

The leak detectors shall be provided in the chlorinator and evaporator areas as well cylinder area. All working tonners shall be provided with full hoods & others with half hoods, interconnected & leading to the neutralisation tower of leak absorption system.

Automatic chlorine leak detection & absorption system shall be provided for tonners. The chlorine leak absorption system shall be sized for absorption and neutralisation of about one tonne chlorine leakage within one hour. The principle of operation for absorption system is to pass the leaked chlorine along with ambient air to the neutralisation tower (with counter flow of absorbent) for chlorine absorption.

6.5.1.6 *CW dosing system*

i) CW dosing shall be designed to meet the following requirements:

- a) Corrosion rate in mild steel part of the system component shall not exceed 2 mpy as measured by mutually agreed procedures.
- b) Scale shall not exceed 10 mg per square decimetre of the total internal tube surface area of the condensers of the units in one year.
- b) Corrosion rate on stainless steel shall not exceed 0.1 mpy without pitting as measured by mutually agreed procedure.
- c) pH: 7- 8
- d) Turbidity: < 20 NTU
- f) Non-toxic effluent. No treatment should be required for the blow down water.

ii) *Acid dosing*

- a) Acid dosing system (98% H₂SO₄) shall be provided for pH correction in CW system and sulphuric acid shall be used for this purpose.
- b) The pH of CW system shall be analysed in a sampling station. This analysis would be used to proportionally control the addition of sulphuric acid by stroke control of the dosing pumps in order to maintain pH within the



Standard Design Criteria/Guidelines for Balance of Plant for Thermal Power
Project 2 X (500MW or above)

Section- 6 (Circulating Water System)

operation range of around 7-8. A pH recorder shall be installed on the local control panel near the acid dosing unit.

- c) Design and configuration of sulphuric acid storage tank (CS construction), acid measuring tanks, unloading system etc. shall be as indicated in water treatment section. Minimum thickness of acid storage tank shall be 10mm.
- d) Acid measuring tanks, pumps etc. shall be sized considering minimum dosage rate of 150 ppm based on CW make up flow rate and for 24 hours dosing requirement of the plant.

iii) *Chemical inhibitor dosing*

- a) Suitable scale, corrosion & biocide inhibitor shall be fed to prevent deposition of scales on heat transfer surfaces. The chemical inhibitors shall be of non-foaming & non-toxic type.
- b) The dosing chemicals proposed shall be freely available in India. Heavy metals based chemicals such as chromate; zinc etc. shall not be acceptable. Further, the chemicals shall not have any deleterious effect on any component of the CW system. Organic polymer/ organic phosphorous/ organic phosphate based chemical shall be used.
- c) Performance curves of the suggested chemical with respect to variation in various constituents of the circulating water viz. Hardness, suspended solids etc. shall be provided. Any dispersant (if required) shall also be included by the bidder.
- d) The chemical used in the treatment programme shall be subject to the approval of State Pollution Control Board.
- e) All tanks, pumps etc. shall be sized based on minimum dosage rate of 25 ppm based on CW make up flow rate and for 24 hours dosing requirement of the plant. Alternatively, the pumps can also be mounted directly on the chemical barrels as per manufacturer's standard practice.
- f) Storage tanks shall be of MS construction with inside rubber lining.

6.5.1.7 *Side stream filtration plant*

- i) Filters shall be designed to remove Total Suspended Solids (TSS) of circulating water operating at high COC and atmospheric dust ingress in the system. Effluent turbidity shall not exceed 2 NTU for inlet turbidity of 25 NTU.
- ii) The input water to the side stream filters shall be tapped from the discharge side of CW pump and the effluent shall be led to the CT sump. Waste water arising from the backwashing of filters shall be led to bottom ash handling plant or inlet of lamella clarifier of ETP.
- iii) Details specification of filters, air blowers & backwash pumps shall be as indicated water treatment section.



6.5.2 Electrical System

For design requirements of Electrical system, Section VII of this document may be referred to.

6.5.3 Control and Instrumentation System

For design requirements of Control & Instrumentation system, Section VIII of this document may be referred to.

6.5.4 Civil Works

For design requirements of Civil Works, Section 9 of this document may be referred to.

6.6 PERFORMANCE AND GUARANTEE TEST

6.6.1 *CW pumps*

- i) After the manufacture, all the CW pumps shall be performance tested at the manufacturer's works to determine the power consumption and to establish the performance characteristic as per requirements of IS: 9137, standards of the Hydraulic Institute, USA or equivalent. Performance test at design duty point shall be done keeping minimum submergence of the pump identical to that specified for the site conditions.
- ii) During shop tests no negative tolerance shall be permitted on head (H), capacity (Q) and the pump efficiency (n). Accuracies of instruments used shall be $\pm 1.5\%$ or better for measurement of flow and $\pm 0.5\%$ or better for measurement of pressure and power.

6.6.2 *Cooling Tower*

Performance testing of cooling towers (both IDCT & NDCT) shall be carried out as per ATC-105 at a time when the atmospheric conditions are within the permissible limits of deviation from the design conditions. Correction curves shall be applied for correction of the test results for deviation of test conditions such as flow rate, cooling range and wet bulb temperature and dry bulb temperature/ relative humidity (for NDCT only) from their respective design.

6.6.3 *CW Treatment System*

The following tests and checks shall be made at site in the presence of the purchaser:

- a) Satisfactory operation of each equipment.
- b) Tests required for establishing the guaranteed performance and chemical consumption.



6.6.4 **Chlorination plant**

Chlorination system shall be performance tested at site for dosing capacity of individual chlorinator capacity.

6.7 **CODES & STANDARDS**

All materials, equipment and safety regulations shall comply with applicable provisions of the latest edition of relevant Indian Standards and other applicable codes/ standards. The following Indian standards (latest edition) shall be applicable to this specification unless otherwise specified:

IS: 804	Rectangular pressed steel tanks
IS: 1239	Mild steel tubes, tubular & other wrought steel fittings
IS: 1520	Horizontal, centrifugal pumps for clear, cold fresh water
IS: 1536	Centrifugally cast (spun) iron pressure pipes for water, gas and sewage
IS: 1537	Vertically cast iron pressure pipes for water, gas and sewage
IS: 1710	Vertical turbine pumps for clear, cold fresh water
IS: 2002	Steel plates for boilers
IS: 2062	Structural steel (Fusion welding quality)
IS: 2594	Horizontal mild steel welded storage tanks
IS: 2825	Code for unfired pressure vessels
IS: 3589	Electrical welded pipes for water, gas & sewage (200 to 2000mm)
IS: 3832	Hand-operated chain pulley block
IS: 4682	Code of practice for lining of vessels and equipment for chemical processes-rubber lining
IS: 5120	Technical requirements for rotodynamic special purpose pumps
IS: 5639	Pumps handling chemicals and corrosive liquids
IS: 5659	Pumps for process water
IS: 6393	Steel pipe flanges
IS: 6547	Electric chain hoist
BS: 5155	Cast iron & carbon steel butterfly valves for general purpose
AWWA-C-504	Rubber seated butterfly valves

Cooling Tower Institute (CTI) codes

Hydraulic Institute Standards (HIS) of USA



6A.0 SCOPE OF WORK

Typical scope of supply of circulating water system for 2x500 MW thermal power plant is described as below:

6A.1 Mechanical

6A.1.1 Circulating water (CW) pumps

- a) Five (5) numbers (4 working + 1 standby) circulating water pumps of vertical wet pit type, mixed flow design and self water lubricated complete along with motors and associated accessories.
- b) Electro-hydraulically operated butterfly valve (with actuators), isolating butterfly valve and rubber expansion joints at discharge of each pump. Electrically operated butterfly valves for interconnection of standby pumps to operate as common standby for both the units.
- c) One number CW re-circulation line for each unit, suitable for handling a flow of 50% of one CW pump flow with electrically operated butterfly valve (with actuators).
- d) Complete piping including discharge piping/header of CW pumps, CW duct from CW pump house to condensers and from condensers to the cooling towers, blow down piping (up to ash handling plant and central monitoring basin of ETP), fittings & valves and other accessories as required.
- e) EOT crane for handling & maintenance of CW pumps and monorail and electrically operated pendant control hoist arrangement for maintenance of stoplog gates and trash racks.
- f) One number trash rack for CW pump house bay and two numbers of stop logs for CW pump house.
- g) Air release valves, with isolation valves, in CW piping as per the system requirement.
- h) Hydraulic transient analysis of CW system.
- i) CW pump model study and CW pump house/ sump model studies as required.



Standard Design Criteria/Guidelines for Balance of Plant for Thermal Power
Project 2 X (500MW or above)

Section- 6 (Circulating Water System)

6A.1.2 Cooling Towers

Four (4) numbers induced draft cooling towers, two (2) for each 500 MW unit, complete with associated accessories

Or

Two (2) number NDCTs of adequate capacity, one for each 500MW unit, complete with associated accessories.

6A.1.3 CW Treatment System

6A.1.3.1 Chlorination Plant

- a) 4 x 33.3% chlorinators with 2 x 100% gas strainers for each chlorinator.
- b) Evaporator for each chlorinator complete with rupture disc, expansion chamber, heating element, water chamber, pressure relief valve etc.
- c) Pipe manifold with accessories.
- d) Chlorine liquid and gas pipelines.
- e) Ton containers for fifteen days requirement with hoods.
- f) Residual Chlorine analyser.
- g) Automatic leak detection and absorption system consisting of leak detectors, 2 x 100% blowers, chlorine absorption tower, caustic preparation & recirculation tank & 2 x 100% caustic solution pumps.
- h) Safety equipments

6A.1.3.2 Chemical dosing system

- a) Sulphuric acid dosing
 - i) 2 number acid storage tanks with total capacity for one month requirement of acid for both units.
 - ii) 2 x 100% acid unloading pumps
 - iii) 2 x 100% acid measuring tanks
 - iii) 2 x 100% acid dosing pumps
- b) Chemical inhibitors dosing (scale/corrosion/ biocide inhibitor)
 - i) One storage tank/ container for each type of chemical inhibitor for one month requirement of plant.
 - ii) 2 x 100% dosing barrels/ tanks for each type of chemical inhibitor
 - iii) 2 x 100% dosing pumps for each type of chemical inhibitor
 - iv) Platform type weighing scale, if required.



Standard Design Criteria/Guidelines for Balance of Plant for Thermal Power
Project 2 X (500MW or above)

Section- 6 (Circulating Water System)

- 6A.1.3.3 Side stream filtration plant
- i) Fourteen (12W + 2S) numbers of pressure filter type side stream filters.
 - ii) 3 Nos. (2W + 1S) filter air blowers.
 - iii) 3 Nos. (2W + 1S) backwash pumps.
- 6A.1.3.4 Two (2) number automatic safety showers with drench & eye bath units, one each for chlorination plant & chemical dosing system.
- 6A.1.3.5 One (1) number overhead tank of adequate capacity to supply clarified/ filtered water for dilution/ chemical preparation, safety shower etc. for entire CW treatment system.
- 6A.1.3.6 Material handling equipment such chain pulley blocks, motorized travelling trolley & monorail etc. for operation and maintenance of CW treatment system.
- 6A.1.3.7 All integral and interconnecting piping, globe valves, diaphragms valves, gate valves, NRVs, control valves and all types of pipe supports, cable racks, pipe/ cable bridges and clamping arrangements required for entire CW system.
- 6A.1.4 Air conditioning of control rooms & ventilation of various buildings.
- 6A.1.5 Distribution piping for service air & instrument air, as required.
- 6A.1.6 Supply of first fill of all types of chemicals, greases, lubricants etc.
- 6A.1.7 One set of necessary tools and tackles required for operation and maintenance of the plant.
- 6A.2 Civil Works**
- i) The civil works to be performed shall cover providing all labour, materials, construction equipment, tools and plant, scaffolding, supplies, transportation, all incidental items necessary for successful completion of the work. The work shall involve earthwork in excavation, de-watering, shoring and strutting, sheet piling, back filling around completed structures and plinth protection, area paving, disposal of surplus excavated materials, piling, concreting including reinforcement and form work, brick work, fabrication and erection of structural / miscellaneous steel works, inserts, architectural items & finishes such as plastering, painting, flooring, acid/alkali proof lining, doors, windows & ventilators, glass and glazing, rolling shutters etc., permanently colour coated profiled steel sheeting, anchor bolts, RCC trenches with covers, laying and testing of water pipes, sanitation, water supply, drainage, damp proofing, water proofing and other ancillary items.



Standard Design Criteria/Guidelines for Balance of Plant for Thermal Power
Project 2 X (500MW or above)

Section- 6 (Circulating Water System)

- ii) Buildings/structures to be provided shall include, but not limited to;
- a) CW pump house & MCC room
 - b) CW forebay & channels etc.
 - c) Cooling towers
 - d) CW treatment plant
 - e) Chlorination plant including ton container storage etc,

All buildings shall be complete with all electrical, civil, structural, architectural works, cable trenches, fire safety walls, foundation, earth mat, fencing, earthing for transformers. All cables, duct banks, trenches, cable trestles shall be complete with associated civil/ structural work and necessary civil foundations.

- iii) Scope shall also include supply and laying earthing mat all around the periphery of buildings, structures, and outdoor equipments, as per the approved drawings.
- iv) Access roads to all buildings/ facilities of CW system including construction and maintenance of temporary access roads for approach to the building/ facilities for construction/ erection activities.

6A.3 Electrical Works

Two no. feeders shall be provided from 11kV Station Switchboard for CW system. Further, distribution of power supply at 415V voltage level (CW treatment & chlorination system) and all other required electrical equipments for putting CW system into successful operation shall be in the scope of work of CW system supplier. All 11kV and 415V Switchgears shall be located in CW pump house Switchgear room. The 415V supply shall be arranged through 11/0.433kV LT auxiliary transformers. In case of IDCT, separate 415V switchgear shall be provided for CT fans and power supply to this switchgear shall be arranged from 415V CW P/H switchgear. Separate DC supply feeders shall also be provided at main plant DC board. Alternatively, Power supply to CW pumps shall be provided from respective 11kV Unit Switchboard. However, power supply for stand-by CW pump (common for both the units) shall be arranged from 11kV Station board. Similarly, feeders required for CW system at 415V level shall be provided from respective 415V unit board(s). In case of IDCT also, feeders for CT pumps shall be provided on unit basis from respective 415V unit board(s). Typically, following electrical equipments shall be included:

- a) 11/0.433kV auxiliary transformers
- b) 11kV and 415V Switchgears
- c) LT Bus duct
- d) Power and Control Cables
- e) Cable laying along with cabling accessories, Cable trays and termination/ jointing kits of cables, and fire sealing
- f) HT and LT Motors
- g) DC distribution boards (if required)
- h) Complete illumination system for internal and external lighting of associated plant and building



Standard Design Criteria/Guidelines for Balance of Plant for Thermal Power
Project 2 X (500MW or above)

Section- 6 (Circulating Water System)

- i) Complete grounding and lightning protections and its interconnection with nearest earth mat
- j) Emergency stop push buttons for all HT and LT motors

6A.4 Control & Instrumentation Works

- i) The CW pumps & associated valves logics shall be realized in purchaser's DDCMIS panels. The control & operation of CW pumps/ system shall be from respective Unit OWS in addition to Desk Top OWS placed locally (extension of purchaser's DDCMIS) in CW pump house.
- ii) PLC based local control panel for operation and control of various drives for Chlorination system.
- iii) Micro-PLC or relay based local control panel for operation and control of various drives for CW treatment plant.
- iv) Instrumentation and control cables including cables laying and termination
- v) Power supply system for C&I system including redundant UPS system, batteries, charges etc.
- vi) The necessary instrumentation shall be provided for CW system including:
 - a) Vibration monitoring system for CW pumps and motors which shall be hooked up with respective unit DDCMIS by serial communication.
 - b) Chlorine leakage detection - Chlorine absorption and neutralizing system would come in to service automatically on detection of chlorine leakage exceeding a stipulated level.



**DESIGN CRITERIA/GUIDELINES FOR BALANCE OF PLANT
OF THERMAL POWER PROJECT 2x (500 MW OR ABOVE)
SECTION-7 : FIRE PROTECTION, DETECTION AND ALARM SYSTEM**

7.1 INTRODUCTION

The fire protection, detection and alarm system is provided for thermal power station to protect the plant against fire damage to avoid loss of life and property. Fire detection system is provided to detect fire in its incipient stage and to actuate the fire protection system to extinguish fire. Alarm system gives warning in case of fire to prompt fire fighting staff and other operation personnel to take necessary action. In addition to fixed automatic system, portable and mobile systems are also provided for fire extinguishing.

7.2 SYSTEM DESCRIPTION

Clarified water is used for fire fighting service. Dedicated storage of clarified water of around 4000 M³ for fire water purpose is kept in two nos. fire water storage tanks. Horizontal fire water pumps are provided in Fire water pump house. Jockey pumps are also provided to take care of system losses and these are also located in Fire water pump house.

Alternatively dedicated storage of clarified water of around 4000 M³ for fire water purpose can also be kept in clarified water storage reservoir. Horizontal fire water pumps shall be provided in clarified water pump house. Jockey pumps are also provided to take care of system losses and these are also located in clarified water pump house.

In case raw water is used for fire fighting purpose, the dead storage of raw water is kept in raw water reservoir and fire water pumps & jockey pumps are kept in raw water pump house.

The complete system is divided into the following:

- i) Fire protection system
- ii) Fire detection and alarm system
- iii) Fire station and other facilities

7.2.1 Fire protection system:

Following types of fire protection systems are provided:

- i) Hydrant system
- ii) Automatic high velocity & medium velocity water spray system
- iii) Automatic fixed foam system for fuel oil storage tank
- iv) Automatic inert gas system
- v) Potable and mobile fire extinguishers



a) *Hydrant system*

Hydrant system comprises of hydrant pumps (2 motor driven + one diesel engine driven + one diesel engine driven as standby), pressurization arrangement [2 nos. motor driven jockey pumps (1 w + 1 standby)], water mains network, hydrants (landing valves, internal hydrants, external hydrants, water monitors), hoses, instantaneous couplings, etc. Hydrants are located throughout the power station area. In case of fire, hose is coupled to respective hydrant valves and jets of water are directed to the fire. Hydrant system is kept pressurized continuously to normal working pressure.

b) *Automatic high velocity water (HVW) & medium velocity water (MVW) spray system*

It consists of spray pumps (1 motor driven main pump + 1 diesel engine standby), pressurization arrangements, water mains network, wet detection system comprising QBD, deluge valves, isolation valves, Y-type strainers, spray nozzles/projectors, spray nozzles piping network, detection & control system, piping, valves, other accessories etc. The system is automatic and is activated by a dedicated detection system to be provided for each equipment/area. The system is kept pressurized continuously to normal working pressure up to the deluge valves.

c) *Automatic fixed foam system for fuel oil storage tanks*

Automatic fixed foam system is envisaged for main HFO/LSHS and LDO storage tanks. In case of fire, the foam system for the respective tank gets automatically activated on detection of fire by probe type heat detectors provided inside the fuel oil tanks resulting in pouring of the foam water mixture on the oil surface inside the tank and foam blanketing the burning oil surface thereby cutting the oxygen supply and extinguishment of fire. The fixed foam system consists of foam concentrate storage tanks, foam pumps (1W+1S), balancing line with automatic controlling valves, foam makers, discharge outlets, interconnection piping, valves, fittings instrumentation and control system. In addition, semi-fixed system consisting of a separate foam solution ring main around the tank farm area with foam hydrant valves at regular intervals is also provided.

Water for foam system for main fuel oil and LDO storage tanks and MVW spray for main LDO storage tank is tapped from nearest hydrant system header.

d) *Automatic inert gas system*

The inert gas system uses any of the inert gas like, 'Argon, Nitrogen, Inergen or Argonite' as inert gas agent. The system consists of inert gas cylinders filled with the agent gas, cylinder mounting accessories, cylinder manifold, automatic discharge valves, discharge piping, nozzles, automatic operating devices, manual actuation devices/ abort switches, etc. The system is automatic and is activated by a dedicated detection system to be provided for each hazard area.



e) *Portable and mobile fire extinguishers*

Portable and mobile fire extinguishers of pressurized water, carbon dioxide, dry chemical powder and foam type are provided for each room/area of power station as per TAC guidelines in addition to fixed fire protection system.

7.2.2 Fire detection and alarm system

Fire detectors are provided in all areas and buildings of thermal power stations to detect the fire in its incipient stage, give alarm and actuate the fixed fire protection system provided to extinguish the fire. Type of fire detectors for various areas depends upon the fire risks. In addition to automatic fire detectors, manual call points are also provided throughout the power station for manually initiating alarm in case fire is noticed by some body. The fire detection and alarm system consists of various types of fire detectors, control cabling, fire alarm panel in control room / control equipment room, CHP control room, ESP control room, switchyard control room service building and administrative building, repeater panel in fire station, PLC based panel in fire water pump house and foam pump house, etc.

7.2.3 Fire station & other facilities

Fire station is provided with facilities to park fire tenders, fire control room, fire officer room, store, dormitory for fire staff etc. Repeater panel is provided in the fire station to monitor and control the fire in power station. This panel is provided with audio-visual alarms regarding status of fire in different areas, status of deluge valves, repeat annunciations from main fire detection and alarm panel in unit control room, PLC based panel fire water control cum alarm panel in fire water pump house & in foam pump house. Following facilities/equipment shall be provided in the fire station:

- i) One foam tender with supplementary agents - carbon dioxide and dry chemical powder conforming to IS: 10460 (latest)
- ii) One water tender as per IS:950 (latest)
- iii) One dry chemical tender 2000Kg as per IS 10993 (latest)
- iv) One fire jeep
- v) Miscellaneous equipment such as oxygen masks with cylinders and other accessories, industrial canister type masks for chlorine contaminated areas and for general purpose, first aid kits, telescopic ladders, fiber glass blankets, fire suits etc.

7.2.4 Sirens

A siren is provided on TG building unit control room roof capable of being clearly heard over a radius of 2 KM all around it for at least 3 minutes continuously over a background noise of Power Station. A highly luminous coloured lamp placed over siren shall glow when the siren is switched on.



7.3 DESIGN CRITERIA

7.3.1 General

- i) All equipments/system components of complete fire protection & detection system should have the approval from one of the following:
 - a) BIS
 - b) Underwriters Laboratories of USA
 - c) VDS - Germany
 - d) FM – USA
 - e) LPCB – UK
- ii) The complete fire detection and protection systems shall be designed in conformity with TAC/NFPA/IS No. 3034/OISD. Fire protection system shall be designed as per the guidelines of Tariff Advisory Committee (TAC) established under Insurance Act 1938 and /or NFPA.

7.3.2 Types of fire detectors for various areas

- i) Multisensor type smoke detection system :
 - a) All switchgear / MCC/Control rooms of main Plant, ESP/VFD, switchyard extension, various auxiliary buildings like ash handling system, compressed air system, ECW system, condensate polishing plant, water treatment plant, pump houses, service building, battery rooms , etc.
 - b) Below false ceiling areas of all air conditioned rooms of main plant building, service building, ESP/VFD building, various control rooms of auxiliaries as defined in Sl. No. (a) above, return air ducts of inert gas protected areas.
- ii) Photo electric type smoke detectors for above false ceiling for all air-conditioned areas.
- iii) However, combination of both multisensor and photoelectric smoke detectors for above & below false ceiling of Inert gas protected areas & various cable galleries. Further, Smoke detectors of multisensor type shall be provided in control room, control equipment room and UPS/ Battery charger areas.
- iv) Linear heat sensing cable and infra red fire detectors shall be provided for coal conveyors. Linear heat sensing cable shall also be provided for cable galleries in addition to photoelectric and multi-sensor type smoke detectors.
- iv) Probe type rate of rise cum fixed temperature shall be provided for main fuel oil and LDO storage tanks.
- v) Quartzoid bulb heat detection system for equipment protected by HVW spray system, coal conveyors, fuel oil tanks and fuel oil pump houses protected by MVW spray system.



- vi) Manual call points for complete Power Station at suitable locations.

7.3.3 Design philosophy for hydrant system

- i) The fire protection system design viz. water requirement, fire water reservoir, number of main fire pumps, number of standby fire pumps, hydrant points, branch pipes etc. shall be designed as per TAC guideline.
- ii) Minimum terminal pressure of 3.5 kg/cm² shall be maintained at the farthest / remotest hydrant point.
- ii) Three hydrant ring mains shall be provided and entire power plant area shall be suitably divided amongst these ring mains. These ring mains shall be interconnected with isolation valves. It shall be possible to enable to take up part of any of the ring mains for maintenance without any loss of system in the balance part.
- iii) All the landings of boiler staircases, turbine buildings, and other multi-storied structures, transfer points in the coal Handling plant, etc shall be provided with hydrant landing valves. Water monitors shall be provided for tall buildings, coal stockpiles, ESP areas, apart from ground hydrants and landing valves.
- iv) All hydrant pipe mains/ pipe lines shall be routed underground as per TAC. The underground pipe lines shall be provided with coating and wrapping as per IS: 10221 / IS:15337. Road, rail, cable trench, cable channels or pipe trench crossing shall be through RCC hume pipes of appropriate pressure class. In main plant area, pipes shall be laid in RCC trenches (with pre-cast slab covers). Alternatively hydrant pipes shall be laid over ground on separate RCC pedestals or on pipe trestles alongwith other pipe lines, but not on fuel oil pipelines.
- v) All hydrant valves should be of stainless steel conforming to IS:5290.
- vi) Fire hydrants shall be spaced 45 meters apart. For buildings etc., at least one hydrant shall be provided for every 45 meter of external wall measurement.
- vii) Hydrants shall not be located less than 2M from building. No building shall be deemed to be protected by a hydrant unless such hydrant is within 15M of the building. When height of structure, tower exceeds 15M, the concerned hydrants shall be replaced by water monitors.

7.3.4 Design philosophy for spray system

- i) For HVW spray system the water pressure at any projector/spray nozzle shall be not less than 3.5kg/cm² and not greater than 5.0 kg/ cm². For MVW spray system minimum water density and minimum pressure shall be as under:

Area	Minimum water density	Minimum pressure
Cable galleries	12.2 LPM/m ²	2.8 kg/cm ²
Coal conveyors	10.2 LPM/m ²	1.4 kg/cm ²
L.D.O. storage tanks	10.2 LPM/m ²	1.4 - 3.5 kg/cm ²



Section- 7 (Fire Protection, Detection And Alarm System)

- ii) The spray system for the boiler burner front shall cover all the fuel oil and coal burner elevations, its adjacent piping structures, floors etc.
- iii) The spray system for the fuel oil pumping station or fuel oil tank shall also cover the piping near the vicinity.
- iv) In cable galleries the water spray shall cover the exposed area of all the trays and racks. As far as possible fire compartmentalization shall be done in case of cable galleries, cable vaults, cable spreader rooms, electrical equipment rooms etc.
- v) The spray system for the coal conveyor system shall cover the exposed area of both the forward and return conveyors and idlers. In transfer points, crusher house, track hopper, pent house etc., the water spray shall cover the drive equipments, pulleys, chutes, other equipments of the floor and at various elevations.
- vi) Wet type fire detection system using quartzoid bulb detectors shall be provided for HWV / MVW spray system employed for coal conveyors, transformers, etc. In case of fire, QB detector shall break due to heat and pressure in wet detector network resulting in fall in pressure, which shall actuate the respective deluge valve resulting in water spray on the protected equipment.
- vii) All spray pipe mains/ pipe lines shall be routed underground & provided with coating and wrapping as per TAC. Road, rail, cable trench, cable channels or pipe trench crossing shall be through RCC hume pipes of appropriate pressure class. Alternatively spray pipes shall be laid over ground on separate RCC pedestals or on pipe trestles alongwith other pipe lines, but not on fuel oil pipelines.
- viii) Each deluge valve shall be suitable for automatic actuation. Each deluge valve shall also be provided with a LCP from which valve may be operated remote manually. In addition, each deluge valve shall also be provided with an operational latch / hand lever. Each deluge valve shall be provided with isolation valves on upstream and downstream side. The valve on downstream side shall be kept locked open.

7.3.5 *Design philosophy for foam system*

- i) The operation of foam system shall be automatic with the aid of fire detection system provided for the fuel oil tank with a provision for manual operation.
- ii) Foam concentrate shall be provided in 2x100% capacity foam concentrate tanks. It shall be discharged to the foam pumps inductors through 2x100% capacity foam pumps (one motor driven and another diesel engine driven) through balancing line, with control valves, flow controllers etc.
- iii) The foam application rate shall be 5 LPM/m² as per NFPA-11.
- iv) Water for foam system shall be tapped from the nearest hydrant header.



7.3.6 Design philosophy for inert gas system

- i) Complete design shall be approved and listed by UL/FM /VDS /LPCB.
- ii) Design, manufacture and installation of inert gas fire extinguishing system shall be in accordance with NFPA-2001 standard and all the system components / equipment shall be certified by UL/FM /VDS /LPCB
- iii) The complete volume of the rooms including the above false ceiling shall be considered for estimation of quantity of gas and containers.
- iv) When determining the gas quantity, the leakage losses from the enclosure shall be taken into account. Further volume of re-circulating type air conditioning system and its duct work (at least upto the automatic fire dampers of the ducts) shall be considered as a part of the total volume so that the design concentration is achieved throughout the hazard area. Further gas quantity shall be adjusted for ambient pressure & temperature conditions.
- v) Centralised inert gas system along with 100% standby / reserve gas quantity and cylinders shall be provided for each of the following:
 - a) Unit control room and control equipment room including programmer room, panel room, etc.
 - b) UPS / Battery charger room
- vi) The discharge time period shall be such that the design concentration is achieved within 60 seconds. The flow calculations shall establish this criteria.
- vii) Operating devices shall be by mechanical, electrical and pneumatic means conforming to NFPA-2001. The power supply to electrical actuators shall be backed up with reliable battery supply. Such batteries shall be charged automatically by battery chargers.
- viii) Facility for manual release of gas through push buttons shall be provided. In addition, local manual release through lever operation shall also be provided near the cylinder banks. Further, manual abort switches shall be provided for each of the area/zone.
- ix) Appropriate warning signs shall be fixed outside of those areas protected by the system and also in areas where the gas may spread indicating the hazard clearly. Apart from written warning signs, audio-visual type warning signs i.e. hooters & strobe lights shall be provided for pre-discharge and post- discharge activity.
- x) To prevent the loss/release of gas automatically or manually during maintenance, the system shall have the facility of "LOCKOUT".

7.3.7 Fire water pumps & pump house

- i) Capacity, discharge pressure and quantity of pumps for the hydrant water system and spray water system shall be individually designed as per the recommendations of Tariff



Standard Design Criteria/Guidelines for Balance of Plant of Thermal Power Project
2 x (500MW or above)

Section- 7 (Fire Protection, Detection And Alarm System)

- Advisory committee. For 2x500 MW thermal power station, two electric motor driven pumps & one diesel engine driven pump each of 410m³/hr capacity at rated discharge head of 105mwc shall be used as main pumps to supply water to hydrant system network. One diesel engine driven pump of same capacity and head shall be used as standby hydrant pump.
- ii) Horizontal type centrifugal pumps shall be provided for hydrant, spray and jockey pumps. These shall be located in fire water pump house. Clarified water shall be used for fire fighting purpose. Maximum speed of the pumps shall be 1500 rpm. However for jockey Pumps, speed up to 3000 rpm shall be acceptable. The motor driven pump and the corresponding diesel engine driven pump shall be completely interchangeable. Dual power supply arrangement shall be provided for the motor driven pumps.
- iii) Spray pumps capacity & head shall be designed on the basis of the following criteria whichever is higher :
- a) Maximum capacity required for the largest risk area/ equipment of HVW spray system
- OR
- b) Simultaneous operation of three zones of MVW spray system of cable galleries
- OR
- c) Simultaneous operation of three zones of MVW spray system of coal conveyors
- For 2x500 MW, main spray pump of 410m³/hr capacity at rated discharge head of 120mwc shall be used to supply water to spray system network. One diesel engine driven pump of same capacity & head shall be used as standby spray pump.
- iv) The water pumping arrangement (for hydrant/spray system) shall be provided with automatic pressurization system with jockey pumps. There shall be 2x100% capacity jockey pumps. Capacity of the jockey pumps shall be as per the recommendations of TAC, 2 nos. electric motor driven jockey pumps each of 40 m³/hr at 110 mwc are recommended
- Booster pumps (for hydrant/spray system) if required shall be provided for maintaining required pressure at higher elevation. The capacity of these pumps shall be as per system requirements/ TAC rules. The pumps shall be motor driven and diesel engine driven pumps of identical capacity shall be kept as standby.
- v) The headers of spray and hydrant system shall be interconnected with an isolation and a non-return valve so that hydrant pumps can feed to spray system but not vice-versa.
- vi) The diesel engine drive of the pump shall conform to the requirements of TAC. Each of the diesel engine shall be provided with batteries (2x100%) and battery chargers (2x100%).
- vii) Motor of all the pumps shall be rated for continuous duty and shall be generously designed. The continuous motor rating shall be at least 10% above the load demand of



driven equipment at design duty point or 5% above maximum power requirement of the driven equipment whichever is higher. The rating shall be such that the motor shall not be overloaded at any operating point of driven equipment from zero to full load. The rating of the drive shall in any case be not less than the power required to drive the pump at 150% of its rated discharge.

- viii) The pumps shall comply with the regulations of BIS/Tariff Advisory Committee (TAC) and shall be approved by TAC.
- ix) The fire water pump house layout shall have sufficient space for the maintenance of the pump and diesel engine. Further the pump house shall be provided with a electrically operated overhead travelling type crane of capacity capable of lifting heaviest component but not less than 5 metric tonnes capacity.

7.3.8 Areas to be covered by different types of systems

- i) Hydrant system shall be provided for complete power plant area and all buildings.
- ii) The following areas are to be covered by HVW spray system
 - a) All transformers located in transformer yard of main plant.
 - b) All other transformers of rating 10 MVA and above.
 - c) Steam turbine lube oil storage tanks & its purifier units.
 - d) Boiler burner fronts.
 - e) Central lube oil tanks (both clean oil & dirty oil units) and purifier units.
 - f) Boiler feed pumps lube oil tanks, coolers, consoles etc.
 - g) Generator seal oil system tanks, cooler assembly etc.
 - h) Turbine oil canal pipelines in main plant.
- iii) Areas to be covered under MVW spray system
 - a) All major cable tunnels/cable galleries/cable vaults/cable spreader rooms and cable riser/shaft in TG Building, ESP control room, switchyard control room.
 - b) Coal handling plant including all coal conveyor transfer points, crusher houses, all coal conveyor galleries, conveyor tunnels etc.
 - c) LDO & DAY oil storage tank.
 - d) All the fuel oil pumping stations (HFO+LDO) and DG building.
- iv) Automatic fixed foam system shall be provided for main HFO and LDO storage tanks.
- v) Areas to be covered by inert gas extinguishing system
 - a) Main plant unit control room (CCR), control equipment rooms and other associated rooms including areas above false ceiling.
 - b) UPS & inverters rooms
- vi) Fire extinguishers or requisite type shall be provided for each area / room of power station as per TAC guidelines.



7.3.9 Design philosophy for fire detection and alarm system

7.3.9.1 General

- i) One (1) no. PLC panel along with two nos. operator works station – one operating & one engineering shall be provided in fire water pump house to indicate the status of each pump, healthiness of power supplies, etc. Alarms from these panels shall also be available to operator at repeater panel in fire station and at main fire detection and alarm panel in unit control room.
- ii) The main fire detection and alarm panel to be located in unit control room shall cover the fire detection and protection system of the complete plant. This shall give audio-visual alarms for fire in each of the risk area / equipment, status of the fire detectors and protection system, etc. In addition, hooter/sounder shall be activated in each of the respective area provided with fire/smoke detection system.

The fire alarm panel shall have separate LCD display to indicate the address of each device and clear text about the location of the alarm/ trouble. It shall record the event within the non-volatile system historical memory. All devices shall be individually identifiable for its type, its zone location, alarm set value, alarm and trouble indication by a unique alpha numerical label.

- iii) One (1) fire alarm panel each at coal handling control room, ESP control room, switchyard control room, service building & administrative building shall be provided to exhibit alarms from detection and protection from respective areas
- iv) Alarms from all the panels shall be repeated at repeater panel in fire station.
- v) Complete fire detection, alarm and monitoring system from the panels shall be operated on DC supply. The panels shall be provided with 2x100% batteries and 2x100% battery chargers with provision for automatic change over from mains to batteries, automatic charging etc.
- vi) All control cables/power cables for fire protection, detection and alarm system shall be 1100 V grade, 1.5mm² core size, stranded tinned copper conductor, PVC insulated, PVC sheathed, GI armoured and overall FRLS PVC sheathed.
- vii) The fire alarm system of each unit shall be provided with necessary interface hardware and software for interconnection with DDCMIS for exchange of signals to the unit control room through a serial link.
- viii) The control system shall be Programmable Logic Control based. The control system for pumps shall be PLC based, while fire alarm & detection system shall be microprocessor based addressable type.



- ix) All types of smoke & heat detectors shall be of addressable type. Conventional smoke and heat detectors with interface modules are not acceptable. Each zone of LHSC (linear heat sensing cable) detector and each IR (infra-red) detector shall be provided with interface module.

7.3.9.2 Smoke Detection System

- i) The design coverage area for smoke detectors to be considered shall not exceed 25 M² for A/C area per each type of detector and 35-40 M² per detector for non-A/C areas.
- ii) Wherever both the multi-sensor type & photo - electric type smoke detection systems are provided, cross zoning of the signal shall be employed to initiate the fire extinguishing system of that area.
- iii) Multisensor type detectors shall be provided for return air ducts of each room which shall consist of intake probe, detector housing, and exhaust pipe etc. The detector shall be mounted outside the duct.

7.3.9.3 Detection System for Coal Conveyors

- i) The LHS cable detector for each conveyor shall be provided for forward and return conveyors & rollers.
- ii) The detection zone/loop divisions of LHSC system shall match with the MVW spray system. Upon detection of fire by LHSC detector, the spray system shall be initiated. It shall also initiate spray system for the two adjacent zones after a time delay settable at site. Wet type Q.B. detectors can also be used in addition to LHS cable.
- iii) The LHSC detector may be either Digital or analogue type.
- iv) The infra red type (IR) detectors shall be suitable for detecting moving fires in coal conveyors and at least one detector shall be provided for each of the conveyor. IR detectors shall trip the running coal conveyor in case of detection of fire as well as give audio-visual annunciation locally and as well in fire alarm panel.
- v) The IR detector shall be outdoor type weather proof and shall be able to function continuously in heavily coal-dust prone atmosphere without regular maintenance.
- vi) The IR detector shall be designed to reject deceptive phenomenon such as electric arc, heaters, artificial light sources (HPSV/LPSV/incandescent lamps etc.)
- vii) Each of the IR detector shall be provided with purging arrangement.



7.3.9.4 Detection system of cable galleries

- i) In cable galleries, MVW spray system shall be actuated either by detection of fire by linear heat sensing cable detectors or by fire signal from smoke (after cross zoning) detection system. Apart from the automatic operation of spray system in the detected zone the adjacent two zones shall also be sprayed with water automatically after a set time delay simultaneously. Cable trays in auxiliary pump houses etc. shall be provided with smoke detection system.
- ii) LHSC detector shall run in a zig-zag fashion (with an included angle of minimum 90⁰ in tray.
- iii) The detection zone/loop divisions shall match with MVW spray zones.

7.3.10 *Design requirement for piping and valves*

- i) Piping for all fire protection systems shall generally be laid under ground. At cable trench/rail/road crossings, fire water pipes shall be laid inside hume pipes of suitable ratings.
- ii) Material of Construction
 - a. Buried Pipes Mild steel as per IS:1239 (Part-I) heavy grade (upto 150 NB) & as per IS:3589 Gr.410 (above 200 NB)
 - b. Overground pipes normally full of water : Mild steel as per IS:1239 (Part-I) medium grade (upto 150 NB) & as per IS:3589 Gr.410 (above 200 NB)
 - c. Over Ground pipes normally empty but with periodically charge of water &air These shall be galvanised as per 4736 medium grade.
- iii) To prevent soil corrosion buried pipes shall be properly lagged with corrosion protection as per S: 10221 / IS:15337. Over ground pipes shall be provided with one coat of primer and three coats of Synthetic enamel paint. However, in case of corrosive environment, overground pipes shall be provided with one coat of epoxy resin based zinc phosphate primer followed up with three coats of epoxy resin based paint pigmented with titanium di-oxide.



**STANDARD DESIGN CRITERIA/GUIDELINES FOR BALANCE OF PLANT OF
THERMAL POWER PROJECT 2x (500MW OR ABOVE)
SECTION-8 : ELECTRICAL AND CONTROL & INSTRUMENTATION
SYSTEM**

8.0 ELECTRICAL AND CONTROL & INSTRUMENTATION SYSTEM :

Electrical and C&I system for Balance of Plant equipment shall meet the following requirements :

8.1 Electrical System - Design Criteria :

- 8.1.1 11kV/ 3.3kV incomers from station switchgears to 11kV/ 3.3kV station auxiliary plant/ system switchgear shall be through adequately rated cables. 3.3kV switchgear shall be fed from transformer either through cable or busduct. For 415V system, busduct shall be used for incoming connection from transformers to the switchgear wherever transformer rating is 1000kVA and above.
- 8.1.2 Each switchgear/ MCC/ distribution board shall be fed by 2x100% transformers/ feeders and, these shall be rated to carry the maximum load expected to be imposed. Each of the above boards shall be sectionalized.
- 8.1.3 Each BOP system shall be provided with two incomers, each from separate switchboard/source so that failure of one supply does not jeopardise the operation of the system.
- 8.1.4 All equipments viz. switchgears and all auxiliary transformers shall be sized with 10% margin at all ambient from 0⁰ to 50⁰C after considering operating load requirements at corresponding ambients.
- 8.1.5 The voltage ratio, taps, impedances and tolerances of transformers shall be optimised to ensure that the auxiliary system voltages are always within permissible limits under the various grid and loading conditions and the equipment are not subjected to unacceptable voltages during operation and starting of motors viz. BFP etc.
- 8.1.6 All 11kV, 3.3kV buses shall have facility for auto/ manual live changeover facility. All 415V switchgears fed from transformers shall be provided with live manual changeover. Auto changeover to the reserve supply source shall be arranged for critical 415V switchgears/ MCCs to prevent the loss of unit or to ensure the equipment safety.
- 8.1.7 11kV, 3.3kV and 415V switchgears, MCC's and DB's shall be provided with interlock to ensure that the different supplies and transformers are never operated in parallel and to avoid the fault level to exceed the switchgear capability, except during momentary paralleling in case of on-load changeover.



- 8.1.8 The motors of rating 110kW and above (except CHP area, where it shall be 160kW) shall be provided with remote controlled electrical circuit breakers. Other motors shall be provided with switch-fuse contactor feeders.
- 8.1.9 A typical single line diagram (Drg. no. CEA-TETD-EL-01) of the power supply arrangement is enclosed.

8.2 Electrical System - General Technical Requirements :

8.2.1 Transformers :

8.2.1.1 The transformers shall be provided with delta-connected primary and a star-connected secondary with the star point brought out and resistance earthed for 3.3kV system and solidly earthed for 415V system.

8.2.1.2 The transformers shall have following technical parameters :

a) Type	Two winding		
b) Service	Outdoor (oil filled) / Indoor (dry type : epoxy cast resin/ resin encapsulated type) ⁽¹⁾		
c) Number of phases	Three		
d) Frequency	50 Hz		
e) Type of cooling	ONAN for oil filled/ AN for dry type		
f) Ratings	As per system requirement.		
g) Impedance	As per system requirement.		
h) Duty	Continuous		
i) Over load	As per IS:6600		
j) System fault level ⁽²⁾			
	11 kV	40 kA for 1 second	
	3.3 kV	40 kA for 1 second	
	415V	50 kA for 1 second	
k) Windings	<u>11 kV</u>	<u>3.3 kV</u>	<u>433V</u>
Insulation	-----Uniform-----		
- Power frequency test level (kV rms)	28	10	3
- Basic impulse level (kV peak)	75	40	--
- Highest voltage for each winding (kV)	12	3.6	1.1
l) Earthing	a) 415V : solidly grounded, b) 11kV, 3.3kV: earthed through resistance to limit the current to 300A or high resistance grounding through artificial earthing transformer and earthing resistance.		



Standard Design Criteria/Guidelines for Balance of Plant of Thermal Power Project
2 x (500MW or above)

Section- 8 (Electrical and Control & Instrumentation System)

m)	Tap changer	Off circuit tap changer with $\pm 5\%$ in steps of 2.5 % on HV side		
n)	Bushing	11 kV	3.3 kV	0.433 kV
	- Rated voltage(kV)	12	3.6	1.1
	- Basic Impulse level (kVp)	75	40	--
	-Wet, dry power withstand voltage (kV)	28	10	3
	- Min. creepage distance (mm)	300	90	25
	- Mounting (mm)	Tank / Transformer body		
o)	Terminal details			
	-High Voltage(3.3 & 11 kV)	Cable		
	- 433V phase and neutral	Busduct/ Cable box		
		However, non-segregated busduct for transformers rated 1000kVA and above shall be provided.		

Note :

- (1) Indoor (dry type) shall be preferred
(2) For units of rating above 500MW, higher fault level, if required, may be considered

8.2.1.3 Temperature rise over an ambient of 50°C

- a) Out-door transformers :
 In top oil (measured by thermometer) 50°C
 In winding (measured by resistance) 55°C
 b) In-door transformers :
 In winding (by resistance method) 90°C or lower as permissible for class of insulation offered

- 8.2.1.4 Class of insulation F or better (for dry type transformers)
 B or better (for oil filled transformers)

- 8.2.1.5 Noise level at rated voltage and frequency As per NEMA Pub TR-1

8.2.1.6 Neutral Grounding Resistor :

- | | | |
|----|--------------------------------|--|
| a) | Resistance (ohm) | As per requirements |
| b) | Rated current and duration | 300A for 10 seconds |
| c) | Application | Grounding of 11kV and 3.3 kV system |
| d) | Service | Outdoor |
| e) | Resistor materials | Punched stainless steel grid element |
| f) | Max. allowable temp. rise | 350°C |
| g) | Mounting | 12kV grade insulator (for 11kV)/
3.6kV grade insulator (for 3.3 kV) |
| h) | Enclosure degree of protection | IP-33 as per IEC/ IS-60947 |
| i) | Terminal bushing | |
| | Rated voltage | 12kV grade insulator (for 11kV)/ 3.6kV |



Standard Design Criteria/Guidelines for Balance of Plant of Thermal Power Project
2 x (500MW or above)

Section- 8 (Electrical and Control & Instrumentation System)

Rated current	grade insulator (for 3.3 kV)
Basic Impulse level	300 A
Quantity	75kVp (for 11kV)/ 20kVp (for 3.3kV)
Mounting	Two each
j) Terminal details :	Roof of enclosure
- To transformer neutral	Copper flat of minimum 50mm x 6 mm
- To earth	Through GS flat of size 50mm x 10mm

8.2.1.7 Codes and Standards :

IS:2026(Part I to IV)	Power transformers
IS:6600/ BS:CP:1010	Guide for loading of oil immersed transformers
IS:335	New insulating oil for transformers and switchgears
IS:3639	Fittings and accessories for power transformers
IS:2099	High voltage porcelain bushings
IS:2705	Current transformers
IS:3347	Dimensions for porcelain transformer bushings
IS:13947	Degree of protection
IS:2071	Method of high voltage testing
IS:3637	Gas operated relays
IS:1271	Classification of insulating materials for electrical machinery and apparatus in relation to their stability in service
IS:5	Colours for ready mixed points
IS:10028 Part I, II, III	Code of practice for selection, installation and maintenance of transformers.
IS:5561	Electric power connectors
CBIP publication 295	Manual on transformers

8.2.2 11kV and 3.3kV Busducts :

8.2.2.1 The technical parameters of 11kV and 3.3kV bus ducts are given below :

	<u>11 kV</u>	<u>3.3 kV</u>
a) Number of phase	3	3
b) Frequency	50 Hz	50 Hz
c) Nominal voltage	11kV	3.3 kV
d) Highest system voltage	12 kV	3.6 kV
e) One minute power frequency withstand voltage (dry and wet)	28 kV	10 kV
f) Impulse voltage withstand value with 1.2/50 micro-sec wave shape	75 kV	40 kV
g) Continuous current rating	as required	as required
h) Short time current rating for 1 second ⁽¹⁾	40kA	40kA
i) Dynamic current withstand rating ⁽¹⁾	100 kA(peak)	100kA(peak)
j) Type of cooling	Natural	Natural
k) Type of bus enclosure	Phase segregated	Phase segregated



Standard Design Criteria/Guidelines for Balance of Plant of Thermal Power Project
2 x (500MW or above)

Section- 8 (Electrical and Control & Instrumentation System)

l)	Service	Indoor/ Outdoor	Indoor/ Outdoor
n)	Clearance of live parts in air	As per IS	As per IS
	- Phase to phase	---do---	---do--
	- Phase to earth	---do---	---do--
o)	Busbar material	Aluminum alloy	Aluminum alloy
p)	Enclosure and partition material	Aluminum alloy	Aluminum alloy
q)	Minimum thickness of enclosure	3 mm	3 mm
r)	Minimum thickness of partition	2 mm	2 mm
s)	Insulators and bushings		
	- Rated voltage	12 kV	3.6 kV
	- One minute power frequency withstand voltage		
	- Dry	35 kV	20 kV
	- Wet	35 kV	20 kV
	- Impulse voltage withstand value with 1.2/50 micro sec. wave shape.	75 kV	40 kV
	- Minimum creepage distance	240 mm	130 mm
	- Material of insulator	Porcelain/ Epoxy	Porcelain/ Epoxy
t)	Size of earthing conductor (mild steel)	65mmx8mm galvanized	65mmx6mm galvanized
u)	Design ambient temperature.	50°C	50°C
v)	Maximum temperature when carrying rated current continuously		
	- Bus conductor:		
	Bolted joints (Plain or tinned)	90°C	90°C
	Bolted joints (silver plated)	105°C	105°C
	- Bus duct enclosure	80°C	80°C

Note :

⁽¹⁾ For units of rating above 500MW, higher fault level, if required, may be considered

8.2.2.2 The bus ducts will be installed partially indoor and partially outdoor and shall be suitable for hot, humid and tropical atmosphere.

8.2.2.3 The maximum temperature of the bus conductor and enclosure shall be as mentioned above when operating at maximum ambient temperature and carrying rated current continuously. For outdoor portions, the effect of solar radiation shall also be considered.

8.2.2.4 Codes and Standards :

IS:226	Structural steel (Standard quality)
IS:737	Specification for wrought aluminum and aluminum alloys, sheet and strip (for engineering purpose).
IS:800	Code of practice for use of structural steel in general building construction.
IS:1367 Part-13	Hot dip galvanised coatings on threaded fasteners.
IS:2099	Bushing for A.C. voltage above 1000 volts.
IS:13947 Part-1	Low voltage switchgear and controlgear
IS:2544	Porcelain post Insulators for system with normal voltage greater



	than 1000 volts.
IS:2633	Methods of testing uniformity of coating on zinc coated articles
IS:4759	Hot dip zinc coating on structural steel and allied products.
IS:5082	Specification for wrought Aluminum alloys bars, rods, tubes and sections for electrical purposes.
IS:8084	Interconnecting bus bars for A.C. voltage above 1KV upto and including 36KV.
ANSI C-37:23	Metal enclosed bus.
ANSI C-37:24	Effect of Solar radiation on metal enclosed bus.

8.2.3 Motors :

8.2.3.1 All the motors shall be suitable for an ambient temperature of 50°C and relative humidity of 95%. The motors shall be suitable for operation in a highly polluted environment.

8.2.3.2 Voltage and Frequency variations :

Frequency	(+) 3% and (-)5%
Voltage	a. (±) 6% for 11kV/ 3.3 kV b. (±) 10% for 415 V
Combined	10% (absolute sum)

8.2.3.3 Voltage level :

1) Upto 200 KW	415V
2) > 200kW & upto 1500kW	3.3 kV
3) > 1500 kW	11 kV

Note : For far-off areas viz. CHP and AHP etc. motors upto 160kW only shall be rated at 415V level to restrict the voltage drop within permissible limit of 2.5%.

8.2.3.4 The motor terminal box shall be suitable for with-standing the maximum system fault current for a duration of at least 0.25 second.

8.2.3.5 System grounding

1) 11 kV and 3.3 kV	Earthed through resistance to limit the current to 300A or high resistance grounding through artificial earthing transformer and earthing resistance
2) 415V	Solidly grounded
3) 220V DC	Ungrounded

8.2.3.6 Degree of protection :

1) Indoor motors	IP 54
2) Outdoor motors	IP 55
3) Cable box – indoor area	IP 54
4) Cable box – outdoor area	IP 55



8.2.3.7 Type :

- a) AC Motors:
 - Squirrel cage induction motor suitable for direct-on-line starting.
 - Crane duty motors shall be slip ring type induction motor
- b) DC Motors: Shunt wound.

8.2.3.8 Rating

- a) Continuously rated (S1). However, crane motors shall be rated for S4 duty i.e. 40% cyclic duration factor.
- b) Maximum continuous motor ratings shall be at least 10% above the maximum load demand of the driven equipment unless otherwise specified, under entire operating range including voltage and frequency variations.
- c) Motors starting shall be as per IS:325/ IEC-60034 (part 12)

8.2.3.9 Temperature Rise

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

8.2.3.10 a) Starting voltage requirement

All motors (except mill motors) :

85% of rated voltage for motors upto 1000 kW
80% of rated voltage for motors above 1000kW and upto 4000 kW
75% of rated voltage for motors above 4000 kW

For mill motors :

85% of rated voltage for motors above 1000 kW
90% of rated voltage for motors upto 1000 kW

b) Breakway starting current :

All motors (except BFP) : six (6) times the rated full load current

8.2.3.11 The motor shall be capable of withstanding the electro dynamic stress and heating imposed if it is started alongwith the driven equipment at voltage of 110% of the rated value.



Section- 8 (Electrical and Control & Instrumentation System)

8.2.3.12 All motors shall be either totally enclosed fan cooled (TEFC) or totally enclosed tube ventilated (TETV) or closed air circuit air cooled (CACA) type. However, motors rated 3000 kW or above can be closed air circuit water cooled (CACW).

8.2.3.13 For hazardous location such as fuel oil facilities area, the enclosure of motors shall have flame proof construction conforming to Group – IIB of IS:2148.

8.2.3.14 Winding and Insulation :

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

8.2.3.15 Energy Conservation :

- a. Motors of energy efficient design shall be preferred subject to application and techno-economic considerations and mutual agreement between the supplier and purchaser.
- b. For conservation of energy during part load operation in respect of large capacity auxiliary motors, variable frequency drive (thyristor control) may be employed.

8.2.3.16 Noise level and vibration shall be limited within the limits prescribed in IS:12065 and IS: 12075 respectively.

8.2.3.17 Motors rated above 1000kW shall have suitable measures to prevent flow of shaft currents.

8.2.3.18 Motors above 1000kW rating shall have 2 sets (i.e. 6 nos.) of PS class CTs for differential protection.

8.2.3.19 Codes and Standards :

- | | |
|--------------------|------------------------------|
| IS:325, IEC:60034 | Three phase induction motors |
| IS:996, IEC:60034 | Single phase AC motors |
| IS:3177, IEC600:34 | Crane duty motors |
| IS:4722 | DC motors |



IS-12615

Energy efficient motors

8.2.4 11kV and 3.3kV Switchgears¹ :

8.2.4.1 The switchgears shall be indoor, metal clad, draw out type. The motor feeders above 2000kW rating shall have vacuum/ SF₆ breakers. The motor feeders below 2000kW rating shall have either vacuum/ SF₆ breakers or vacuum/ SF₆ contactors backed up by HRC fuses. However, in an application, where frequent start/ stop operations are required, vacuum contactors/ breakers shall be preferred. The operating mechanism of the circuit breakers shall be of the stored energy type DC motor operated charging springs.

8.2.4.2 10% spare feeders with at least one of each type of highest rating shall be provided in each switchgear.

8.2.4.3 The circuit breaker, contactor and switchgear assembly shall have the following technical parameters :

a)		System parameters	
1)	Nominal System voltage	11 kV	3.3 kV
2)	Highest System voltage	12 kV	3.6 kV
3)	Rated Frequency	50 Hz	50 Hz
4)	Number of phases	Three	Three
5)	System neutral earthing	Earthed through resistance to limit fault current to 300A or High resistance grounding through artificial earthing transformer and earthing resistor	
6)	One minute power frequency withstand voltage		
	- for Type tests	28	10
	- for Routine tests	28	10
7)	1.2/50 microsecond Impulse withstand voltage	75 kV (peak)	40 kV(peak)
8)	Maximum system fault level including initial motor contribution ⁽¹⁾	40 kA for 1 second	40 kA for 1 second
9)	Dynamic withstand rating ⁽¹⁾	100 kA (peak)	100 kA (peak)

¹ In special case of projects, where raw water area and ash dyke area are at quite far-off places, power supply may be required to be taken through overhead 33kV transmission lines in place of 11kV/ 3.3kV.



Standard Design Criteria/Guidelines for Balance of Plant of Thermal Power Project
2 x (500MW or above)

Section- 8 (Electrical and Control & Instrumentation System)

	10)	Control supply voltage		
		- Trip and closing coils	----	220V DC ----
		- Spring charging motor	-----	220V DC ----- (240V AC can be accepted for off-site areas)
		- Space heaters	-----	240V AC ----
	11)	Ambient temperature		50°C
b)		Busbars		
	1)	Continuous current rating at 50°C ambient		as per system requirements
	2)	Temperature rise		- 40°C for plain joints - 65°C for silver plated joints
c)		Constructional requirements		
	1)	Cable entry		
		- Power cables		Bottom
		- Control cables		Bottom
	2)	Bus duct entry		---Top---
	3)	Earthing conductor		Galvanised steel strip
d)		Circuit breakers		
	1)	Short circuit breaking current		
		- AC component		40 kA
		- DC component		As per IS 13118 or IEC 62271
	2)	Short circuit making current ⁽¹⁾		100 kA (peak)
	3)	Operating Duty		B – 3min – MB – 3min – MB
	4)	Total break time		Not more than 4 cycles
	5)	Total make time		Not more than 5 cycles
	6)	Operating Mechanism		Motor wound spring charged stored energy type as per IEC 62271
e)		Relays		
		One minute power frequency	2.0 kV (rms)	2.0 kV (rms)
f)		Meters		



Standard Design Criteria/Guidelines for Balance of Plant of Thermal Power Project
2 x (500MW or above)

Section- 8 (Electrical and Control & Instrumentation System)

	1)	Accuracy class for Energy accounting and audit meters - on each incoming feeder of 11kV/ 3.3kV buses -on all 11kV and 3.3kV motor feeder - other meters All meters shall also meet CEA regulations on Metering In case, numerical relays having built-in features of energy measurement of requisite accuracy are provided in switchgear, separate energy meter is not necessary.	Not inferior to 1.0S ----do--- 1.0
	2)	One minute power frequency	2.0 kV (rms)
g)	Current Transformer		
	1)	Class of Insulation	Class E or better
	2)	Rated output of each	Adequate for the relays and devices connected, but not less than five (5) VA.
	3)	Accuracy class	
		Measurement core for energy accounting and audit meters - on each incoming feeder of 11kV/ 3.3kV buses -on all 11kV and 3.3kV motor feeder - other meters All CT's shall also meet CEA regulations on Metering	Not inferior to 1.0S ----do--- 1.0
		Protection core - differential and core balance CTs - other protection CTs	PS 5P20
	4)	Minimum primary earth fault current to be detected by core balance CT	3 A
h)	Voltage Transformers		
	1)	Rated voltage factor	1.2 continuous for all VTs, and 1.9 for 30 sec. for star connected VTs
	2)	Measurement - for energy accounting and audit - for others All VT's shall also meet CEA regulations on Metering	Not inferior to 1.0S 1.0
	3)	Protection	3P
i)	Fuses		
		Voltage class	11kV 3.3kV



Standard Design Criteria/Guidelines for Balance of Plant of Thermal Power Project
2 x (500MW or above)

Section- 8 (Electrical and Control & Instrumentation System)

		Rupturing Capacity	Adequate for 100 kA (peak)	
		Rated current	As per application	
j)	Surge arresters			
			11 kV	3.3kV
	1)	Nominal discharge current (8x20 micro second)	5kA	5kA
	2)	Maximum system voltage	12 kV	3.6kV
	3)	Max. standard impulse spark over voltage (peak) (without any positive tolerance)	25kV	10 kV
	4)	Residual voltage at nominal discharge current	25 kV	8kV
	5)	Temporary over voltage capability (rms)		
		- Continuous	12 kV	3.6kV
		- For 10 seconds	9.9kV	3.3kV
	6)	Installation	Inside the switchgear panel	
k)	Contactors			
	1)	Nominal system voltage	----	3.3kV
	2)	Highest system voltage	----	3.6kV
	3)	Rated frequency	----	50Hz
	4)	Control supply voltage	-----	220 V DC
	5)	Utilization category	----	AC-3
l)	Transducers			
	1)	Current transducers		
	a)	Input	0-1 A (CT secondary)	
	b)	Rated frequency	50 Hz	
	c)	Output	4-20 mA (2 Nos. decoupled)	
	d)	Accuracy	0.5%	
	2)	Voltage transducers		
	a)	Input	110V, 50 Hz (from VT secondary)	
	b)	Output	4-20 mA (2 Nos. de-coupled)	
	c)	Accuracy	0.5%	
	3)	VAR transducers		
	a)	Input	3 phase, 3-wire 1 A (CT secondary) 110 V (VT secondary)	
	b)	Rated frequency	50 Hz	



Standard Design Criteria/Guidelines for Balance of Plant of Thermal Power Project
2 x (500MW or above)

Section- 8 (Electrical and Control & Instrumentation System)

	c)	Output	4-20 mA (2 nos. de-coupled)
	d)	Accuracy	0.5%
4)	Watt transducers		
	a)	Input	3 phase, 3-wire 1A (CT secondary) 110V (VT secondary)
	b)	Rated frequency	50 Hz
	c)	Output	4-20 mA (2 nos. decoupled)
	d)	Accuracy	0.5%
5)	Frequency transducers		
	a)	Input	110V (VT secondary)
	b)	Rated frequency	50 Hz
	c)	Range	45 to 55 Hz
	d)	Output	4-20 mA (2 nos. decoupled)
	e)	Accuracy	0.5%
Note : ⁽¹⁾ For units of rating above 500MW, higher fault level, if required, may be considered			

8.2.4.4 Protection :

- a) Incomer, bus-coupler and outgoing feeders except motor and transformer feeders
 - Time graded over-current protection
 - Under voltage protection for bus to trip motors under sustained under voltage conditions
 - Earth fault relays shall be provided for selective tripping of feeders
- b) Outgoing 11kV/3.3kV, 11kV/433V auxiliary service transformers feeders
 - Inverse/ Definite time over-current protection (with instantaneous element)
 - Buchholz protection (for oil filled transformers)
 - Zero sequence/ earth fault current protection for transformer feeder protection
 - Winding temperature high (alarm and trip)
 - Oil temperature high (alarm and trip) (for oil filled transformers)
 - Zero sequence protection on LV side (neutral CT to be provided in case of solid grounding)
 - Differential current protection (for 5MVA and above)
 - Restricted earth fault protection for LV side (if applicable for 1MVA and above)



c) Outgoing 11kV, 3.3kV motor feeders :

- Instantaneous short- circuit protection
- Over-load protection with unbalance current feature
- Differential protection (for motors above 1000KW)
- Locked rotor protection, if not covered by the overload protection
- Zero sequence current protection
- Winding/ bearing temperature protection by means of RTDs connecting the same to DDCMIS.

8.2.4.5 Surge arrestor :

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

8.2.4.6 Metering :

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

- on each incoming feeder of 11kV and 3.3kV buses.
- on all 11kV and 3.3kV motor feeders.

Energy accounting and audit meters shall be of accuracy class of 1.0S. The accuracy class of CTs and VTs shall not be inferior to that of associated meters. In case, numerical relays having built-in features of energy measurement of requisite accuracy are provided in switchgear, separate energy meter is not necessary.

8.2.4.7 Relays and meters :

- a) The protective relays shall be static or numerical type. However, numerical type shall be preferred. All relays, auxiliary relays and devices shall be of reputed make and types proven for the application and shall be subject to purchaser approval. The relays and timers shall have appropriate setting ranges, accuracy, resetting ratio, transient over-reach and other characteristics to provide required sensitivity to the satisfaction of the owner.
- b) Relays shall be suitable for efficient and reliable operation of the protection scheme. Necessary auxiliary relays, timers, trip relays, etc. required for complete scheme, interlocking, alarm, logging, etc. shall be provided. Control relay shall not trip the circuit breaker when relay is de-energized.



- c) Relays shall be flush mounted on the front with connections at the rear shall be draw-out or plug-in type/ modular case with proper testing facilities. Provision shall be made for easy isolation of trip circuits for testing and maintenance.
- d) Auxiliary relays shall be provided in the trip circuits of protections located outside the board, such as buchholz relay, temperature indicators, fire protection, etc. Alternatively, binary signals from protections located outside the board may be taken directly to the numerical protection relays provided in the board without providing auxiliary relays
- e) The closing coils and other auxiliary devices shall operate satisfactorily at all voltages between 85-110% of the rated control voltage and trip coils between 70-110% of rated control voltage.
- f) Control circuits shall operate at suitable voltage of 110V AC or 220V DC. Necessary control supply transformers having primary and secondary fuses shall be provided for each MCC, 2x100% per section. However the breakers shall operate on 220V DC. The auxiliary bus bars for control supply shall be segregated from main bus bars. The control supplies shall be monitored.
- g) Contractor shall fully co-ordinate overload and short circuit tripping of breaker with upstream and down stream breakers/ fuses/ MCCBs motor starters. Various equipments shall meet requirement of Type-II class of coordination as per IEC.
- h) In case of remote controlled breaker panels, following shall be provided.

Each feeder shall have local/ remote selector switch. Closing from local shall be possible only in test position whereas closing from remote shall be possible in either service or test position. Tripping from local shall be possible only when local/ remote selector switch is in local position. Tripping from remote shall be possible when breaker is in service position or selector switch is in remote position.
- i) Suitable self powered transducers as per IS : 12784 Part – I (if required) for feeding signals to panel mounted electrical meters (ammeters, voltmeters, VAR meters and watt meters etc.) and DCCMIS shall be provided. Alternatively, analog signals from numerical relays shall be directly used.
- j) The motor feeders for essential auxiliaries shall have contactors with delayed drop-out feature adjustable up to three seconds.

8.2.4.8 Codes and Standards :

IS : 722	AC electricity meters
IS : 996	Single phase small AC and universal electrical motors.
IS : 1248	Direct Acting indicating analogue electrical measuring instruments and Accessories
IS : 13947	Degree of protection provided by enclosures for low voltage switchgear



Section- 8 (Electrical and Control & Instrumentation System)

	and control gear
IS : 2544	Porcelain post insulators for systems with nominal voltages greater than 1000V
IS : 2705	Current transformers.
IS : 3156	Voltage Transformers
IS : 3231	Electrical relays for power system protection
IS : 3427	Metal enclosed switchgear and control gear
IS : 5082	Specification for wrought aluminium and aluminium alloy bars, rods, tubes and selections for electrical purposes.
IS : 6005	Code of practice for phosphating of iron and steel.
IS : 8686	Specification for static protective relays.
IS : 9046	AC contactors for voltages above 1000 volts and upto and including 11000V.
IS : 9224	Low voltage fuses
IS : 9385	HV fuses
IS : 9431	Specification for indoor post insulators of organic material for system with nominal voltages greater than 1000 V upto and including 300 kV
IS : 9921	AC dis-connectors (isolators) and earthing switches for voltages above 1000V
IS : 11353	Guide for uniform system of marking and identification of conductors and apparatus terminals.
IS : 13118	Specification for high voltage AC circuit breakers.
IEC-60099	Metal oxide surge arrester without gap for AC system
part 4	
IEC-62271-100	High voltage alternating current circuit breakers.
IEC-60099-1	Non-linear resistor type gapped arrester for AC systems
IEC-60298	High voltage metal enclosed switchgear and control gear.
CIGRE WG 13.02 Ch.-3	Recommendation for substitute test for switching over voltage test

8.2.5 415V Switchgears and 415V Non Segregated Busduct :

8.2.5.1 The switchgears shall be indoor, metal clad having following features :

Circuit Breakers	Air break, three pole, spring charged, horizontal drawout type, suitable for electrical operation
Switchgear	Fully drawout type, single front
MCC/ VDDC	Fully drawout type, single front/ double front
ACDB/ DCDB	Fixed type, single front/ double front

8.2.5.2 System parameters

1)	Nominal system voltage	415VAC	220V DC
2)	Highest system voltage	433V	240V DC
3)	Voltage variation	± 10%	187 – 242V DC
4)	Rated frequency	50 Hz	--
5)	Frequency variation	(+) 3 to (-) 5%	--



Standard Design Criteria/Guidelines for Balance of Plant of Thermal Power Project
2 x (500MW or above)

Section- 8 (Electrical and Control & Instrumentation System)

6)	System earthing	solidly grounded	Unearthed
7)	Maximum system fault level	50kA for 1 seconds	25kA for 1 second

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

- a) Shall be of single front, fully draw-out, metal enclosed, indoor, floor mounted and free standing type.
- b) All frames and load bearing members shall be fabricated using mild steel structural sections or pressed and shaped cold rolled sheet steel of thickness not less than 2mm.
- c) Frame shall be enclosed in cold rolled sheet steel of thickness not less than 2mm (CR). Doors and covers shall also be of cold rolled sheet steel of thickness not less than 1.6 mm. Stiffeners shall be provided wherever necessary. Removable gland plates of thickness 3mm (hot/ cold rolled sheet steel) or 4 mm (non-magnetic material) shall be provided for all panels.
- d) For motors above 110kW (except for CHP, where it shall be 160kW), remote controlled electrical circuit breakers, and for smaller motors, switch-fuse contactor feeders shall be provided. The other outgoing feeders would be switch-fuse units or moulded case circuit breakers.
- e) The switchboards/ MCC/ DBs of 1600A and above rating shall be of DOP IP42 and of IP52 for less than 1600A rating.
- f) Minimum air clearance in air between phases and phase-earth shall be 25 mm for busbars and cable terminations. For all other components, the Clearances shall be at least 10mm. Wherever above is not possible except for horizontal and vertical busbars, insulation shall be provided by anti tracking sleeving or barriers. However for horizontal and vertical busbars, clearances specified above shall be maintained even when busbars are insulated/ sleeved. Entire bus system shall be insulated with PVC sleeves (cable terminals in the cable alley shall be designed to meet for IV(b) of Type 7 as per IEC:60439 for safety purpose). In case of DCDBs/ fuse boards, the busbar system shall be insulated or physically segregated with barriers to prevent interpole short circuit.

8.2.5.4 Metering :

The energy meters shall be provided on LV side of each incoming transformer feeder of 415V buses as per the Central Electricity Authority (Installation and Operation of Meters) Regulations,2006 and its amendments.

Energy accounting and audit meters shall be of accuracy class not inferior to 1.0S as per CEA regulations. The accuracy class of CTs and VTs shall not be inferior to that of associated meters. In case, numerical relays having built-in features of energy



measurement of requisite accuracy are provided in switchgear, separate energy meter is not necessary.

8.2.5.5 Relays :

- a) The protective relays shall be static or numerical type. However, numerical type shall be preferred. All relays, auxiliary relays and devices shall be of reputed make and types proven for the application and shall be subject to purchaser approval. The relays and timers shall have appropriate setting ranges, accuracy, resetting ratio, transient over-reach and other characteristics to provide required sensitivity to the satisfaction of the owner.
- b) Relays shall be suitable for efficient and reliable operation of the protection scheme. Necessary auxiliary relays, timers, trip relays, etc. required for complete scheme, interlocking, alarm, logging, etc. shall be provided. Control relay shall not trip the circuit breaker when relay is de-energized.
- c) Relays shall be flush mounted on the front with connections at the rear shall be draw-out or plug-in type/ modular case with proper testing facilities. Provision shall be made for easy isolation of trip circuits for testing and maintenance.
- d) Auxiliary relays shall be provided in the trip circuits of protections located outside the board, such as buchholz relay, temperature indicators, fire protection, etc.
- e) Control circuits shall operate at suitable voltage of 110V AC or 220V DC. Necessary control supply transformers having primary and secondary fuses shall be provided for each MCC, 2x100% per section. However the breakers shall operate on 220V DC. The auxiliary bus bars for control supply shall be segregated from main bus bars. The control supplies shall be monitored.
- f) Contractor shall fully co-ordinate overload and short circuit tripping of breaker with upstream and down stream breakers/ fuses/ MCCBs motor starters. Various equipments shall meet requirement of Type-II class of coordination as per IEC.
- g) In case of remote controlled breaker panels, following shall be provided.

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

- h) Suitable self powered transducers as per IS : 12784 Part - I (if required) for feeding signals to panel mounted electrical meters (ammeters, voltmeters, VAR meters and watt meters etc.) and DCCMIS shall be provided. Alternatively, analog signals from numerical relays shall be directly used.



- i) The motor feeders for essential auxiliaries shall have contactors with delayed drop-out feature adjustable up to three seconds.

8.2.5.6 Protection :

- a) 415V AC and 220V DC Incomers
- Time graded short circuit protection on incoming supply feeder circuit breakers to main switchgears (PCCs and MCCs)
 - Instantaneous over-current protection on all outgoing feeders
 - Under-voltage protection for 415V bus
 - Sensitive earth fault detectors shall be provided in DC system to annunciate earth faults
- b) 415 Volts motor feeders
- 1) Contactor controlled motor feeders :
- Instantaneous short circuit protection on all phases through HRC cartridge type fuses rated for 80 kA rms (prospective breaking capacity at 415V).
 - Thermal overload protection
 - Single phasing protection for motors protected by fuses
- 2) Breaker controlled motors feeders :
- Instantaneous short circuit protection on all phases
 - Overload protection on two phases
 - Over load alarm on third phase
 - Earth fault protection
 - Under voltage protection
 - Hand reset lockout relay with a blue lamp for monitoring

8.2.5.7 Spare feeders - 20% spare outgoing feeders with atleast one of each type and rating shall be provided in each switchgear.

8.2.5.8 415V Non-segregated phase busduct :

- a) The entire bus duct shall be designed for dust, vermin and weather proof construction. A suitable aluminium sheet flange-protection hood shall be provided to cover all outdoor bus duct enclosure joints to facilitate additional protection against rain water ingress. All horizontal runs of bus duct shall have a suitable sloped enclosure top to prevent retention of water for both indoor and out door portion of bus ducts. Bus duct enclosure shall have a degree of protection of IP-55. b)



Standard Design Criteria/Guidelines for Balance of Plant of Thermal Power Project
2 x (500MW or above)

Section- 8 (Electrical and Control & Instrumentation System)

- b) The material of the conductor shall be aluminium. The bus bars shall be rated in accordance with the service conditions and the rated continuous and short time current ratings.
- c) All steel structures required for bus duct support shall be hot dip galvanised.
- d) The temperature rise of the bus bars and joints when carrying ninety percent (90%) of the rated current along the full run shall not exceed 40⁰C over an ambient of 50⁰C. The maximum temperature rise during short circuit conditions shall not exceed 200⁰C.
- e) Technical Data
- | | |
|---|-------------------------|
| i) Type | Non-segregated |
| ii) 1 min. power freq. withstand voltage | 2.5 kV |
| iii) Max. short circuit withstand current | 45kA/ 50kA for 1 second |
| iv) Momentary dynamic current withstand | 94.5/ 105kA (Peak) |

8.2.5.9 Codes and Standards :

IS : 5	Colours for ready-mixed paints and enamels.
IS: 694	PVC insulated cables for working voltages upto and including 1100V
IS : 722	AC Electricity Meters
IS : 1248	Electrical Indicating instruments
IS : 13947 Part 1	Degree of protection provided by enclosures for low voltage Switchgear and Control gear
IS : 13947Part-2 / IEC-60947	AC Circuit Breakers
IS : 2551	Danger Notice Plates
IS : 2629	Hot dip galvanising
IS : 2705	Current Transformers
IS : 13947Pt 4,Sec-1 (IEC-60947)	Contactors and motors starter for voltages not exceeding 1000 V AC or 1200 V DC
IS : 3043	Code of practice for earthing
IS : 3072	Code of practice for installation and maintenance of Switchgear
IS : 3156	Voltage Transformers
IS : 3202	Code of practice for climate proofing of electrical equipment
IS : 3231	Electrical relays for power system protection
IS : 13947	Air-Break Switches, air break disconnectors, air Break disconnector and fuse combination units for voltages not exceeding 1000V AC or 1200 V DC.
IS : 13947 Pt. - I IEC -60947	General Requirements for Switchgear and Control gear for voltages <1000 V
IS : 5082	Wrought Aluminium and Aluminium alloys for electrical purposes.
IS : 6005	Code of practice of phosphating of iron and steel



Section- 8 (Electrical and Control & Instrumentation System)

IS:13947 Pt.-5 Sec.1, IEC-60947	LV switchgear and Control gear Control current devices and switching element
IS : 8623(3 parts) / IEC-60439	Specification for factory built assemblies of Switchgear and Control gear for voltages upto and including 1000V AC and 1200V DC
IS : 8686	Static Relays
IS : 13703 / IEC- 60269	HRC Cartridge fuses
IS : 10118 (4 parts)	Code of practice for selection, installation and maintenance of switchgear and control gear
IS : 11171	Specification for dry type transformers
IS : 11353	Guide for uniform system of marking and identification of conductors and apparatus terminals
IS : 12021	Specification of control transformers for switchgear and Control gear for voltage not exceeding 1000V AC
IS:8084 Updated upto:1992	Interconnecting bus bars for A.C. voltage above 1KV upto and including 36KV.
ANSI C37:20	Switchgear Assemblies including Metal enclosed Bus.

8.2.6 DC System :

8.2.6.1 DC system comprising of DC storage batteries suitably rated Trickle and Boost chargers and DC distribution boards shall be provided to cater the normal DC loads. The DC system shall be generally comprising of :

8.2.6.2 1x100% sets of 220V of either Lead–Acid Plante or Nickel-Cadmium Battery banks catering CHP load shall be provided.

8.2.6.3 The Ampere-hour capacity of DC storage battery shall be based on half an hour supply.

8.2.6.4 2x100% float cum boost charger shall be provided for each battery bank.

8.2.6.5 Codes and Standards :

IS : 266	Specification for sulphuric acid
IS : 1069	Specification for water for storage batteries
IS : 1146	Specification for rubber and plastic containers for lead acid storage batteries
IS : 1652	Specification for stationary cells and batteries, lead acid type (with plant positive plates).
IS : 3116	Specification for sealing compound for lead acid batteries.
IS : 8320	General requirements and methods of tests for lead acid storage batteries
IS : 6071	Specification for synthetic separators for lead acid batteries
IS : 10918	Specification for vented type Nickel Cadmium Batteries.
IS : 1069	Quality tolerances for water for storage batteries
ANSI-C 37.90a	Guide for surge withstand capability tests
IS:5	Colours for ready mix paints.
IS : 694	PVC Insulated Cable for working voltages upto and including 1100V
IS : 1248	Specification for Direct acting indicating analogue electrical measuring



	instruments.
IS:13947 Pt-1	Degree of protection provided by enclosures for low voltage switch gear and control gear.
IS : 13947	Specification for low voltage switch gear and control gear
IS : 3231	Electrical relays for power system protection.
IS : 3842	Application guide for Electrical relays for AC System
IS : 3895	Mono-crystalline semi-conductor Rectifier Cells and Stacks
IS : 4540	Mono crystalline semi-conductor Rectifier assemblies and equipment.
IS:6005	Code of practice for phosphating of Iron and Steel
IS:6619	Safety Code for Semi-conductor Rectifier Equipment.
IS:6875	Control switches (switching devices for control and auxiliary circuits including contactor relays) for voltages upto 1000 VAC or 1200V DC
IS : 9000	Basic environmental testing procedures for electronic and electrical items.
IS:13703	Low voltage fuses for voltages not exceeding 1000 V AC, 1500VDC.
EEUA-45D	Performance requirements for electrical Alarm Annunciation system

8.2.7 Power and Control cables and Laying & Termination :

8.2.7.1 For 11/ 3.3kV system, Power cables shall be XLPE insulated with conductor and insulation screens armoured and FRLS PVC outer sheathed. The 415V system cables and control cables shall be 1.1kV grade, PVC insulated, armoured and FRLS PVC outer sheathed. The sizing of all power cables shall be done on the basis of current rating taking into account proper de-rating factors for temp. deration and group deration. However, 11/3.3kV cables shall be chosen on the basis of magnitude of fault current and fault clearing time. Certain important auxiliaries as given below shall be provided with fire survival (FS) cables as these cables can withstand 750⁰C for three (3) hours.

- Fire alarm, annunciation and protection system.
- DC supply cables to switchgears.
- DC cables from batteries to DC boards.
- DC emergency lighting cables for main building etc.

8.2.7.2 Cable shall have suitable filters laid up with the conductors to provide a substantially circular cross section before the sheath is applied. The constructional requirement shall be as follows :

- 11 kV system power cables - The cable shall be 11kV/11kV (unearthed) grade, heavy duty, stranded aluminium conductor, XLPE insulated, provided with conductor screening and insulation screening, galvanized steel wire/strip armoured (non-magnetic material for single core cables), flame retardant low smoke (FRLS) extruded PVC of type ST2 outer sheathed.
- 3.3 kV system power cables - The cable shall be 3.3kV/3.3kV (unearthed) grade, heavy duty, stranded aluminium conductor, XLPE insulated, provided with conductor screening and insulation screening, galvanized steel wire/ strip armoured (non-magnetic material for single core cables), flame retardant low smoke (FRLS) extruded PVC of type ST2 outer sheathed.



- c) 415V system power cables - The cable shall be 1.1kV, grade, heavy duty, stranded aluminium conductor, PVC Type-A Insulated galvanized steel wire/strip armoured (non-magnetic material for single core cables), flame retardant low smoke (FRLS) extruded PVC type ST1 outer sheathed.
- d) Control cables - The cable shall be 1.1kV grade, heavy duty, stranded copper conductor, PVC Type-A insulated, galvanized steel wire/ strip armoured, flame retardant low smoke (FRLS) extruded PVC of Type-ST1 outer sheathed.

8.2.7.3 Special properties : All the above cables shall be conforming to the relevant Indian/ IEC standard in general, with the following special properties:

- a) Oxygen Index of the outer sheath shall not be less than 29, when tested as per ASTM-D-2863.
- b) Temperature Index of the outer sheath shall not be less than 250⁰C and 350⁰C for FRLS and FS cables respectively, when tested as per ASTM-D-2863.
- c) Halogen acid contents in outer sheath shall not be more than 20% and 2% for FRLS and FS cables respectively, when tested as per IEC-60754.
- d) The maximum smoke density in percent light absorption should not exceed 60% in case of PVC compound and 20% in case of fire survival cables, when tested as per ASTM-D-2843.
- e) Swedish chimney test as per SS-4241475 class F3 and ladder test for flammability as per IEEE-383.

8.2.7.4 All cables shall be run in GI cable trays/ rigid GI conduits as far as possible. Cable trays shall be ladder/ perforated type. Cable tray support system shall be pre-fabricated. Cable trays shall have standard width of 150 mm, 300 mm and 600 mm and standard lengths of 2.5 metre. Minimum thickness of mild steel sheets used for fabrication of cable trays and fittings shall be 2 mm. The thickness of side coupler plates shall be minimum 3 mm. Cable installation shall be carried out as per IS:1255 and other applicable standards.

8.2.7.5 Power and control cables shall be laid on separate tiers. The laying of different voltage grade cables shall be on different tiers according to the voltage grade of the cables. In horizontal tray stacks, HT cables shall be laid on topmost tier and cables of subsequent lower voltage grades on lower tiers of trays. Single core cable in trefoil formation shall be laid with a distance of four times the diameter of cable between trefoil center lines and clamped at every two metre. All multi-core cables shall be laid in touching formation. Where cables cross roads/ rail tracks, the cables shall be laid in hume pipe/ PVC pipe. Joints for less than 250 Meters run of cable shall not be permitted.

8.2.7.6 Termination and jointing kits for 11/ 3.3 kV grade XLPE insulated cables shall be of proven design and make and type tested. Termination kits and jointing kits shall be pre-moulded type, tapex type or heat shrinkable type and shall be type tested as per IS:13573.



8.2.7.7 Wherever the cables pass through walls/ floors, fire proof cable penetration seals rated for two hours shall be provided. The system offered shall be of proven type as per BS:476 (Part-20) or equivalent standard.

8.2.7.8 Codes and Standards :

IS:1554 (Part-I)	PVC insulated (heavy duty) electric cables for working voltage up to and including 1100 V.
IS:1554 (Part-II)	PVC insulated (heavy duty) electric cables for working voltage from 3.3kV upto and including 11kV.
IS:7098 (Part-II)	XLPE insulated PVC sheathed cables for working voltages from 3.3 kV upto and including 33kV.
IS:3961	Recommended current ratings for cables.
IS:8130	Conductors for insulated electric cables and flexible cords.
IS:5831	PVC insulation and sheath of electric cables.
IS:2982	Copper conductor in insulated cables and cords.
IS:3975	Mild steel wires, strips and tapes for armouring cables
IS:5609	Specification for low frequency wirers and cables with PVC insulation and PVC Sheath.
IS:6380	Spec. of elastomeric insulation of sheath of electric cables.
IS:434(I and II)	Specification for rubber insulation cables
IEC:540	The methods for insulations and sheaths of electric cables and cords (elastomeric and thermoplastic compounds).
IEC:230	Impulse tests on cables and their accessories.
IEC:60	High voltage test techniques.
IEC:287	Calculations of the continuous current rating of cables (100% load factor).
IEC:288	Nominal cross-sectional area and composition of conductor of insulated cables.
IEC:502	Extruded solid dielectric insulated power cables for rated voltages from 1.00 kV upto 30 kV.
NEMA-WC-5	Thermoplastic insulated wires and cables for transmission and distribution of electrical energy.
IEEE:383	Standard for type test for class IE electric cables, filled splices and connections for nuclear power generation stations
IEC: 332-1	Test on electric cables under fire conditions.
ASTM-D-2843	Standard test method for density of smoke from burning/ decomposition of plastics.
ASTM-D-2863	Test for determination of Oxygen Index.
IEC-754-I	Test method for acid gas generation.
IEC-331	Fire resisting characteristics of electric cables.
SVENSK Standard	SS- 4241475 Class F3
BICC Hand Book	For cables in fire regarding temperature index-chapter-6



8.2.8 Lighting system:

8.2.8.1 The auxiliary building shall be provided with a) Main Lighting system for full illumination under normal power supply conditions and shall operate from 415/ 240V AC Power supply tapped from respective 415V switchgear b) Emergency lighting system for reduced illumination operated by DG supply feeders during failure of main power supply. It will cover only 20% of fixtures in the building and associated area c) Minimum emergency lighting system for reduced illumination during failure of main power supply with the help of 220V DC batteries/ supply feeders and d) Suitable no. of Portable lighting units

8.2.8.2 Various lighting branch boards shall be fed directly from 415V switchgear through 1:1 transformers to reduce fault level. If the fault level can be contained in 9kA by virtue of cable impedance involved, then use of 1:1 transformers can be dispensed with.

8.2.8.3 Illumination Levels and Type of Fixtures and Luminaries :

SN	Location	Average Illumination level (lux)	Type of Fixture
1.	Switchgear rooms	200	Industrial trough type fluorescent
2.	Control Room	300	Mirror optics with anti-glare features
3.	Battery rooms	100	Totally enclosed corrosion resistant/ vapour proof
4.	Street lighting		HPSV street lights
	- primary roads	20	
	- secondary roads	10	
5.	Outdoor storage handling and unloading area	20	HPSV flood light, weather proof
6.	Permanent stores	150	Industrial trough type fluorescent
7.	Garage/ Car parking	70	Industrial trough type fluorescent
8.	Facility building, canteen	150	Industrial trough type fluorescent

8.2.8.4 Wherever possible Energy Efficient lamps shall be used.

8.2.8.5 Automatic ON/ OFF shall be preferred for street lighting through timers/ photo cells.

8.2.9 Earthing and Lightning Protection system:

Earthing system shall be designed to meet the following requirements:-

8.2.9.1 Earthing and lightning protection for the entire areas or buildings covered shall be provided in accordance with IS 3043, IS 2309, IEEE 80 and IEEE 665 and Indian Electricity Rules/ Acts.

8.2.9.2 Earthing system will be designed considering suitable corrosion allowance based on earthing conductor material and type of soil, for a service life of at least forty (40) years for maximum fault current or system fault current of 40kA whichever is higher for 1



Section- 8 (Electrical and Control & Instrumentation System)

second. The minimum rate of corrosion of earthing conductor shall be considered as 0.12mm per year while determining the conductor size.

8.2.9.3 Down conductors shall be connected to separate earth electrodes through test points located at height of 1000mm above ground level. These earth electrodes shall in-turn be connected to earth mat at two points.

8.2.9.4 Dedicated earthing system (Electronic grounding system) shall be provided for instrumentation system. The grounding system for electronic grounding shall be kept insulated from the other grounding system such as motor, transformer, switchgear etc.

8.2.9.5 The material of the earthing conductors shall be as follows :

- | | |
|---|------------------|
| a) Conductors above ground level and in built up trenches | Galvanized steel |
| b) Conductors buried in earth | Mild steel |
| c) Earth electrodes | Mild steel rod |

8.2.9.6 The sizes of earthing conductors for various electrical equipments shall be as below:

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

8.2.9.7 Metallic frame of all electrical equipment shall be earthed by two separate and distinct connections to earthing system,

8.2.9.8 Each continuous laid lengths of cable tray shall be earthed at minimum two places by GS flats to earthing system.

8.2.9.9 Earth pit shall be constructed as per IS:3043. Electrodes shall be embedded below permanent moisture level. Minimum spacing between electrodes shall be 6000mm. Earth



- pits shall be treated with salt and charcoal if average resistance of soil is more than 20 ohm metre.
- 8.2.9.10 Fences included within the ground grid area should have a conductor parallel to the fence on the outside at a distance of 500 to 1500mm with 1000mm generally recommended and the fence and conductor should be bonded together and to the ground grid at frequent intervals as per ANSI/ IEEE-665.
- 8.2.9.11 Lightning protection system shall comprise vertical air terminations, horizontal air terminations, down conductors, test links and earth electrodes.
- 8.2.9.12 Conductors of lightning protection system shall not be connected with conductors of earthing system above ground level.
- 8.2.9.13 Air terminations, down conductors and test links shall be of galvanized steel conductors and earth connection below ground level shall be of mild steel rod.

8.3 Control & Instrumentation System - Design Criteria :

- 8.3.1 A totally integrated instrumentation and control system covering the total functional requirements of sequential control, interlock, protection, monitoring, alarm, data logging, fault analysis etc. to ensure operability, maintainability and reliability with latest state of art equipment shall be provided. The control system for each of BOP system shall either be Programmable Logic Controller (PLC) based or shall be implemented through micro-processor based distributed control system (DCS).
- 8.3.2 All electrical instruments, solenoid valves shall be provided with explosion proof enclosure as per National Electric Code (USA) Article 500, Class-I, Division-I located in the hazardous areas, viz. Fuel oil area, Coal handling area etc.. Further, all fittings, cable glands etc shall be strictly as per NEC recommendation article, 500 to 503.
- 8.3.3 Environmental Conditions

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



Standard Design Criteria/Guidelines for Balance of Plant of Thermal Power Project
2 x (500MW or above)

Section- 8 (Electrical and Control & Instrumentation System)

Ambient temperature (outside cabinets)	Pressure	Relative humidity	Atmosphere	Required protection Class of panels/ cabinets/ desks
Outdoor location				
55°C max	Atmosphere	100% max	Air (dirty)	IP 55***
4°C min	Atmosphere	5% min	Air (dirty)	IP 55***
Indoor location				
55°C max	Atmosphere	95% max	Air	IP 54**
4°C min	Atmosphere	5% min	Air	IP 54**
Air-conditioned areas				
24±5°C normal	Atmosphere	95% max	Air	IP 22
50°C max *	Atmosphere	5%.min	Air	IP 22
* During air conditioning failure.				
** For non-ventilated enclosures. For ventilated enclosures, protection class shall be IP 42.				
*** With a suitable canopy at the top to prevent ingress of dripping water.				

8.3.4 Operability & Maintainability

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

The types of failure, which shall be taken into account for ensuring operability of



the plant shall include but not be limited to:

- Failure of sensor or transmitter
- Failure of main and/ or redundant controller/ other modules
- Loss of motive power to final control element
- Loss of control power
- Loss of instrument air

b) The choice of hardware shall also take into account sound maintainability principles and techniques. The same shall include but shall not be limited to the following:

- Standardization of parts
- Minimum use of special tools
- Grouping of functions
- Interchangeability
- Malfunction identification facility/ self surveillance facility
- Easy modular replacement
- Fool proof design providing proper identification and other features to preclude improper mounting and installation
- Appropriate de-rating of electronic components and parts

8.3.5 Programmable Logic Controller based control system

a) Each PLC unit shall be provided with two processors; one for normal operation and one as hot standby. In case of failure of working processor, there shall be an appropriate alarm and simultaneously, the hot standby processor shall take over the complete plant operation automatically. The transfer from main processor to standby processor shall be totally bump-less and shall not cause any plant disturbance whatsoever. In the event of both processors failing, the system shall revert to fail safe mode.

It shall be possible to keep any of the processors as master and other as standby. The standby processor shall be updated in line with the changes made in working processor.

- b) The PLC system shall be provided with necessary interface hardware and software for dual fibre-optic connectivity & inter-connection with station wide LAN for two-way transfer of important signals for respective systems for the purpose of information sharing.
- c) Two (2) nos. PC based Operator Work Stations (OWS) shall be provided for i) control & monitoring and ii) programming function with each PLC assignable to any of the above two tasks.
- d) The sequence startup mode shall be of the following types.
- Automatic Mode



In this mode of operation, the sequence shall progress without involving any action from the operator. The sequence start/ stop command shall be issued from the TFT/ KBD's.

- Semi-Automatic Mode

In this mode of operation, once the sequence is initiated, the step progressing shall be displayed on the TFT. But the step execution command shall be prevented and shall be sent by the operator via the keyboards. It shall be possible to bypass and/ or simulate one or more criteria to enable the program to proceed. This facility shall allow the program to be executed even if some criteria are not fulfilled because of defective switching device, etc., while the plant condition is satisfactory. All the criteria by-passed shall be logged and displayed. It shall be possible to put the system on the auto-mode after operating it on semi-automatic mode for some steps or vice-versa, without disturbance to the sequence operation.

- Operator Test Mode

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

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

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

- e) Priority of different commands shall be as follows:
- i) Manual intervention shall be possible at any stage of operation. Protection commands shall have priority over manual commands and manual commands shall prevail over auto commands.
 - ii) In PLC controller, memory shall exist as to where the sequence was aborted due to power supply failure, so that further operation from that



Section- 8 (Electrical and Control & Instrumentation System)

point can restart on restoration of power supply. This restart shall be through operator's intervention, so as to enable verification of readiness of other related equipments.

- f) Input/ Output (I/O) Modules
- i) The PLC system shall be designed according to the location of the input/output cabinets whether in the same cabinet or mounted in a separate rack.
- ii) I/O modules for all type of field input signals (4-20mA, RTDs, thermocouples, non-changeover/ changeover contact inputs etc.) and outputs from the control system (non-changeover/ change over contact, 24/48VDC output signals for energising interface relays, 4-20mA output etc.) shall be provided. Redundant field sensors shall be provided for critical applications.
- iii) Electrical isolation of 1.5kV with optical couplers between the plant input/ output and controller shall be provided on the I/O cards. The isolation shall ensure that any inadvertent voltage or voltage spikes shall not damage or mal-operate the internal processing equipment.
- iv) The I/O system shall facilitate modular expansion in fixed stages. The individual I/O cards shall incorporate indications on the module front panels for displaying individual signal status.
- v) Individually fused output circuits with the blower fuse indicator shall be provided. All I/O points shall be provided with status indicator. Input circuits shall be provided with fuses preferably for each input; alternatively, suitable combination of inputs shall be done and provided with fuses such that for any fault, fuse failure shall affect the particular drive system only without affecting other systems.
- vi) All I/O cards shall have quick disconnect terminations allowing for card replacement without disconnection of external wiring and without switching of power supply.
- vii) The following features shall be provided:-
- Power supply monitoring;
 - Contact bounce filtering;
 - Optical isolation for binary signals and galvanic isolation for analogue signals.

In case of power supply failure or hardware fault, the critical outputs shall be automatically switched to the fail-safe mode.

- viii) Keying-in of individual wire connectors shall be provided to ensure that



Section- 8 (Electrical and Control & Instrumentation System)

only the correct card is plugged on the I/O module. It shall be possible to remove I/O module without disconnecting wiring from field inputs or outputs. There shall be atleast 20% spare capacity available on input, output and memory modules, over and above the system requirement.

- ix) Binary Output modules shall be rated to switch ON/ OFF coupling relays of approx. 3VA at 24VDC. Analog output modules shall be able to drive a load impedance of minimum 500Ω.
- x) Output module shall be capable of switching ON/ OFF inductive loads like solenoid valves, auxiliary relays etc. without any extra hardware.
- xi) Only one changeover contact shall be provided in MCC for control and interlock requirement. Further, multiplication, if required, shall be done in PLC.
- xii) All input field interrogation voltage shall be 24V DC or 48V DC.
- xiii) In case of loss of I/O communication link with the main processing unit, the I/O shall be able to go to predetermined fail safe mode with proper annunciation.
- xiv) 20% spare I/O modules in each system cabinet shall be provided.

g) Data Communication System (DCS)

Redundant communication controllers shall be provided to handle the communication between I/O Modules (including remote I/O) and PLC's and between PLC's and operator work station.

h) Operator interface displays/ logs

Suitable displays and reports for control operation and monitoring shall be provided.

8.3.6 Control and power supply scheme

- i) For PLC system, redundant 24V DC power supply system shall be provided. The system shall consist of two sets, each set provided with 1x100% Ni- Cd batteries, 1x100% DC distribution board, 1x100% microprocessor controlled intelligent modular rectifier banks and 1x100% controller for each bank. Necessary power supply from 415V, 3-phase redundant incomers shall be arranged from 415V MCC .

For separately mounted I/O racks, separate power supplies shall be provided. Power supply module shall be of adequate capacity to supply all modules. In addition 20% spare capacity for future shall be provided. All the drives shall be switched ON/ OFF through 24VDC coupling relays to be provided in HT/ LT



switchgears.

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

8.3.7 Annunciation system

Annunciation system shall be integral part of PLC system. Field contacts shall be acquired through PLC only. The annunciation sequence logics shall be implemented as a part of PLC controllers.



**STANDARD DESIGN CRITERIA/GUIDELINES FOR BALANCE OF PLANT OF
THERMAL POWER PROJECT 2 x (500MW OR ABOVE)**

SECTION- 9: (CIVIL WORKS)

9.1 GENERAL

9.1.1 Intent and Scope

This section covers technical requirements for design criteria/guidelines for civil and structural works for Balance of Plant Packages. The scope of civil works has been described in respective Section of Balance of Plant packages.

9.1.2 Site Grading and Leveling

i) Design criteria

Leveling and grading shall be carried out by selected cutting and filling of existing ground surface and earth. The cutting and filling requirements should balance each other to avoid earth from borrow pits as far as possible. Different grade levels may be adopted for different areas. Following levels may generally be adopted for the plant:-

- | | | |
|--|---|---------------|
| a) Formation level of the plant | : | $\pm 0.0M$ |
| b) Road level of the plant | : | +0.25 to 0.3M |
| c) Finished floor level of all buildings | : | +0.5M |

Formation level of the plant shall be kept minimum 1.0 m above the highest flood level (HFL).

ii) General site excavation and fill

General site excavation and fill shall establish a uniform, stable working surface in active station areas, provide for positive drainage compatible with natural drainage system around buildings and other structures, and provide adequate soil cover for underground utilities. Before the placement of fill material, the existing sub grade shall be prepared as follows:-

- a) All vegetation, organic or otherwise incompetent material shall be removed. The remaining in-situ material shall be compacted to the depth and density determined by the detailed design. Slope stability, moisture and density relationship, and compaction requirements shall be determined as a result of the geotechnical field and laboratory investigations.



- b) The size of the general site fill is defined by its geometrical boundaries. These shall be established in conformity with the arrangement of site facilities and the site design parameters subject to constraints imposed by the interfacing systems.
 - c) The natural soil strata and fill material shall be tested for presence of sulphates and chlorides. In the event high percentages of such compounds are found to be present, required special treatment/coatings shall be provided to the concrete and reinforcement surfaces for foundations and structures below ground for protection against the deterioration during the life-time of such structures.
- iii) Structure backfill
- a) Structure backfill shall provide stable fill around and adjacent to structure foundations and buried utilities.
 - b) All organic and other existing material which can cause settlements due to soil volume change shall be removed prior to placing the fill material. Backfill shall be placed and compacted to the required limits. The use of heavy equipment or inundation for placing structure backfill shall be prohibited.
- iv) Slope protection
- Slope protection shall protect earth slopes from erosion due to storm water runoff and wind damage or other natural phenomena consisting of grass cover, grout filled fabric forms rip rap. The type of slope protection shall be determined by expected velocities of storm water run off.

9.1.3 Roads

- i) Design criteria
- a) The roads system shall provide vehicular access throughout the plant area including access to all building and structure etc. The system shall provide access to all building and major activity areas of the site.
 - b) The roads system shall be subjected to heavy vehicles and construction equipment during construction. All roads shall be subject to heavy wheel loads of off-road haul trucks, wheel loaders, and scrapers. Road system shall be designed for minimum class 'A' loading or higher conforming to IRC standards. All roads should be provided with adequate camber as per IRC standards.
 - c) The roads shall be divided into two types of roads as follows:-
 1. All main roads shall be 8 meter wide with raised foot path on both sides of roads.
 2. All secondary plant roads shall be 4.5 meter wide provided with 1.5 meter wide hard shoulders on either side and shall be for access to plant auxiliary areas and buildings. Peripheral road along the boundary wall shall have adequate nos. of watch towers as per requirement.



- d) Secondary access roads within the station complex shall be constructed during the site preparation phase of construction with RCC culvert at road junctions to cater for crossing of drains/cables etc. to avoid major road cuttings at a later date.
 - e) All roads shall be constructed on prepared sub-grade and stone sub-base and base of two (2) layers of water bound macadam each of minimum 75 mm thickness, with Gr. II crushed rock aggregate conforming to IRC-19 laid over prepared sub-base. The sub-grade for the road shall be the natural ground, which shall be cleared of all loose material, organic matter, grass etc, scarified, rolled and compacted to proctor density of 95%. The sub-base shall consist of crushed stone laid to a minimum thickness of 200 mm, in 2 layers of 100 mm compacted thickness each, with Gr. I aggregate conforming to IRC-19. All the roads shall be topped with bitumen. Road side drainage shall be provided preferably on both sides of road. The total thickness and composition of the layers of the pavement shall be provided as per IRC – 37. “Design of flexible pavement.”
- ii) Road sub-grades
- a) The sub-grades shall provide uniform and stable foundations for the roads.
 - b) Embankment fill material shall consist of specified fill material obtained from excavation at other onsite grading areas, buildings, or roadbeds. This material shall be placed and compacted to the density and geometry determined by the detailed design to provide the strength required and to limit settlements within the allowable limits.
- iii) Type of roads
- a) Access within the plant site shall be provided by a system of roadways.
 - b) Roads shall be three types: Type I, Type II and Type III.
 - c) Type I roads shall be 8 meter wide and consist of asphalt paved carriageways with 1.5 m wide hard shoulders.
 - d) Type II roads shall be 4.5 m wide with 1.5 m wide hard shoulders on either side. Type III roads, 3 meter wide, shall be provided along the plant boundary for access for security and maintenance.
 - e) All roads shall be surfaced with gravel during the construction period. Occasional applications of a dust palliative material shall be used to minimize the dust problem during the dry seasons.
 - f) All Type I and Type II roads shall have a minimum turning radius of 15.2 m. Bollards shall be provided along side all type roadways near equipment which requires protection. Spare duct banks shall be provided under all type roads spaced at 100 m intervals.
 - g) Signs shall be provided for vehicle management and shall meet Indian standards. All signs shall be dual worded in both English and the local Indian language.



9.1.4 Storm Water Runoff Drainage

- i) Design criteria
 - a) Grading shall provide stable sub-grades for transportation facilities, flow ways for the transportation of runoff, flood protection, and stable earth surfaces for access and for handling of materials during plant construction and operation.
 - b) Storm water runoff drainage shall direct runoff from roof drains and other areas to the proper drainage collection basins or to natural drainage as appropriate. Rainfall runoff shall be directed from facility areas and construction lay-down areas in a manner which allows maximum freedom of vehicular traffic patterns.
 - c) Various classes of compacted earth fill materials with stone base shall form roadbed embankments, foundation bearing surfaces, and stable earth surfaces for access roads and parking areas.
 - d) Grading and engineered ditches shall direct the site drainage. Roof drainage and ditch flow shall be based on a 1 in 50 year frequency rainfall event for the power block area, the railroad, and for the plant access roads.
 - e) Whenever possible, drainage shall run parallel to roadways and traffic areas to direct runoff to culverts used in the storm water runoff drainage system.
 - f) In case collection basin is provided, the basin shall be designed to contain general site drainage, neutralization basin flows, oil/water separator flows, and service water system flows, septic tank. The basin shall be sized to contain the 24 hours storm runoff from two recent consecutive rainfall events and shall be designed not to have a normal discharge.

- ii) Storm water runoff drainage and culverts

Offsite runoff entering the site from surrounding areas shall be routed around the site area through the use of overland flow, open channel flow, and underground piping. Runoff originating from areas of the site not disturbed by construction activities or unit operation shall be allowed to flow to the natural site drainage system. Runoff from disturbed areas of the site shall be controlled as described below:-

- a) Open areas shall be sloped a minimum of 1 percent to drain away from buildings and structures towards drainage channels. All runoff shall be conveyed by gravity to the drainage system. Open drains shall be utilized primarily except for roof and floor drainage. In areas where surface space limitations prevent the use of open drains, catch basins/pits shall be used. Catch basins shall discharge to the nearest open drain through underground piping. RCC box culverts/pipe culverts shall be used to pass flows under roads, railroads, and other locations where surface conveyance would not be practical. For pipe culverts, reinforced concrete pipes class NP3 conforming to IS-458 shall be provided. For all other underground piping work reinforced concrete pipe class NP2 of IS-458 (minimum) shall be provided.



- b) All plant drains shall be of covered RCC construction and shall be rectangular or trapezoidal in shape depending upon the space available. Drains shall be provided with RCC slab covers if required from aesthetic and operational requirements. MS edge angles 50x50x6 shall be provided on the drain side walls supporting the cover slabs. The pre-cast cover slabs shall also be provided with MS flats/angles for edge protection. All culverts shall be equipped with headwalls and aprons at both the upstream and downstream ends. Wherever vehicular or other loading is anticipated to occur over drain covers, these shall be designed for it. Beyond the plant boundary, the drains can be of Brick work/masonry without covers.
 - c) The general site drainage system shall be designed for a 1 in 50 year frequency rainfall event for the power block area and for the main access roads.
 - d) Culvert wall thickness shall be sized to provide adequate strength and allow for corrosion protection over the unit lifetime. The opening shall be sized to carry the design flow most efficiently accounting for the constraints of the discharge channel and the embankment.
 - e) All runoff from outside area flowing through the site shall be suitably diverted to the natural drainage system by constructing the open channels, underground pipes or closed channels as per site requirement. The natural drainage system may need to be modified to take care the additional discharge from the site.
 - f) The plant area drainage shall be designed to cater to storm water run off resulting from a three (3) hour storm or 1 hour rainfall intensity with a return period of 50 years which ever is higher. The three (3) hour values shall be based on the recommendation of Indian Meteorological Department (IMD).
 - g) The plant storm water drainage shall be designed taking into account the finished grade levels of the plant and invert levels of existing drains, area drainage pattern within and outside plant area, intensity of rainfall etc. The maximum velocity for pipe drains and open drains shall be limited to 2.4 m/sec and 1.8 m/sec respectively. However, minimum velocity of 0.6/sec. for self cleansing shall be ensured. Bed slope not milder than 1 in 1000 shall be provided.
- iii) Road Drainage
- a) Runoff from onsite road roadbeds and other embankments shall be collected and directed to general site drainage. Roads and their embankments shall be sloped to drain to toe drains which shall collect and transport the runoff. Intermediate culverts shall convey runoff through embankment fills.
 - b) Toe drains and culverts shall be designed as described in general site drainage. Drainage system study within plant boundary as well as outside the plant boundary shall be carried out.

9.1.5 Drains and Plumbing

i) General



The drains and plumbing system shall carry contaminated and other waste fluids by gravity to a waste collection and treatment system through an over ground piping system and embedded underground pipes.

ii) Major Components

The drains and plumbing system shall consist of the following major components:-

- a) Roof drains.
- b) Trenches, floor, equipment, and oil drains.
- c) Hot drains.
- d) Plumbing.

iii) Description

- a) The drains and plumbing system shall consist of drain trenches covered with pre-cast RCC covers or gratings, floor drains, feeder drain pipes, down comers, bell-ups, inspection chambers/manholes with covers, main pipe headers, and supply piping. This system, along with the interfacing waste collection and treatment systems shall drain the floor drains and fixtures to the proper drainage or treatment facility.
- b) All components of the drains and plumbing system shall be designed to ensure efficient drainage of the associated areas or equipment.
- c) The water or storm drainage facilities and piping shall be located at elevations to allow gravity drainage adequately.

iv) Roof Drains Design Criteria

- a) The roof drains shall transport rainfall runoff from roofs to the grading and storm water runoff drainage system.
- b) The roof drains shall be sized for the roof area runoff for a maximum rainfall per hour at site. Fixing of rain water gutters and down pipes for roof drainage shall conform to IS-2527.

v) Plumbing Design Criteria

- a) The plumbing shall consist of all the hot and cold water supply distribution piping from the potable water header connection to and including the plumbing fixtures. The plumbing fixtures shall include water heaters, lavatories, urinals, toilets, etc. The plumbing shall be rigidly anchored to walls and steel with suitable pipe hangers or wall brackets. All plumbing materials and fixtures shall be of the best quality and make conforming to relevant IS codes with water conserving features and shall be as approved by Purchaser.



- b) The plumbing shall be sufficient to supply the quantity of water required by the plumbing fixtures. All plumbing work shall correspond to IS-2065 and IS-1172.
- c) The design, layout, construction etc of drains for waste-water, surface water and sewage together with connections, manholes, inspection chambers etc., used within the building and from the building to the septic tank or treatment works shall conform to IS-1742.

9.1.6 Concrete/Steel Structural Design

9.1.6.1 Codes and standards

All design criteria must conform to the latest edition of the Indian codes and standards or other Internationally accepted standards which ensure a quality equal to or higher than the Indian standards unless otherwise specified.

Indian Standards

- Different Bureau of Indian standards codes (IS)
- Special publications (SP)
- Indian Road Congress standards (IRC)
- National Building Codes (NBC)

If any, standard/ clauses of the standard contains a provision which is inconsistent with a provision in Indian standard, the more stringent requirement as per the interpretation of the Owner/Purchaser shall prevail. All design work shall be carried out on the basis of latest edition of applicable codes and standards mentioned.

9.1.6.2 Natural Phenomena Design Criteria

The design criteria based on the natural phenomena (wind speed, seismicity, ambient temperature and relative humidity) are discussed below.

i) Wind speed

- a) The basic wind speed shall be based on IS: 875 (part 3). This basic wind speed shall be used to determine wind load for all structures.
- b) All structures shall be designed for wind forces in accordance with IS: 875 (Part 3) for site specific information with reference to basic wind speed V_b at 10 metres above mean ground level. The risk co-efficient K_1 & category of terrain, but notwithstanding the values of the above mentioned parameters, the design wind pressure so computed at any point shall not be taken less than 1500 N/sq.m for all classes of structures, i.e. A, B & C as defined in IS-875(Part 3).
- c) Along wind forces shall generally be computed by peak (ie 3 second gust) wind speed method. Along wind forces for slender & wind sensitive structures shall be computed for dynamic effects using gust factor or gust effectiveness factor



method. The structure shall be designed for higher of the forces obtained from gust factor method and the peak wind speed method.

- d) Analysis for dynamic effects of wind must be undertaken for any structure which has a height to minimum lateral dimension ratio greater than 5 & if fundamental frequency of structure is less than 1 HZ.
- e) Susceptibility of structure to across wind forces, galloping, flutter/ovalling etc. be examined and designed/detailed as per recommendations of IS: 875 (Part 3).
- f) The size & relative position of other structures likely to enhance wind loading on structure under consideration shall be considered. Enhancement factor, if necessary, shall be estimated and applied to wind loading.
- g) *Damping in structures*

The damping factors to be adopted shall not be more than as indicated below:

Welded steel structures	1.0%
Belted steel structures	2.0%
Reinforced steel structures	1.6%
Steel stacks	As per IS:6533 & CICIND model code whichever is more critical

ii) Seismicity

- a) The zone factor as per IS: 1893 shall be applied for the plant site.
- b) The seismic risk zone for this site determined from the IS : 1893. Seismic loading shall be used in the design of structures. Wind load and seismic load shall not be considered to act simultaneously. Under seismic condition, the whole frame except the roof, shall be assumed loaded with 50% design live load. No further reduction in column live load shall be considered as per clause 1.7.2.1 under seismic conditions. Dynamic analysis of buildings and structures shall be carried out in accordance with clause 7.8 of IS 1893.
- c) All structures and equipment shall be designed for seismic forces adopting the site specific seismic information provided in IS: codes and using the other provisions in accordance with IS: 1893 (Part 1): 2002 and IS: 1893 (part 4) : 2005. Pending finalization of Parts 2,3 and 5 of IS : 1893, provisions of part 1 shall be read along with the relevant clauses of IS : 1893 : 1984, for structures other than the buildings and industrial structures including stack-like structures.
- d) A site specific seismic study shall be conducted for 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) shall be modified as per IS 1893 (Part 4):2005.

Alternatively, in the areas not covered in high seismic zones (zone 4 & 5) and if there is paucity of time, the data of IS: 1893 can be adopted.



- e) Horizontal seismic acceleration spectral coefficients in units of 'g' (Site Specific)

Period Sec	Damping factor (as percentage of critical damping)					
	0.8%	1%	1.6%	2%	3%	5%

- f) Vertical acceleration spectral values shall be taken as $2/3^{\text{rd}}$ of the corresponding horizontal values.
- g) 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 Annexure-1 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 important factor (I) and response reduction factor (R) as used in the IS : 1893 (Part 1 and Part 4).
- h) Damping in Structures

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

Steel structures	:	2%
Reinforced Concrete structures	:	5%
Reinforced Concrete Stacks	:	3%
Steel stacks	:	2%

- i) Method of Analysis

- 1) 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 shall 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 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).
- 2) 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 (Part1).

- 3) For regular type general buildings, IS 1893 Part 1 can be followed for enhancement of Base shear as per empirical time period Clause 7.8.2 of IS 1893 Part 1.

Industrial buildings shall be designed as per IS 1893 Part -4.

- 4) Further, 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.

- j) 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 IS:800-2007 for steel structure and as per IS: 13920 for RCC structures to achieve ductility.

iii) **Temperature**

Systems and system component design criteria which require ambient temperature extremes shall use the range from minimum to maximum temperature existing at site for dry-bulb temperatures.

iv) **Relative humidity**

- | | | |
|--------------------------|---|-----------------------|
| i) Absolute maximum | : | 100% |
| ii) Highest monthly mean | : | As per site condition |

9.1.6.3 **Design Loads**

Design loads for all structures shall be determined according to the criteria described below, unless the applicable Indian building code requires more severe design conditions.

- i) Dead loads

Dead loads shall consist of the weights of the structure and all equipment of a permanent or semi-permanent nature including tanks, silos, bins, wall panels, partitions, roofing, piping, drains, electrical trays, bus ducts, and the contents of tanks measured at full capacity. However, the contents of tanks and other loads of semi-permanent nature shall not be considered as effective in resisting column uplift, overturning and sliding.

- ii) Live loads

- a) Live loads shall consist of uniform live loads and equipment live loads. Uniform live loads are assumed unit loads which are sufficient to provide for movable and transitory loads, such as the weight of people, portable equipment and tools, plank-



ing and small equipment, or parts which may be moved over or placed on floors during maintenance operations. These uniform live loads should not be applied to floor areas which shall be permanently covered with equipment.

- b) Equipment live loads are calculated loads based upon the actual weight and size of the equipment and parts to be placed on floors during dismantling and maintenance, or to be temporarily placed on or moved over floors during installation.
- c) Floors and supporting members which are subject to heavy equipment live loads shall be designed on the basis of the weight of the equipment in addition to a uniform load of 500 kg/m^2 , or specifically defined live loads, whichever is greater. Each member in the floor which may carry these loads shall be designed for the heaviest piece or pieces of equipment arranged in the most critical position. For loads caused by moving equipment over the floor for installation, consideration shall be given to the shoring of beams and floor from floors below. When moving equipment over floors for installation, stress increases of 25 percent are permitted in beams and columns.
- d) Live loads shall be used as follows:-

Description	Floor slabs
Grade floors slabs	1500 kg/m^2 (minimum)
Maintenance area in ground floor	3000 kg/m^2
Storage areas	Actual load of stored material or 1500 kg/m^2 (minimum)
Suspended floors and control room floor	1500 kg/m^2 (minimum) or actual whichever is higher
Roofs (concrete slab)	As per IS:875.
Steel grating / chequered plate platforms	- 500 kg/m^2 for grating/ chequered plate - 500 kg/m^2 for supporting beams
Inclined Roof	As per IS – 875 (Part-2)

Areas designated for different loadings on the same floor shall be clearly and permanently marked.

- e) Column live loads

Live loads carried from the floors to the columns shall include 100 percent of the roof live load. In addition to the roof live load, the columns must carry floor live load. If the floor live load is 500 kg/m^2 or less, no reduction in live loads carried from the floors to the columns is allowed. If the floor live load is greater than 500 kg/m^2 , reduction in live loads carried from the floors to the columns shall be considered as per clause 3.2 of IS-875 (Part-2) for design. However, reduction in live load from all floors to be carried by the member under consideration shall not exceed 20% irrespective of the codal provisions.



iii) Impact loads

Impact loads shall be added to other loads for components supporting reciprocating or rotating machines, elevators, hoists, cranes, or other equipment creating dynamic forces. The following impact loads shall be used, unless analysis indicates higher or lower values:-

- | | | | |
|----|--|----|---|
| a) | Elevators | -- | 100 % of lifted load. |
| b) | Hoists and cranes: | | |
| | • Vertical | -- | 25 % of the maximum static wheel load. |
| | • Horizontal-lateral | -- | 20 % of the sum of the lifted load plus the weight of the hoisting component. |
| | • Horizontal-longitudinal | -- | 10 % of the total moving load. |
| c) | Rotating and reciprocating equipment | -- | 50 % of the machine weight |
| d) | Hangers supporting floors and platforms | -- | 33 % of the sum of the dead load and reduced live load. |
| e) | Steel members supporting boiler drum hangers | -- | 100 percent.. |

iv) Equipment loads

Equipment loads shall be specifically determined and located. For major equipment, structural members and bases shall be specifically located and designed to carry the equipment load into the structural system. For equipment weighing less than the live load, the structural system shall be designed for the live load. Equipment loads shall be noted in the design calculations to permit separation in calculation of uplift and stability.

v) Access walkways, stair, handrails, and ladders

Design loads shall conform to the requirements of IS: 875 (part I and II) and the minimum requirements following, whichever are the most severe:

- a) The walkways shall be designed for the dead loads of the structure plus a superimposed live load of 500 kg/m² uniformly distributed, or a concentrated load of 500 kg at any point, whichever produces the most severe effect.



- b) Stair treads shall be designed for a distributed load of 225 kg/linear meter of tread width or a concentrated load of 100 kg, whichever produces the most severe effect.
- c) Handrail forces shall be 100 kg applied outward at the center of the span and vertical between posts. Ladders shall be designed to withstand a line load of 100 kg or, alternatively, a number of line load units of 100 kg, the number of units and their spacing being in accordance with the anticipated usage of the ladder.

vi) Test load

The test load shall be defined as the gravity load imposed by method necessary to test vessels, tanks, equipment or piping.

vii) Wind loads

Wind load for all structures shall be based on IS: 875 (part 3). Basic wind speed shall be as specified in IS: 875(part-3).

viii) Seismic loads

The seismic risk zone for the site shall be determined from IS: 1893. Under seismic condition, the whole frame except the roof shall be assumed loaded with dead load, super imposed dead load (SIDL) and 50% design live load. No further reduction in column live load shall be considered as per clause 5.3.2.1 under seismic condition.

ix) Construction loads

The integrity of the structures shall be maintained without use of temporary framing struts or ties and cable bracing insofar as possible. However, construction or crane access considerations may dictate the use of temporary structural systems. Special studies shall be made and documented to ensure the stability and integrity of the structures during any periods involving use of temporary bracing systems.

x) Estimated loads

Loadings imposed by equipment shall be specifically determined or estimated before detailed structural design. Estimated loadings shall be noted as such in hand calculations or computer input and verified as information is made final.

xi) Dust Load

All buildings and structures shall be designed for dust load of 50 kg/m² wherever applicable.

xii) Thermal load

Thermal loads shall be defined as forces caused by changes in temperature. The primary source of thermal loads in an industrial plant is the expansion or contraction of vessels and



pipings. Another source of thermal loads in a redundant structure is the expansion or contraction of the entire structure or individual structural components. For temperature loading calculation the total temperature variation shall be considered as 2/3 of the average maximum annual variation in temperature. The average maximum annual variation in temperature for this purpose shall be taken as the difference between the mean of daily minimum ambient temperature during the coldest month of the year and mean of daily maximum ambient temperature during the hottest month of the year. The structure shall be designed to withstand stresses due to 50% of the total temperature variation. Suitable expansion joints shall be provided in the longitudinal direction wherever necessary with provision of twin columns. The structures shall also be checked for temperature effects in the areas where the temperature rise is expected to be high.

xiii) Future load

Loads from future expansion shall be considered when so directed by the purchaser./owner. Future loads may include any of the loads listed above.

xiv) Surge load

Surge loads may occur in some vessels or equipment. In such cases, the magnitude and direction of the load shall be given by the equipment supplier.

xv) Miscellaneous load

Miscellaneous loads shall be defined as loads that do not fit into the categories listed in this section. Typical miscellaneous loads are loads, during erection, maintenance and repair.

For the design of individual structural components, realistic load combinations in accordance with the relevant design standards shall be considered.

All loadings considered in the design shall be justified with supporting details.

9.1.6.4 General Requirements

9.1.6.4.1 Design requirements

- i) Reinforced concrete structures shall be designed in accordance with the latest Indian standards IS: 456- Building code requirements for reinforced concrete.
- ii) Structural steel buildings shall be designed in accordance with latest IS – 800. “Building code requirements for steel buildings.”
- iii) The design of all structures shall be such that differential and total settlements or other movements shall not exceed acceptable limits and full provision shall be made for all expansion and other joints.
- iv) Structural members subjected to flexure shall be designed to have adequate stiffness to limit deflections or any deformations that affect strength or serviceability of a structure adversely. The maximum allowable deflections of structural members



shall be in accordance with the relevant design standards and/or the limits prescribed by the machinery manufacturers (whichever is less).

- v) The superstructures and foundations subjected to vibrations (the primary source of these vibrations being the unbalanced forces generated by rotating or reciprocating equipment) shall be designed such that vibrations will be neither intolerable nor troublesome to personnel and will not cause damage to the machine or structure.
- vi) The natural frequency of the whole of the superstructures and foundations or parts thereof and all structures adjacent thereto shall not coincide with the operating frequency of the vibrating equipment.
- vii) The differences between frequencies and the dynamic analysis of the superstructures and foundations shall be in accordance with the relevant design standard.
- viii) The dimensions of all the buildings shall be such as to provide adequate space for the safe installation and proper operation, maintenance and repair of all plant and equipment.

9.1.6.4.2 Design of steel connections

- i) Fabrication drawings shall be prepared according to the provision of IS: 800, IS: 816, IS: 9595, IS: 1367 and IS: 9178.
- ii) Connection of vertical bracings with connecting members and diagonals of truss members shall be designed for full tensile capacity of the bracings.
- iii) Size of fillet weld for flange to web connection for built-up section shall be as follows:-
 - a) Full shear capacity or actual shear whichever is more for box section.
 - b) 80% of full shear capacity or actual shear or 0.5 times of the web thickness whichever is more for I section weld shall be double fillet.
 - c) All welds shall be continuous. The minimum size of the fillet weld shall be 6 mm.
- iv) Shear connections shall be designed for 75% of section strength or actual shear for rolled sections and 80% of section strength or actual shear whichever is higher for built-up section or rolled section with cover plates.
- v) Moment connections between beam and column shall be designed for 120% of moment capacity of the beam section as per IS:800-2007 to provide ductility to structure.
- vi) All butt-welds shall be full penetration butt-welds.
- vii) The connection between top flange and web of crane girder shall be full penetration butt-weld and for bottom flange, connection may be fillet weld.



- viii) Connection of base plate and gusset members with the columns shall be done considering that total load gets transferred through weld.
- ix) Splicing: All splicing work shall be full strength. Field splicing shall be done with web/flange cover plates. For exceptional cases, the field splicing shall be designed for 50% of load carried by the cover plates and remaining 50% load through full penetration butt-weld. Shop splicing for all sections other than rolled shall be carried out by full penetration butt-welds with no cover plates. Splicing for all rolled sections shall be carried out using web and flange cover plate. Connections shall be designed as per IS 800-2007.

9.1.7 Foundations

9.1.7.1 Foundations for Building

- i) General
 - a) Detailed geo-technical investigation shall be required to be carried out to ascertain the safe bearing capacity and appropriate type of foundation for heavy equipment and structures.
 - b) The geo-technical exploration, testing and analysis information shall be used to determine the most suitable bearing method to support each foundation. The bearing method may include engineered fill, piling, drilled shafts, pressure injected footings or soil densification.

- ii) Bearing capacity

The foundations shall be designed for the following factors of safety:-

Shallow foundations	:	3.0
Deep foundation systems	:	2.0

- iii) Settlement criteria

Allowable settlements, elastic plus consolidation, shall be limited as follows:-

For foundation of Tall Steel Structures e.g. Crusher house, Transfer point, Conveyor Trestle, etc. the total settlement may generally limited to 25 mm and Differential settlement to 6mm.

For other buildings:-

Total settlement	:	38 mm
Differential settlement	:	6 mm

Foundations for equipment shall be designed to meet the total and differential settlement established by the equipment manufacturer if they are more stringent than



the allowable settlements listed above. Foundations for buildings shall be designed to meet the total and differential settlement as required for the building function if they are more stringent than the allowable settlements listed above.

iv) Settlement and expansion joints

- a) Joints are to be arranged in such a way that stresses and strains caused by settlements, temperature, differential settlement, etc do not adversely affect the structures. This primarily applies to differently loaded areas and structures having different foundations or foundations of different depths. The settlement joints shall run through the complete structure down to foundation level, the expansion joints however shall stop on the top level of foundations.
- b) The joint width which is to be at least 2 cm is to be planned considering all relevant factors (settlements, tilting, movements, aspects etc.).
- c) Settlements of all relevant structures shall be measured, recorded and shown in diagrams according to IS: 8009 – “Code of practice for calculation of settlement of foundation”.

v) Foundations at different depths

Foundations at different levels should be based beyond a load spread angle of $/30^\circ$ (against the horizontal). Otherwise, the load influence (e.g. earth pressure) of the higher level structures on the lower ones must be taken into consideration.

vi) Safety against uplift

For all parts of the structures extending into the ground water, safety against uplift has to be guaranteed during all execution stages, especially when ground water lowering is terminated.

vii) Shallow foundations

Shallow foundations shall rest on the natural bearing soil. For this kind of foundation especially the following standard is to be applied:

IS: 1080 Code of practice for design and construction of shallow foundations on soil

IS: 6403 Code of practice for determination of bearing capacity of shallow foundations

viii) Pile Foundations

The pile foundation shall be of cast-in-situ bored piles as per IS: 2911 or approved international standard (relevant part).

- a) Only RCC piles shall be provided.



- b) Minimum diameter of bored piles generally shall be 450 mm. The allowable load carrying capacity of the pile in vertical compression shall be limited to its structural capacity. The uplift and lateral load capacities shall be restricted to 20% and 5% respectively of the allowable load capacity in vertical compression. However, the pile capacities to be adopted shall be the least of the estimated design values and that obtained from the pile load tests. Maximum permissible lateral deflection at pile head shall be 5.0 mm.
- c) Only straight piles shall be used. Raker piles may be adopted where horizontal load is predominant.
- d) The piling work shall be carried out in accordance with the provisions of IS: 2911 (relevant part) or approved International Standard and approved construction methodology.
- e) The pile shall be tested for vertical, lateral and uplift capacity. The safe load shall be as per IS _ 2911 (Part-IV).

9.1.7.2 Foundation for rotating Equipment

Special foundation requirements for rotating equipment

- i) The foundation systems for rotating equipment shall be sized and proportioned not to exceed the bearing and settlement criteria and to assure satisfactory performance of the equipment. In addition to a static analysis, a dynamic analysis shall be performed to determine the fundamental frequencies of the foundation system. To preclude resonance, the fundamental frequency of the foundation shall be 20 percent removed from the operational frequency of the equipment. The dynamic behavior of the foundation shall meet the requirements of IS: 2974 (part I to IV) – Code of practice for design and construction of machine foundations.
- ii) All rotating equipment shall be provided with rigid foundation system or vibration isolation spring system mounted foundations. The vibration isolation system supplied should be of proven make, consisting of steel helical spring units and viscous dampers (providing damping resistance in all three planes).
- iii) For minor equipments supported on building structures, floors etc. suitable vibration isolation shall be provided.

9.1.8 Underground Structures

9.1.8.1 Loads

In addition to other loads, the following loads shall also be considered for underground structures:-

- i) Earth pressure



Earth pressure for all underground structures shall be calculated using co-efficient of earth pressure at rest, co-efficient of active or passive earth pressure (whichever is applicable).

ii) Ground water pressure

Ground water pressure due to the highest water table at the location shall be considered.

iii) Surcharge load

Minimum surcharge load of 20 kN/m^2 shall be considered for the design of all underground structures located in the vicinity affected by vehicular traffic; including channels, sumps, cable and pipe trenches etc to provide for increase in earth pressure due to vehicular traffic; or else a minimum surcharge load of 5 kN/m^2 should be applied including channels, sumps, cable and pipe trenches etc. to provide for increase in earth pressure due to vehicular traffic.

iv) Hydrostatic load and buoyancy

Hydrostatic load is the load due to water pressure. The design of structures shall include hydrostatic loads when applicable. The buoyancy load is equal to the weight of the volume of displaced water.

9.1.8.2 Design Concepts

- i) RCC water retaining structures like storage tanks shall be designed as uncracked section in accordance with IS:3370 (Part-1 to IV) by working stress method. However, fore-bay, water channels and substructure of pump houses shall be designed as cracked section with limited steel stress as per IS: 3370 (Part 1 to IV) by working stress method.
- ii) For design of all underground structures foundations/ground water table shall be assumed at level emphasized as per soil test report in respect of water table for that area.
- iii) Earth pressure for all underground structures shall be calculated using coefficient of earth pressure at rest. Co-efficient of active or passive earth pressure whichever is applicable depending upon the structural configuration. However, for the design of sub-structure of pump houses, earth pressure at rest shall be considered.
- iv) For design of all underground structures/foundations, ground water tables shall be assumed at the finished ground level unless specified otherwise.
- v) Earth pressure for all underground structures shall be calculated using coefficient of earth pressure at rest, co-efficient of active or passive earth pressure whichever is applicable depending upon the structural configuration. However, for the design of sub structure of pump houses, earth pressure at rest shall be considered.



9.1.8.3 Liquid Retaining/Conveying Structures

- i) All RCC liquid retaining/conveying structures shall be designed as uncracked sections with reduced steel stresses in accordance with IS : 3370.
- ii) All water retaining structures shall be tested for water tightness as per the provisions of IS : 3370 and IS : 6494 and chemical injection grouting to be provided, incase required.

9.1.8.4 Substructures of Pump Houses, channels/tanks and other underground structures containing liquid, the following conditions shall be considered in addition to loading from super structure for design of sub structure.

- i) Water pressure from inside upto full height and no pressure from outside.
- ii) Earth pressure, surcharge pressure and ground water pressure from outside and no water pressure from inside.
- iii) Base slab of pump houses shall also be designed for different combinations of pump sumps being empty during maintenance stages with ground water level at finished ground level.
- iv) All pump houses/sub structures shall be checked for stability against sliding during construction. In case where dead load provides the storing moment, only 0.90 times the characteristics dead load shall be considered. Factor of safety shall not be less than 1.40 under most combinations.
- v) All pump house/sub structures shall be checked for stability against over turning and shall not be less than 1.20 due to dead load.
- vi) Design against uplift due to ground water table at finished level during construction with minimum factor of safety of 1.20 against uplift considering 0.9 times dead load. Inclined wedge action shall be limited to 15 degree. Factor of safety of 1.0 shall be considered for dead weight of structure and earth resting on sides in vertical plane with provisions of pressure relieve valves/flaps valves etc. shall not be permitted to counter the buoyancy. The inclined wedge not considered.

9.1.8.5 Following loading conditions shall be considered, in addition to the loading from super structure for the design of sub structure of pump house, channels, sumps, tanks, trenches, tunnels and other underground structures :

- i) Water pressure from inside and no earth pressure, ground water pressure & surcharge pressure from outside (applicable only to structures which are liable to be filled up with water or any other liquid).
- ii) Earth pressure, surcharge pressure and ground water pressure from outside and no water pressure from inside.



- a) Design shall also be checked against buoyancy due to the ground water during construction and after construction and after construction stages. Minimum factor of safety as per IS : 3370 against buoyancy shall be ensured considering empty condition inside and ignoring the superimposed loadings. For safety against buoyancy, pressure release valves can be provided as per relevant IS code if mixing of ground water with stored water does not affect the system adversely.

Base slab and piers of the pump houses shall also be designed for the condition of different combination of pump sumps being empty during maintenance stages with maximum ground water level.

For structures affected by mobile crane load movement underground structures in Foundation, Tunnels, Trench shall be designed for full mobile crane load or additional surcharge of 5.9 T/m².

Intermediate dividing pier of pump sumps and partition wall (if applicable) in channel shall be designed considering water on one side only and other side being empty for maintenance.

- 9.1.8.6 All pump houses and other substructures (wherever applicable) shall be checked for stability against sliding and overturning during construction as well as operating conditions for various combinations of loads. Factor of safety for these cases shall be taken as mentioned in relevant IS Codes or as stipulated elsewhere in this specification

9.1.9 Overground Structures

- i) The design of steel structures shall be done by working stress method. Design and fabrication shall be as per provisions of IS : 800 and other relevant IS standards. Structural member shall be of minimum 6 mm thickness. For design of coal bins and ash hoppers, IS : 9178 (Part – 1 to III) shall also be followed.
- ii) Welding shall be used for fabrication and joints. For site connections, welding or High Strength Friction Grip (HSFG) bolts shall be used. In few cases for shear connection or removable beam connections, bolted joints with M.S. block bolts may be adopted. For HSFG bolt connection, IS : 4000 shall be followed. IS : 816 and IS : 9595 shall be followed for welding of structures. Welding shall be of minimum 6 mm thickness.
- iii) Trestles supporting coal/ash conveyor galleries shall be so proportioned that the transverse deflection of trestles due to wind/seismic load shall not exceed trestle height/1000 as stipulated in IS : 11592. The crusher and transfer house structures shall be so designed that transverse deflection at places where conveyor galleries meet, should be equal to the respective transverse deflection of conveyor supporting trestles.



- iv) All structures close to railway line shall have clearances conforming to Railway norms.
- v) The following loads are considered for design :
 - a) Density of bottom ash shall be 650 kg/cu.m. for volume calculations.
 - b) Density of bottom ash shall be 1600 kg/cu.m. for load calculations.
 - c) Density of fly ash shall be 750 kg/cu.m. for volume calculations.
 - d) Density of fly ash shall be 1600 kg/cu.m. for load calculations.
 - e) Density of dry fly ash to be considered for design of supporting structures for dry fly ash conveying pipes shall be taken as 1000 kg/cu.m. The pipes shall be considered with dry fly ash.
- vi) The design and construction of RCC structures shall be carried out as per IS : 456. Working stress method shall be adopted for the design wherever specifically mentioned.
- vii) For design and construction of steel-concrete composite members, IS : 11384 shall be followed.
- viii) A minimum clearance (clear head room) of 8 M shall be kept for all road/rail crossing and in other areas as specified elsewhere for all pipe/cable galleries conveyors etc. Before and after the crossings, barrier of suitable height shall be constructed so as to prevent the approach of cranes having height more than 8 M etc. upto the pipe/cable racks.



9.2 SPECIFIC REQUIREMENTS

9.2.1 Coal Handling Plant

i) Track Hopper

The track hopper extends more than 10 m below ground level and has to withstand considerable earth pressure. If the ground water level is high, precautions have to be taken to prevent empty hoppers tendency to float by increasing the dead weight of whole construction or increase the width of base slab and use weight of soil above the projections to counteract the tendency. The beams supporting track over hopper should be as narrow as practicable so that discharge coal from railway wagons is not impeded.

ii) Wagon Tippler Hopper

Wagon Tippler Hopper shall be of RCC underground structure of required length & size as per design. The wagon tippler hopper is designed as per criteria for design of reinforced concrete bins for the storage of granular and powdery materials as per IS : 4995 Part – 1-1974 “General Requirements and Assessment of Bin Loads.” and Part-II , “Design Criteria”.

The wagon tippler and conveyor tunnels shall be provided with adequate slopes and sumps for dewatering. The spacing of sumps shall not exceed 50 meters. The wagon tippler hopper shall be provided with structural steel shed for full length with roof and side cladding with colour coated steel sheeting.

iii) Reclaim Hopper

Reclaim hopper shall consist of RCC hoppers with liners and steel bar grid at top designed for passage of dozer. A structural steel shed above reclaim hopper shall be provided. It is part underground & part over ground structure.

iv) Underground Works

All the conveyor tunnels shall be designed for dozer load of approximately 36 Tons or to withstand movement of crane 150 Ton self weight. Suitable inserts at 3 m intervals shall be embedded in both sides and undersides for supporting cables. Drains of 250 mm depth shall be provided for drainage of tunnels and sump pits at 50 m intervals of 1.5 m deep. The clear head room of 2.5 m shall be provided in tunnels.

v) Transfer Points/Drive House

Transfer points shall be in steel framed construction with pre-coated galvanized steel sheeting above 2 m and brick work below 2 m. Floors of all transfer points shall be in RCC. Independent staircase shall be provided to all transfer points with landing facility at all floors. The underground transfer points shall be completely in RCC construction with brick wall cladding above ground.



vi) Conveyor Tunnels

All conveyor tunnels shall be designed for dozer load of approximately 36 tons or to withstand movement of crane with loads of cranes as per manufacture. Crushers shall be supported on spring and Visco-damper system. Suitable inserts at 3 m intervals shall be embedded in both sides and underside for supporting cables. Drains of 250 mm depth shall be provided for drainage of tunnels and with sump pits at 50 m intervals of 1.5 m depth. The height of tunnels shall not be less than 2.5 m.

All conveyor tunnels shall be designed to withstand the load due to movement of crane having 150 T self wt. at a maximum speed of 5 km/Hr.

vii) Crusher House

The crusher house building shall be provided with number of floors. The building super structure shall be of structural steel frame. All flooring in crusher house shall be of RCC. Crusher equipment foundation shall be in RCC and provided with independent building structure and foundations to avoid transfer of vibrations to crusher house building. The crusher foundations shall be provided with spring and Visco-damper system. Crusher house building shall be provided with brick walls upto 2 m from ground floor and side cladding thereafter. Equipment hatch with removable grating shall be provided. The lift beam shall extend 2 m outside the crusher house for removal of equipment to ground.

viii) General Design Requirements

Bulk density of coal shall be taken as 800 kg/m^3 for capacity calculation and 1050 kg/m^3 for stress on structure for Structural Design. For calculation of coal load on moving conveyor, a multiplication factor of 1.60 shall be used to take care of inertial forces, over burden and impact factor.

For Rail tracks passing over wagon tippler hopper/tunnels/loco having 160 T self weight & with 60 fully loaded wagons having 110 T gross weight of each wagon shall be considered.

ix) Galleries and Trestles

- a) Galleries, trestles, transfer points, buildings shall be designed to withstand wind pressure as per BIS Codes. The conveyor gallery structure & trestles shall be designed considering both conveyors operating simultaneously.
- b) Dynamic analysis of conveyor galleries and conveyor supporting system shall be carried out for spans greater than 25 m.
- c) Permissible deflection for latticed frame work floor beams shall be $\text{span}/325$ minimum clear head room of 2.50 m shall be provided in conveyor galleries, trestle spacing shall not exceed 15 m as far as possible.
- d) The clearance between top of road and bottom of conveyor gallery where crane is likely to pass shall be 8 meters minimum.



- e) 3.15 mm thick seal plate shall be provided where gallery crosses roads/buildings/railway tracks extending additional 5 meters on both sides of crossing.
- f) For all conveyor galleries, a minimum clear gap of 300 mm at top & 150 mm at bottom and side sheeting shall be provided for natural ventilation. The gallery roof shall be pre colour coated.
- g) For natural lighting in conveyor gallery every sixth panel of side sheeting shall be provided with F&P translucent sheets which shall be staggered on opposite sides of gallery.

x) Main switchgear cum Central Control Room

The complete CHP is operated from a building located near crusher house. It shall be RCC building of minimum size 15 m x 25 m. It will house MCC/electrical, battery room and control desk/mimic panel/relay panels. The space for MCC etc. shall be provided with exhaust ventilation system. Central control desk area shall be provided with false ceilings suitable for air conditioning.

Coal yard office & electrical maintenance room shall be provided on first floor with attached toilets & drinking water facilities. Coal yard office shall be air conditioned. All electrical buildings/control room shall have a clear head of 3.50 m (minimum) at all floors.

The Building shall be complete with toilets, drains, plumbing space conditioning for air conditioned area and false ceiling and glass panels.

xi) Wagon Tippler/Track Hopper Control Building

Wagon Tippler/Track Hopper Control Building shall be located in Wagon Tippler/Track House Complex. & will house appropriate electricals such as MCC battery room at ground floor. The control room shall be located at first floor complete with glass panels all round to have full view of rake unloading (i) the building will be of RCC construction with air conditioning space to locate mimic panel weigh bridge control panel & space for operators.(ii) Space for MCC's/Junction Boxes/other electrical equipment etc shall be provided with pressurized ventilation system. (iii) Ventilated Battery room and (iv)Two toilets & drinking water facility

xi) Coal Stock Pile

The angle of repose for coal stock pile is assumed as 37° . The height of stock pile is assumed as 10 m height. Civil & Structural designing tunnels shall be suitable to cater to all loads due to passing of dozer which may weight upto 35 tonnes.



9.2.2 Ash Dyke

- i) The ash dyke in the power plant is constructed with ash and is constructed in stages. The starter dyke around storage pond has a capacity to store ash for five years of plant life. The raising of dyke is done in stages of 3M. effective height increase. The starter dyke is constructed as an earthen embankment with excavated earth from ash pond area and is made strong enough to withstand load from all the future stages as well as the ultimate ash filling. The ultimate capacity of dyke is calculated for 25 years. The height varies depending upon the seismic zones topography, subsoil strata etc. And the top surface of ash is covered with good earth of about 0.3m.
- ii) 50 M. wide green belt is also to be provided all around the ash dyke
- iii) The slurry accumulates within pond till water level reaches the design FRL i.e. 1.5 meter below dyke top in each phase.
- iv) The upstream side slope shall be protected by 115 mm thick brick layer laid over a 50 mm thick sand cushion and 750 μ m thick LDPE lining. Bottom of pond is provided with 300 mm thick sand layer over 500 μ m thick LDPE layer. This layer protects the water entry from ash pond to dyke. The downstream side slope will be protected by 50 mm thick cast-in-situ concrete apron cast in panels of 1.50 m x 1.20 m approximately. A rock toe of 750 mm height using 100 mm – 400 mm thick graded stones laid over 150 mm thick sand graded filter will be provided in the toe. As per MOEF stipulations the liner material can be either natural or synthetic.
- v) Discharge pipe in RCC encasing with PCC bedding shall be laid upto decantation wells. A steel bridge shall be provided over ash dyke upto decantation well and with steel trestle and concrete foundation. Decanted water with low percentage of ash from ash pond shall go to stilling pond by means of RCC collecting circular wells which are provided with vents at various levels, which can be blocked progressively as the level of ash settles in the pond rises. The water from the collecting wells in the stilling ponds is led to the ash water recovery system for further treatment by means of pipes
- vi) Ash Pond Stability Analysis

Seismicity :- The horizontal seismic coefficient is worked out taking 1.50 as Important factor as per IS : 1893 (Table-4).

The dyke is designed as homogeneous section. The soil parameters considered for stability analysis are found as per field investigations from field investigations. The design parameters considered for stability analysis are Unit weight, cohesion, angle of internal friction for ash, bund fill material and Foundation. Top width of dyke is generally kept as 6.0 m Upstream dyke slope is generally kept as 2H :1 V and with no berm Downstream side slope is 2.25H :1V At bottom and a berm of 1.5 m at intermediate level. The slope above berm is of 2H: 1V The upstream side slope is protected by 115 mm thick brick layer laid over a 50 mm thick sand cushion and 750 μ m thick LDPE lining. This layer protects the water entry from ash pond to the dyke. The downstream side slope is protected by 50 mm thick cast-in-situ concrete apron cast in panels of 1.50 m x 1.20 m. A rock toe of 75 mm height using 100 – 400 mm thick graded



stones laid over 150 mm thick sand graded filter is provided in toe. The slope stability analysis of dyke is carried by a suitable slope stability analysis software. FOS
Static- sudden draw down -1.5 seismic- 1.0

- a) The three loading conditions considered for stability analysis are empty stage condition with 10 KN/sq.m. on top width as surcharge and without earthquake forces and with earthquake forces.
 - b) Two stage loading with ash fill of 3 H : 1 vertical with forces/surcharge without earthquake and with earthquake.
 - c) Three stage loading with ash fill and 3 H :1 vertical with two road Berm's with surcharge without earthquake forces and with earthquake forces.
- vii) Supports for ash pipes:
- a) Over ground pipes shall be supported on RCC footing with top of RCC of pedestal at least +500 mm above ground level.
 - b) RCC culvert shall be constructed with culvert top generally not more than +100 mm above road.
 - c) For water body/Nallah suitable structural arrangement with 800 mm wide walkway shall be provided with minimum clearance of 1.50 m above highest flood level.
 - d) Centre to centre distance of pedestals for ash disposal pipes shall be designed on the basis of pipe diameters. Maximum centre to centre distance of supports shall be restricted to 7.0 m.
 - e) Thrust block shall be provided at locations where direction of ash pipe changes

9.2.3 Oil Tank foundations

Tank foundations can be of earth type foundation or concrete ring wall foundation. Pile foundation with raft/pile cap shall be provided where soil conditions are adverse or foundation can subside due to poor soil conditions. For earth foundation, tank is supported over compacted fill of gravel, coarse sand, over which 75 mm minimum compacted crushed stone, screenings/fine gravel, clean sand mixed in Hot Asphalt 8 to 10 percent by volume is laid, rolled & compacted in slope of 1 in 100 from centre of tank as detailed in IS : 803 – 1976.

9.2.4 Raw Water Reservoir

The raw water reservoir shall be provided with HDPE sheet at bottom & sides on a 100 mm thick cushion of sand. The lining shall be protected by 75 mm P.C.C. (M 15) cast-in-situ concrete in panels set on 25 mm thick 1:4 mortar. Side slope of 1:2 is generally provided for raw water reservoir.



9.2.5 Natural Draft Cooling Tower (NDCT)

NDCT shall be of reinforced concrete construction and of hyperbolic shape in vertical section and circular in plan. The analysis and design of NDCT is done considering wind and seismic loads in addition to dead and imposed loads. The effects of temperature & moisture variations are also considered. The cooling tower basin and structure shall be constructed of reinforced cement concrete. The tower basin shall be designed as uncracked section. Each basin is divided in two parts for hydrostatic pressure. All exposed surfaces of concrete viz, inside surface of tower basin, inner surface of shell, fill support beams, columns & bracings, raker column etc which are in contact with moisture/water shall be given three coats of water proof bituminous paint of approved make. All concrete surfaces which are in contact with earth shall be applied with anti corrosive coat system.

As specific requirement, natural draft cooling towers shall be designed for

- 1) Dead load
- 2) Imposed load (including construction loads)
- 3) Wind load
- 4) Earthquake loads
- 5) Thermal loads

ii) Dead Loads

Dead loads shall include the weight of structure complete with finishes, fixtures and partitions and shall be as per IS 875 (Part – 1). Dead loads for NDCT shall include self weight of structure, weight of fill materials, weight due to algae growth, weight of drift eliminator, weight of falling water, weight of hot water pipe, weight of water in hot water channel and distribution system including the self weight of channel and distribution system.

iii) Imposed Loads :-

Imposed loads on various structures shall be as follows :

Basin, sump, duct & underground pipe	Besides earth pressure under dry and wet condition, an additional surcharge of 2.0 T/m ² shall be taken.
Covers for hot water channels HW distribution basin	0.30 T/m ²
Walkway inside CT distribution basin	0.30 T/m ²

iv) Construction Loads

Temporary loadings likely to be imposed during construction shall also be considered in design of CT structures.



v) Wind Load :-

Basic wind speed is taken at 10 m above mean retarding surface as per IS – 875.

Risk coefficients, terrain category, topography factor shall be k_3 as per IS : 875. Wind loading shall be calculated as per gust effective factor (GEF) as well as by peak wind method & analysed for both the cases and designed for the most unfavourable condition & higher of the two values is adopted, while calculating wind load. The term 'b' shall be taken as diameter of the throat in Fig. 10g IS – 875 (Part 3) 1987.

For design of Raker columns, a load enhancement factor of 1.43 shall be applied to wind loading calculated to account for natural turbulence in the incident wind resulting from obstructions and as well as adjacent cooling tower.

The wind pressure distribution around shell shall be calculated as per Cosine Fourier given in Appendix A of IS – 11504. The actual design wind pressure is obtained by multiplying the basic wind pressure (P_z) by coefficient 'p' (as Appendix A) and the wind load enhancement factor 1.43 based on wind tunnel test; the total load enhancement factor will be taken as maximum of

- i) 1.43
- ii) factor as per wind tunnel test 1.10

For tower sizes more than 100 m height & 120 m in base diameter, acro-elastic model testing in wind tunnel shall be done as the wind pressure distribution suggested in Appendix 'A' of IS – 11504 is applicable for towers not more than 100 m in height & 120 m base diameter. The cooling towers in group shall be spaced at clear distance of not less than 0.50 times the base diameter of largest cooling tower in group.

A damping factor of 1% of critical damping shall be considered while analyzing the structure for wind induced ovaling oscillations as well as any dynamic phenomenon involving wind effects.

vi) Earthquake Load

- a) Seismic Zone as per IS : 1893 – 2002 shall be considered for evaluation of seismic forces.
- b) The tower shall be designed with sufficient ductility.
- c) Modern analysis using response spectrum method shall be done for design of tower, raker column/seismic loads.

vii) Temperature Load :

- (a) For temperature loading, the total temperature variation shall be considered as $2/3^{\text{rd}}$ of average maximum annual variation in temperature.



The structure shall be designed to withstand stresses due to 50% of total temperature variation.

- (b) Temperature effects due to solar radiation shall also be considered for one sided solar radiation effect.
- (c) Detailed analysis of actual thermal gradient by considering temperatures inside the tower & outside ambient temperature variation of 3⁰ C to 50⁰ C shall be carried out.. An effective temperature difference of at least 25⁰ C across shell thickness constant over the height and following a sine function along half the circumference shall be considered.

viii) Method of Analysis

The analysis shall be carried out using a finite element modeling software. Design shall be carried out using working stress method as per IS – 11504 and IS : 456.

ix) Foundation of Cooling Towers

- a) Cooling tower shall be provided with suitable foundation & checked for uplift forces considering empty conditions with ground water table at finished ground. A minimum factor of safety of 1.20 against uplift shall be ensured.
- b) Depth of basins shall be fixed to allow for proper flow of water by gravity upto CW.

x) Liquid Retaining Structures

Design of cooling tower basin, sump, outlet channel, HW distribution basin,/HW channel shall be designed as per IS – 3370.

xi) Shell Analysis & Design

- (a) Shell shall be designed as per C1 – 6.3 of IS – 11504 & minimum grade of concrete shall be M-30.
- (b) Bending analysis be carried out for shell using finite element.
- (c) Boundary conditions shall be as outlined in 6.3.1 of IS – 11504.
- (d) Provisions of IS : 2210, IS : 2204 & BS – 4485 shall also be followed.
- (e) Buckling of Tower Shells

Critical dynamic wind pressure & shell buckling shall be checked using dynamic wind pressure. The factor of safety against buckling shall not be less than 5 for completed tower.



- xii) (a) Cooling Tower shall be provided with external RC staircase leading to a heavy duty door giving access to the distribution system. Hand rails on both sides of the staircase shall be applied with anti-corrosive coating system.
- (b) Approved walkways & platforms shall be provided inside the tower for safe and clear access to all sprayers and distribution pipes.
- xii) Codes :
- a) IS : 11504
- b) (BS – 4485 Part 1 to IV) British Standard.
- c) Cooling Tower Institute USA and other international Codes as applicable.

9.2.6 Induced Draft Cooling Tower

IDCT consists of R.C C basin for collection of cold water , it has a de-sledging sump and outlet channel. The floor of the basin shall be sloped 1:500 towards the drain sump. The flow of water shall be controlled with a stop log arrangement.

Raft type foundation shall be provided for columns. For superstructure the beams/slab etc shall be of M25 grade as per IS-456 The civil structures in contact with water shall be designed as per IS : 3370 .Cooling tower cells shall be of RCC Column, beams and walls. Cell division partition wall shall be cast in situ RCC or precast concrete block.. Hot water channel shall be of RCC covered with pre cast/ cast in situ concrete slab. Gear box and fan assembly shall be supported over beam. Dynamic load shall be considered for design of beams supporting fan. One RCC stair case on each side of cooling tower shall be provided at gable end.

9.2.7 Chimney

- i) Design Criteria

The chimney shall be RCC Construction comprising of two nos. steel flues, one for each unit supported from floor at 40 m intervals starting from topmost floor at 6m below the top of chimney the support bracket and bearing assembly shall be bolted to the locally thickened portion of flue on the support platform with arrangement to cater for thermal movement of flue element and enclosed by wind shield of reinforced concrete shell. Internal and external platforms shall be provided not more than 40 m intervals and shall satisfy the requirements of high intensity aviation obstruction lights as per IS 4998/I.C.A.O. regulations, aviation lights are provided at three levels at 1/3, 2/3 and at top.

Lightning protection, down conductors shall be provided as per Clause no.12.2.3 of IS:2309.

For chimney with brick lined flue, the thickness of brick wall is generally 230 mm & internal platforms are provided at 10m interval.



The chimney flues will be of mild steel/ corrosion resistant steel., with mineral wool insulation. Secured by G.I .Chicken wire mesh to insulate whole exterior of the flues.

The design & construction of steel chimney liners shall be based on published report by fossil power committee, power Division, ASCE.

The steel flues are supported from floor at elevation 6M below chimney top and restrained laterally and also at several levels by access/ restrained platforms. Corrosion allowance shall be considered over structural considerations. The chimney roof shall be of reinforced concrete & with provision for water proofing and acid by laying acid resistant tiles in acid resistant mortar.

Provision of chimney ventilation and rack & pinion elevator in the chimney is to be made.

Arrangements shall be provided for flue gas measuring instruments with necessary arrangement of earthing.

Opening in the shell shall be provided for duct work, access door etc. The total plan area of openings at a particular section shall not be more than 15% of plan area of concrete shell at that location. The maximum width of opening shall be limited to an angle of not more than 30 degree subtended at center of concrete shell. The extra reinforcement around opening shall be highest given in

- a) IS _ 4998 (Part 1)
- b) ACI – 307
- c) Reinforced concrete chimney and tower by M.Q. Pinfold. The valve & k1 shall be taken as 0.11 as per data on page No. 186 Minimum half the number of extra horizontal haws in shell around the opening to continue for circle round both faces and both sides.

ii) Materials

All material shall conform to IS Codes. However, the following shall apply :

The flue duct shall be of “COR TEN – B”. Top 10 M length of liner shall be fabricated from stainless steel grade 316 L.

iii) Platform supporting Structure

The floor supporting beams shall take support on shell by making a pocket in the shell and Elastomeric bearings shall be provided below supporting beams. The platforms shall be designed for following loads

1) Dead Load

2) Live load on platforms during operation and maintenance (750 Kg/m²) for chequered plate & 500 Kg/m² for platform supporting beams



3) Construction Loads of 750 Kg/m²

4) Maximum deflection of platform beams shall be L/325. The Beams will be epoxy painted
And as such no corrosion is taken into account

iv) Foundation

Foundation system shall be either bored cast in situ piles with pile cap or raft foundation. Circular cap or Raft shall be provided. Reference shall be made to CICIND Chimney book 2005, Design is based as per working stress method. Foundation will be designed for SRSS of across wind and concurrent along wind response.

v) Platforms

Shall satisfy the requirement of aviation warning lights as per IS : 4988: I.C.A.O regulations & instructions issued by Director General of Civil Aviation. The minimum clear width shall be 1000 mm & minimum live load shall be 500 Kg/m².

At roof level and all platform levels on upper surface 35 mm acid resistant tiles conforming to IS : 4457 over water proofing shall be provided. The average thickness shall be 10mm & shall be sloping outwards.

vi) Roll up Door

A rolling steel chain operated door of 4.0 m x 5.0 m shall be installed at base of shell for trucks could inside as per detail conforming to IS: 6248 “ Metal Rolling Shutters & rolling grids “

vii) Personnel/ Access Doors

A Steel door of size 1000 mm x 2100 mm shall provide access at grade level

viii) Hatch

A mild steel hatch shall be provided as an access to the roof of the chimney. It shall be constructed of two outer sheets not less than 3mm thick mild steel with Steel stiffeners and to withstand Live load of 300 Kg/m². Hatch shall be painted with acid and heat resistant epoxy paint on both sides

ix) Elevator

Chimney Elevator within R.C.C shell with staircase shall be provided for transportation of personnel and equipment

x) Liner Hood /Cap



The Liner hood is fabricated from Cast iron or 10 mm thick stainless steel plate. It covers the annular area packed with insulation material between stainless steel flue cladding to protect insulation from surrounding flue gas environment

xi) Acid Drains & Manholes

Due to condensation within flue, acid drains at base with provision of stainless steel pipes & the acid is lead to manholes which is diluted by flushing system

xii) Chimney Roof & Roof Drainage

The roof is of R.C.C. slab supported on MS beams. Roof is sloped towards rainwater down take pipes for drainage within interior of the shell.

xiii) Flue Support Arrangement

Alternatively, the flue shall be of “Top Hung” type & supported from top. Support bracket and bearing assembly shall be bolted to the locally thickened portion of the flue & in turn support the flue on the support platform. The arrangement shall cater to thermal movement of flue elements.

xiv) Chimney Painting

The entire inside surface of shell for full height with acid & heat resistant black bitumen paint as per IS : 158 to give a point DFT not less than 150 micron. For outside surface, the shell shall be painted top 50 m, with acid and heat resistant paint in alternate bands of signal red and white colour. The remaining portion on the outside surface with synthetic enamel paint in alternative bands of signal red and white colour. The spacing and width of bands shall be as per I.C.A.O. Guidelines.

xv) Platform Supporting Structure

The floor supporting beams shall take support on shell by making a pocket in the shell and elastomeric bearings shall be provided below supporting beams. The platforms shall be designed for following loads

xvi) Flue Ducts

The function of chimney flue duct is to exhaust the combustion gases from the boiler. Flue ducts are designed to protect the chimney shell from high temperature, prenuve and corrosive abrasive properties of the gases & protected from weathering elements by means of aluminum cladding.

Resin bonded mineral coal insulation of density not less than 96 kg/cu.m. shall be laid in two layers composed of 40 mm & 25 mm thickness on external surface of steel flue. The insulation shall be tightly secured to the exterior surface of the liner by impaling them on studs welded to the surface at 450 mm c/c both horizontally & vertically. The studs shall extend minimum 25 mm beyond insulation and provided with circular or square speed washers. 20 gauge



galvanized wire mesh with 25 mm hexagonal pattern conforming to IS : 3150 shall be wrapped around with minimum 150 mm overlap. The mesh is tied in place with 16 gauge GI wire at 300 mm centers.

Insulation for exposed portion of flue at top shall be 150 mm & in 2 to 3 layers with minimum density of 200 kg/cu.m.

The maximum deflection at top is limited to $H/500$ where “H” is the total height above foundation.

The lower values in the range of valves specified in IS-4998 (Part 1) for dynamic modulus of elasticity shall be taken.

The static modulus of elasticity of concrete shall be $5000 \sqrt{f_{ck}}$.

Maximum spacing of reinforcement in shell shall not be more than 250 mm

Vertical bars shall be uniformly spaced.

xvii) Permissible Stresses for Chimney Shell

The stresses in steel reinforcement & concrete shall not exceed limits as per cl. 7.0 of IS : 4998 – 1975. For Dead load + Wind the permissible stress in concrete shall not exceed $0.28 f_{ck}$.

xviii) General Criteria

- 1) The chimney flues will be corrosion resistant steel of type COR TEN B with mineral wool insulation outside.
- 2) The flues shall be sized to give effective nominal gas velocity of 20 m/sec. under design operating conditions. The height of chimney is dependent upon
 - a) Flue gas efflux velocity should be 25m/s.
 - b) Sulphur dioxide content of the flue gas calculated from sulphur content of fuel
 - c) Maximum burning rate of fuel
 - d) Topography of surrounding area
 - e) Height of adjacent buildings
 - f) Size of adjacent buildings.
 - g) The natural draught produced by chimney is dependent upon height of chimney, temperature difference between flue gas & external air.
 - h) Provision to be made for ducts to expand both circumferentially and vertically without producing stress in concrete chimney shell.
 - i) Thickness of flue duct shall be minimum 6 mm.

Internal and external platforms is generally provided at 40 m intervals .Internal platforms will be of structural steel supported over RCC shell. A Structural steel staircase is provided to access platforms.



An opening in windshield at ground level shall be provided for installation of flue with suitable door for access of personnel & trucks. Aviation obstruction lighting for warning aircraft of chimney obstruction shall be provided.

xix) Basis of Design

The reinforced concrete twin flue chimney is designed in accordance with IS-4998(both 1975 & 1992 edition as applicable) and “Criteria for design of Reinforced concrete chimney for reference ACI-307-1979” “specification for design & construction of reinforced concrete chimney” for items not covered in Indian /CICIND Code (International Committee for Industrial Chimneys and stacks).

The chimney shell is modeled as Beam elements made of annular conical sections of appropriate diameter and thickness . Chimney foundation shall be in concrete grade M-25 with minimum cement concrete of 400 kg/cu.m & wind shield shall be grade M-30 with minimum cement content 425 kg/cum. 43 Grade OPC for concrete foundation & shell be used.

xx) Loading and their Combinations

Dead load:- All permanent loads due to weight of chimney shell, internal platforms and lining supported on them, ladders, flue ducts, staircase etc.

Imposed load:-

- (i) Imposed load on service platform around chimney shall be 500 kg/sqm & design live load shall be 750 kg/sq.m during construction / erection.
- (ii) Imposed load from ducts joining the chimney shall be considered .

xxi) Analysis

Calculation of natural frequencies and mode shape shall be carried out. For this purpose chimney shaft is idealized as vertical cantilever with limited masses at different nodes. These nodes shall be provided at each platform. Minimum five modes will be considered.

a) Wind Loads :-

Wind load will be based on IS:4998(Part-I) and 875 (Part3) Dynamic analysis shall be carried out and stability ensured under such conditions.

Along Wind Static Analysis

The basic wind speed ,terrain category, K1 & K2, K3 Values will be as per table 2 of IS:875 (part-3).

The gust factor will be calculated as per code IS:4998,(PartI). Dynamic modulus of elasticity of concrete as recommended in IS.4998(Part1) is used for calculating natural frequencies of chimney, Cd is taken as 0.80 for concrete shell, along wind response of chimney shall be calculated as per gust factor method as in



(A-5.1)& Simplified method as in A-4.10 of IS-4998-Part-1, for design, higher of the along wind loads shall be used.

b) Across Wind

The across wind response of chimney will be evaluated as per section A-4&A-5 of IS-4998(Part-1). CL will be assumed as 0.16 & S=0.20. Higher of the two moments shall be considered for design of chimney .

c) Ring Moments due to Wind

The circumferential ring moments due to wind is calculated as per clause 5.40 of IS:4998(Part 1); The wind induced stresses in concrete and steel shall be calculated as per cl.No D-2.2.7, D-2.2.28 & D-2.2.29 of IS -4998 (Part 1).

xxii) Component Design Criteria

The concrete shell shall be designed as per working stress method as per load combinations. The modular ratio shall be calculated as per Annexure -3 of IS -456

- (a) Dead load
- (b) Dead Load + Wind Load
- (c) Dead load +Earth Quake force
- (d) Dead load +Temperature effects
- (e) Dead load +wind load +Temperature effects
- (f) Dead load + Earth quake+ Temperature effect
- (g) Circumferential stresses due to temperature effects
- (h) Circumferential tensile stresses due to wind inducing ring moment
- (i) Circumferential Compressive stresses due to wind induced ring moment combined with temperature.

In load combination (a) to (i) ,dead load considered shall be with or without the weight of steel lining for flues whichever condition is more critical.

1. Across wind loads shall be combined with co-existing along wind loads. The combined design moment shall be taken as SRSS(Square root of summation of squares) of the moments due to across wind loads and co-existing along wind loads.
2. The concrete shell shall support platforms, the beam supporting the platform shall be made to rest on shell by making a pocket in shell, elastomeric bearing pads are provided below main girders & steel-lead bearing for other beam.
3. Minimum shell thickness is 350 mm at top & 750 mm at junction of shell with foundation junction.
4. The maximum deflection at top is limited to $H/500$ where it is the total weight above foundation.
5. The lower valves in the range of valves specified in IS-4998(Part 1) for dynamic modulus of elasticity shall be taken.



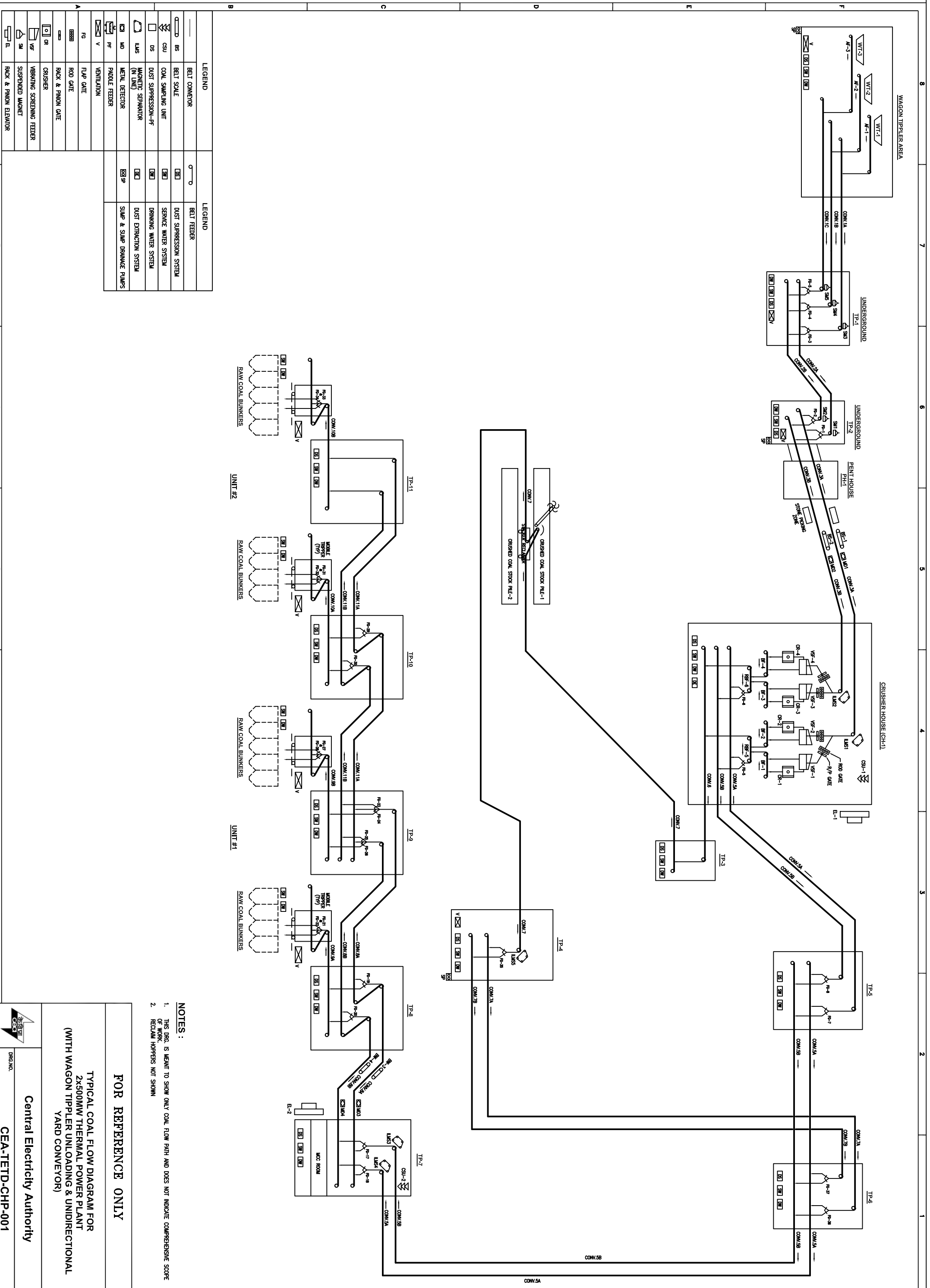
6. The static modulus of elasticity of concrete shall be $5000 \sqrt{f_{ck}}$.
7. Maximum spacing of reinforcement in shell shall not be more than 250 mm.
8. Vertical bars shall be uniformly spaced.

xxiii) Permissible Stresses for Chimney Shell

The stresses in steel reinforcement & concrete shall not exceed limits as per cl. 7.0 & IS: 4998:19H, for dead load + wind the permissible stress in concrete shall not exceed 0.28 .

The chimney flues will be corrosion resistant steel of type COR TEN B with mineral wool insulation.

- c) Reinforced concrete chimney and tower by M.G. Pinfield. The value of K1 shall be taken as 0.11 as per data on page No. 186. Minimum half the number of extra horizontal bars in shell around the opening to continue for circle round both faces and both sides.



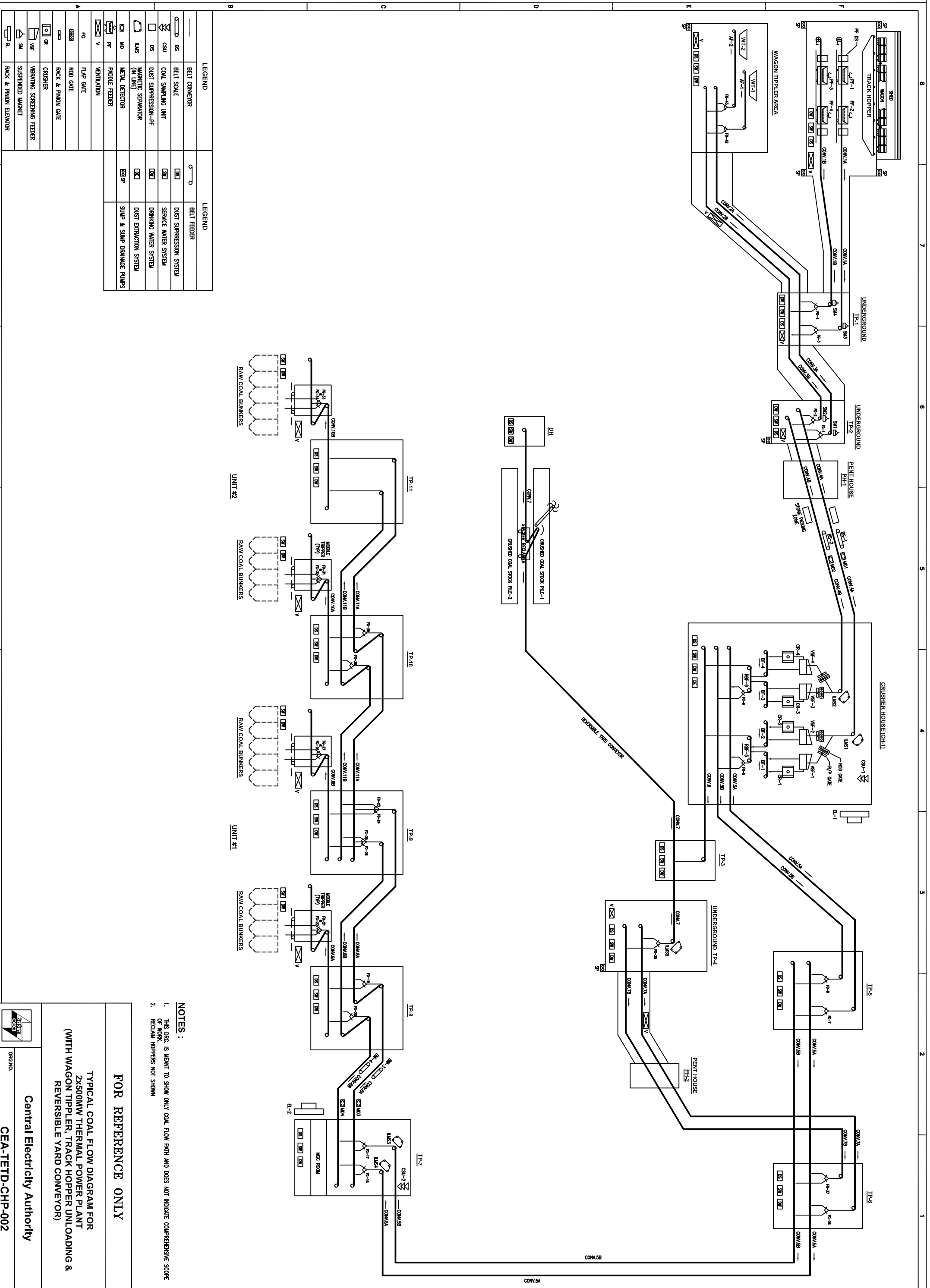
LEGEND		LEGEND	
	BELT CONVEYOR		BELT FEEDER
	BELT SCALE		DUST SUPPRESSION SYSTEM
	COAL SAMPLING UNIT		SERVICE WATER SYSTEM
	DUST SUPPRESSION-PP		DRINKING WATER SYSTEM
	MAGNETIC SEPARATOR (IN LINE)		DUST EXTRACTION SYSTEM
	METAL DETECTOR		SLUMP & SLUMP DRAINAGE PUMPS
	PADDLER FEEDER		
	VENTILATION		
	FLAP GATE		
	ROD GATE		
	RACK & PINION GATE		
	CRUSHER		
	VIBRATING SCREENING FEEDER		
	SUSPENDED MAGNET		
	RACK & PINION ELEVATOR		

NOTES :

1. THIS DRG. IS MEANT TO SHOW ONLY COAL FLOW PATH AND DOES NOT INDICATE COMPREHENSIVE SCOPE OF WORK
2. RECLAIM HOPPERS NOT SHOWN

FOR REFERENCE ONLY

**TYPICAL COAL FLOW DIAGRAM FOR
2x500MW THERMAL POWER PLANT
(WITH WAGON TIPPLER UNLOADING & UNIDIRECTIONAL
YARD CONVEYOR)**



LEGEND		LEGEND	
	BELT CONNECTOR		BELT FEEDER
	BELT SCALE		DUST SUPPRESSION SYSTEM
	COAL SAMPLING UNIT		SERVICE WATER SYSTEM
	DUST SUPPRESSION-PF		DRINKING WATER SYSTEM
	MAGNETIC SEPARATOR (IN LINE)		DUST EXTRACTION SYSTEM
	METAL DETECTOR		SUMP & SUMP DRAINAGE PUMPS
	PALETTE FEEDER		
	VENTILATION		
	FLAP GATE		
	RACK & PINION GATE		
	CRUSHER		
	VIBRATING SCREENING FEEDER		
	SUSPENDED MAGNET		
	RACK & PINION ELEVATOR		

FOR REFERENCE ONLY

TYPICAL COAL FLOW DIAGRAM FOR 2x500MW THERMAL POWER PLANT (WITH WAGON TIPPLER, TRACK HOPPER UNLOADING & REVERSIBLE YARD CONVEYOR)

Central Electricity Authority
CEA-TETD-CHP-002

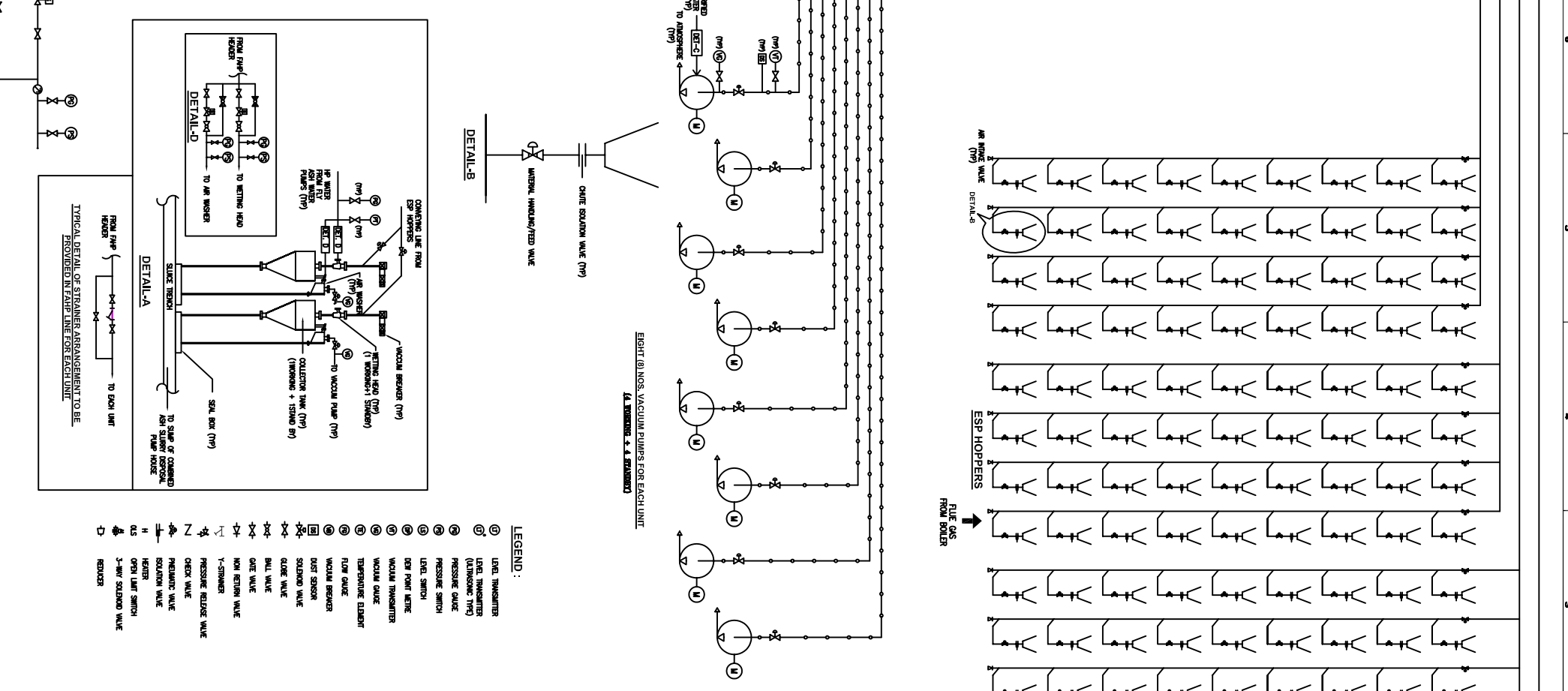
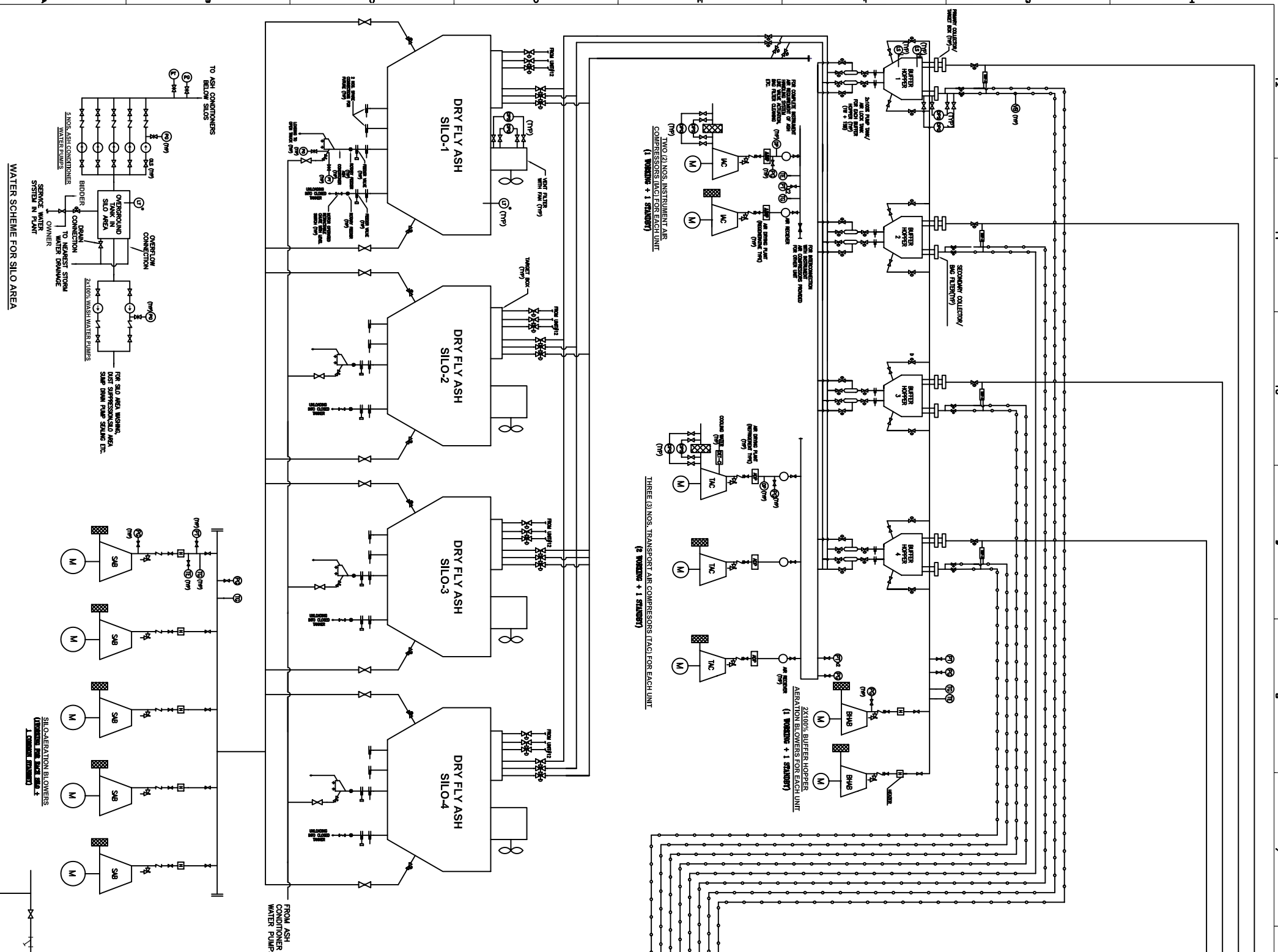
NOTES :

1. THIS DFC IS MEANT TO SHOW ONLY COAL FLOW PATH AND DOES NOT INDICATE COMPREHENSIVE SCOPE OF WORK
2. RECLAIM HOPPERS NOT SHOWN

DRG NO.

DRG NO. CEA-TETD-CHP-002

WATER SCHEME FOR SILO AREA



FOR REFERENCE ONLY

TYPICAL FLOW DIAGRAM FOR ASH HANDLING PLANT-2x500MW COAL BASED THERMAL POWER PLANT (VACUUM SYSTEM)

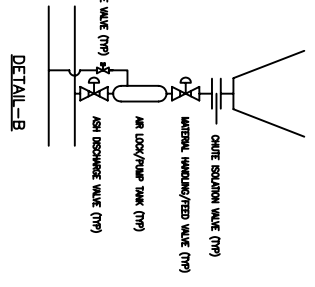
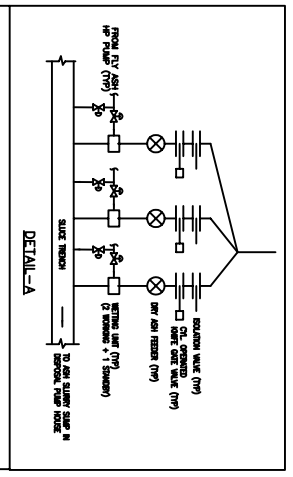
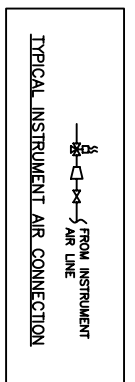
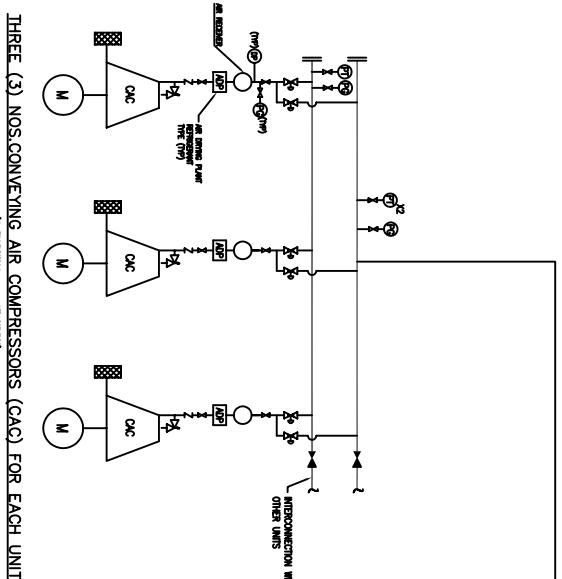
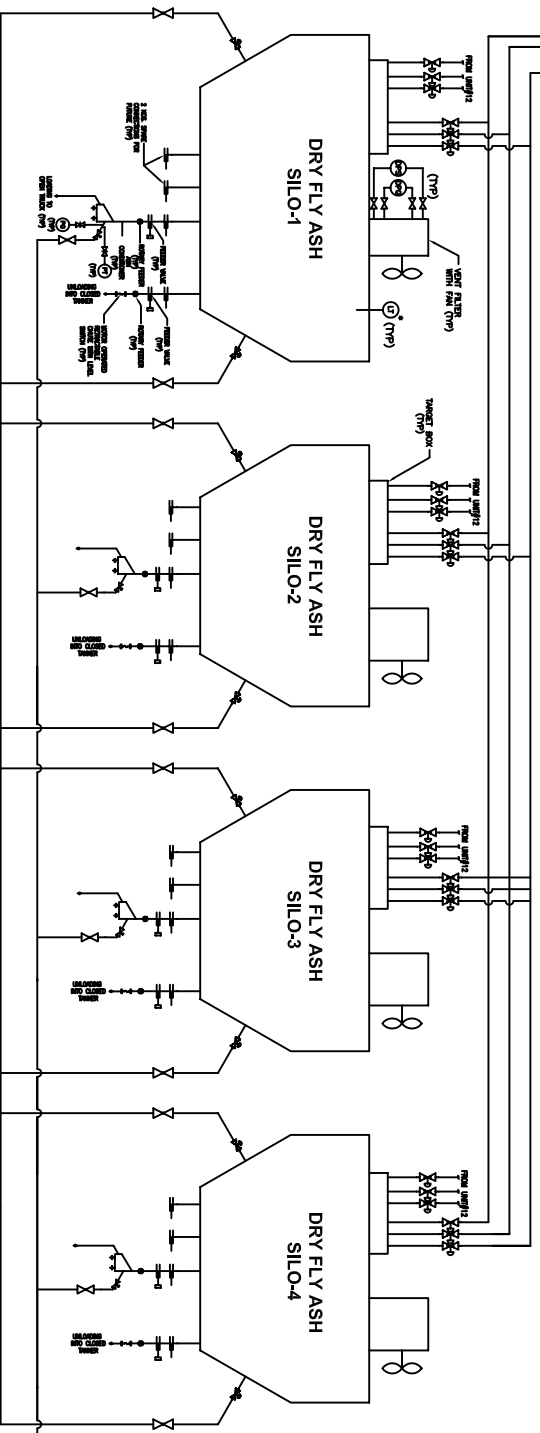
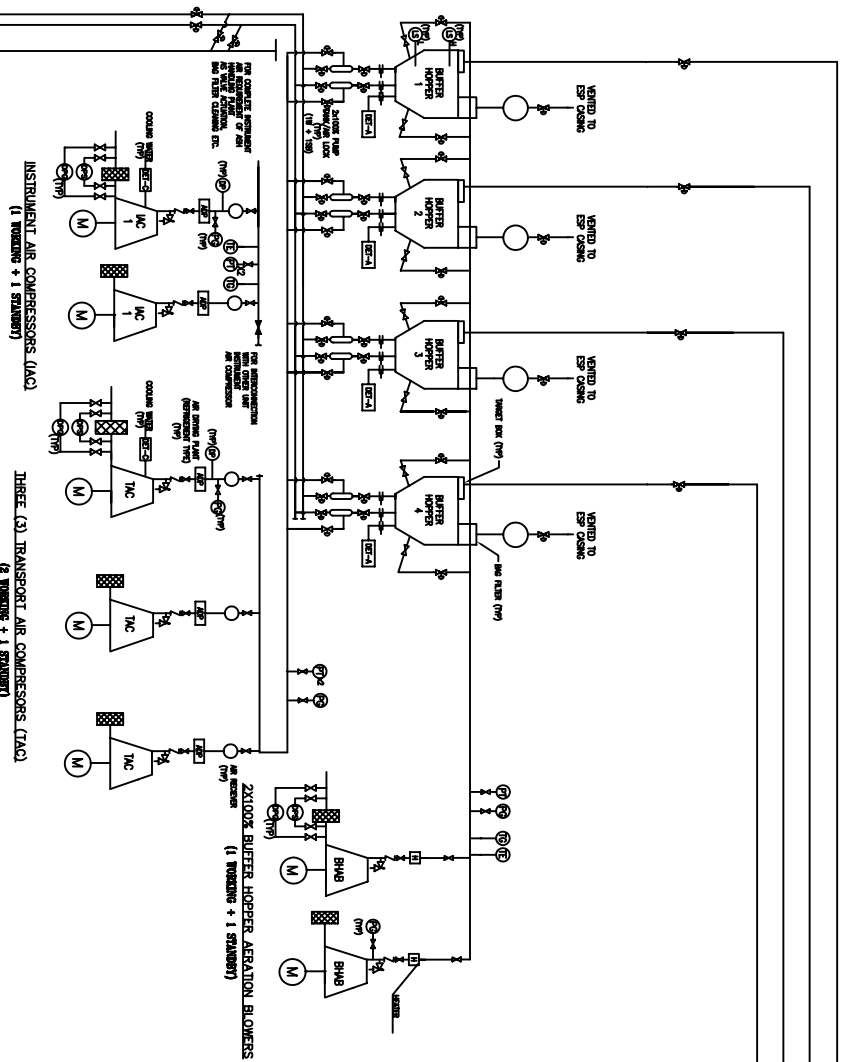
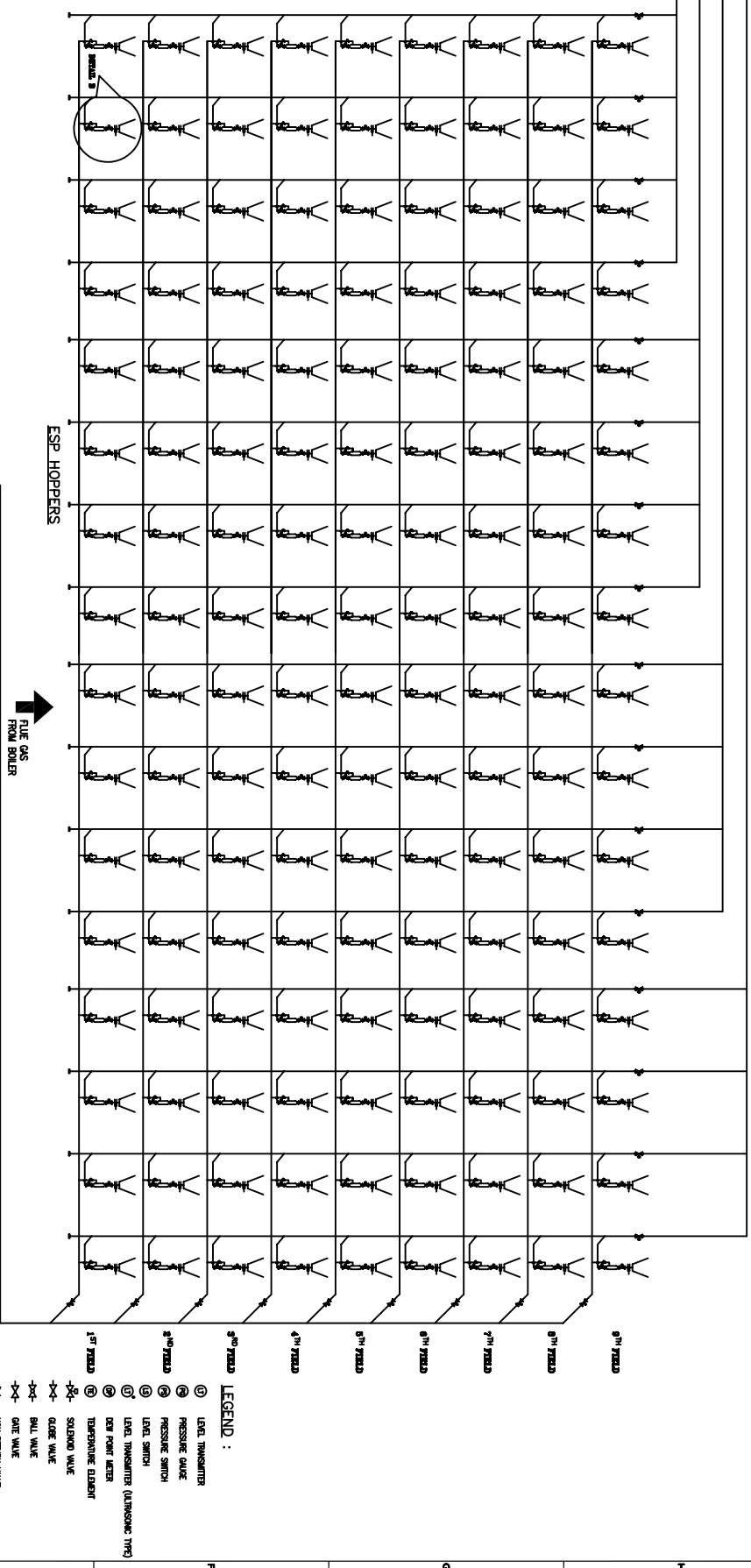
Central Electricity Authority
CEA-TETD-AHP-001

LEGEND:

- ① LEVEL TRANSMITTER
- ② LEVEL TRANSMITTER (ULTRASONIC TYPE)
- ③ PRESSURE GAUGE
- ④ PRESSURE GAUGE
- ⑤ LABEL SWITCH
- ⑥ KEYS POINT LABEL
- ⑦ VACUUM TRANSMITTER
- ⑧ VACUUM GAUGE
- ⑨ TEMPERATURE ELEMENT
- ⑩ FLOW GAUGE
- ⑪ VACUUM BREAKER
- ⑫ DATE SENSOR
- ⑬ SOLID VALVE
- ⑭ SLIDE VALVE
- ⑮ CHECK VALVE
- ⑯ NON RETURN VALVE
- ⑰ PRESSURE RELIEF VALVE
- ⑱ CHECK VALVE
- ⑲ PRESSURE RELIEF VALVE
- ⑳ PREHEAT VALVE
- ㉑ SOLID VALVE
- ㉒ OPEN LIMIT SWITCH
- ㉓ 5-AMP SOLID VALVE
- ㉔ REMOVER

NOTES:

1. FLY ASH CONDUIT SYSTEM FOR ESP HOPPERS SHOWN IS FOR ONE UNIT ONLY AND THE SAME SHALL BE IDENTICAL FOR OTHER UNIT.
2. VACUUM TRANSMITTER HOPPER REMOVER ARRANGEMENT AND COMPRESSOR, TRANSPORT AIR COMPRESSORS SHOWN ARE TYPICAL FOR EACH UNIT.
3. NO. OF ESP FEELS SHOWN IS INDICATIVE ONLY WITH VARYING DESIGN.
4. INSTRUMENT AIR PIPING IS NOT SHOWN IN THE DIAG. IT SHALL BE ADAPTED TO VARIOUS VALUES, BRANCHED ETC. IN FLY ASH HANDLING SYSTEM AS PER SYSTEM DESIGN AND REQUIREMENTS.
5. OTHER FACILITIES IN SILO AREA SUCH AS SLURRY DRAINAGE PIPING ETC. ARE NOT SHOWN IN THE SCHEME AND SHALL BE PROVIDED AS PER TENDR SPEC. REQUIREMENTS.
6. EACH INSTRUMENT AIR COMPRESSOR SHALL BE PROVIDED WITH INDEPENDENT AIR DRAINING PLANT AND AIR RECEIVER.
7. a) EACH TRANSPORT AIR COMPRESSOR SHALL BE PROVIDED WITH INDEPENDENT AIR DRAINING PLANT (REPRESSURE TANK) AND AIR RECEIVER. b) EACH TRANSPORT AIR COMPRESSOR SHALL BE PROVIDED WITH INDEPENDENT AIR DRAINING PLANT AND AIR RECEIVER.
8. EACH SILO REMOVER AND REMOVER HOPPER REMOVER BLOWERS SHALL BE PROVIDED WITH INDEPENDENT AIR REMOVERS AND ACCESSORIES.
9. HOT AIR LINE FROM DISCHARGE OF HOPPER OF BATTERY HOPPER REMOVER BLOWER (LTD) BATTERY HOPPER & FROM REMOVER OF SILO REMOVER BLOWER (LTD) SILOS SHALL BE PROVIDED INSULATED. INSULATION TO BE PROVIDED BELOW SILO FOR RAIL CONDUIT/TRENCH.
10. COOLING OF WINDUP EXHAUSTORS SHALL BE MET BY COOLING WATER SUPPLY PROVIDED AT REMOVER'S TERMINAL POINT. WATER HEADERS CONNECTIONS FOR SUPPLY OF COOLING WATER & RETURN OF HOT WATER SHALL BE PROVIDED BY THE OWNER AT THE REMOVER'S SUPPLY & RETURN POINTS (FOR REMOVER NECESSARY WATER CONNECTION BY THE BLOWER WITH FOLLOWING PARAMETERS):
11. WET HEADERS PRESSURE OF WATER : 2.25kg/cm²
12. QUALITY TEMP. : 45°C (MAX)
13. WAT. PRESSURE DROP ALLOWED IN COOLING CIRCUIT (BETWEEN SUPPLY AND RETURN) : 1.5kg/cm²
14. BATTERY SILO REMOVER AND BATTERY HOPPER REMOVER BLOWERS SHALL BE AIR COOLED.
15. AIR COOLING PRESSURE DROPS AND AIR FLOW PRESSURE DROPS ARE TO BE PROVIDED.
16. ALL DEVICES REQUIRED INSTRUMENT AIR SHALL BE PROVIDED WITH MANUAL ISOLATION VALVE IN LINE. THIS IS APPLICABLE FOR SHINE (SH) WINDUP STRIPPER.
17. AIR COMPRESSORS ARE TO BE PROVIDED FOR MANUAL VALVES AS PER SYSTEM REQUIREMENT.
18. AIR COMPRESSORS ARE TO BE PROVIDED FOR MANUAL VALVES AS PER SYSTEM REQUIREMENT.
19. REMOVER SHALL BE PROVIDED IN PAIR BRANCH LINE TO EACH UNIT FOR PROTECTING COOLING OF REMOVER HEAD WINDUPS AND AIR REMOVER WINDUPS (TYPICAL DESIGN PROVIDED) ONLY. THIS SHALL BE PROVIDED ACROSS STRIPPER.

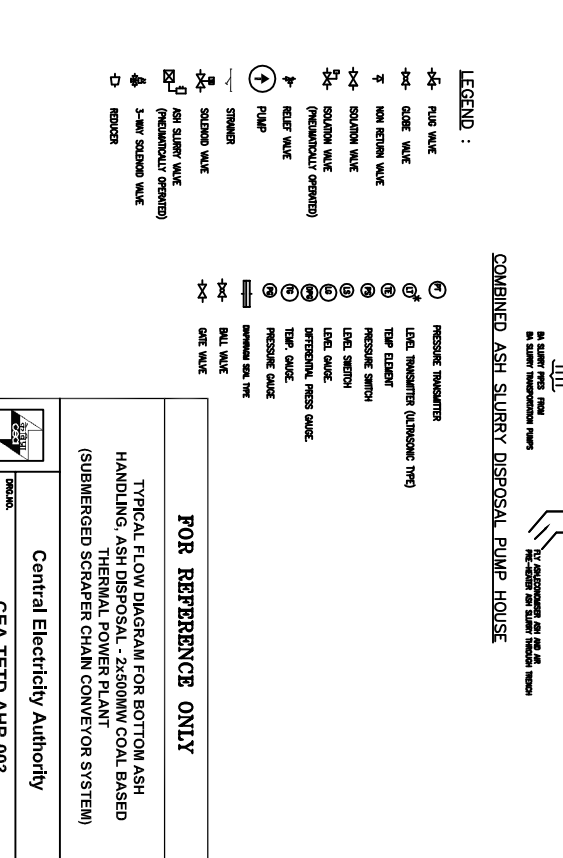
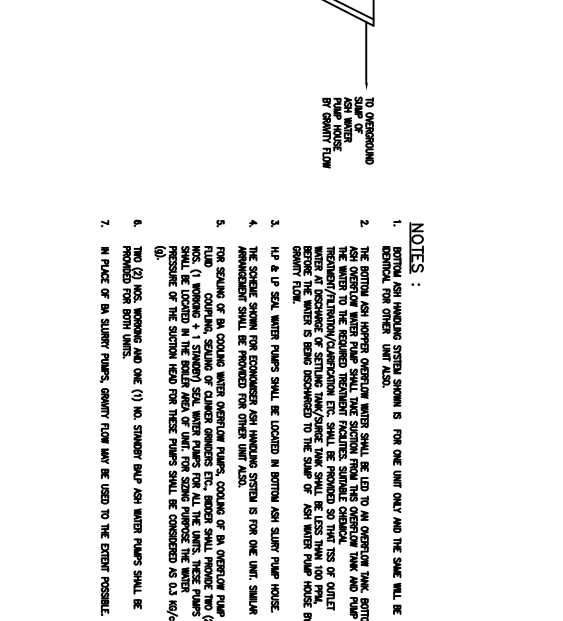
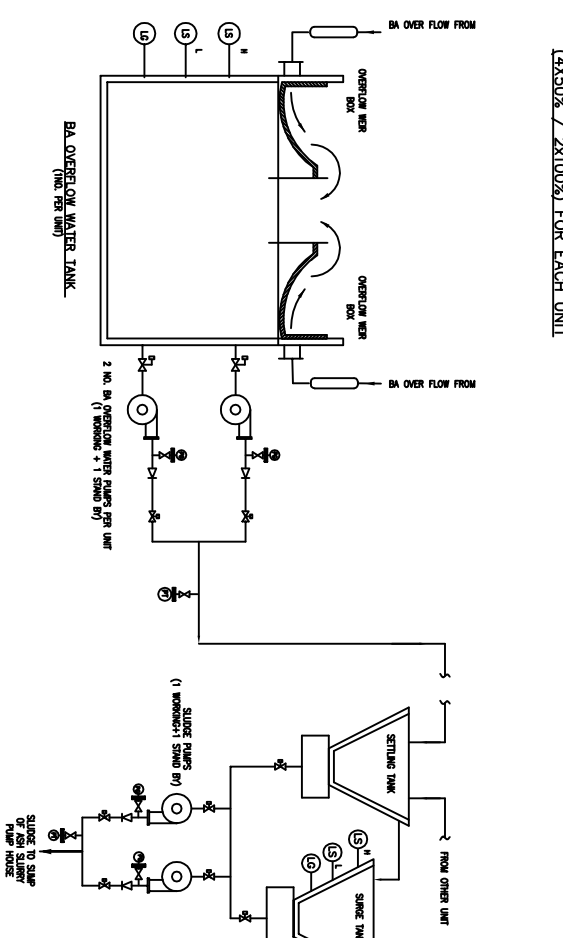
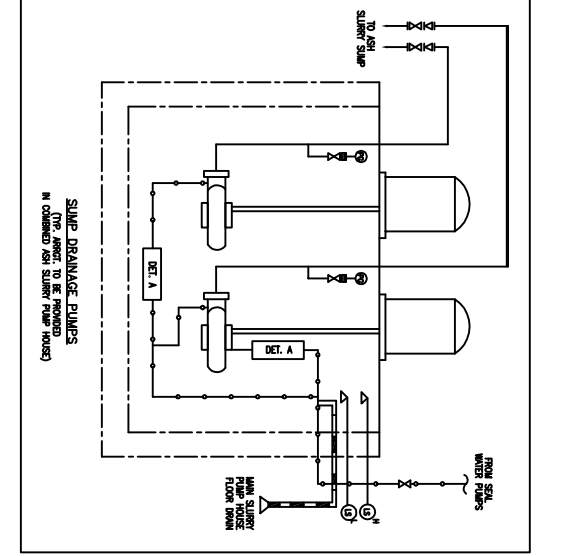
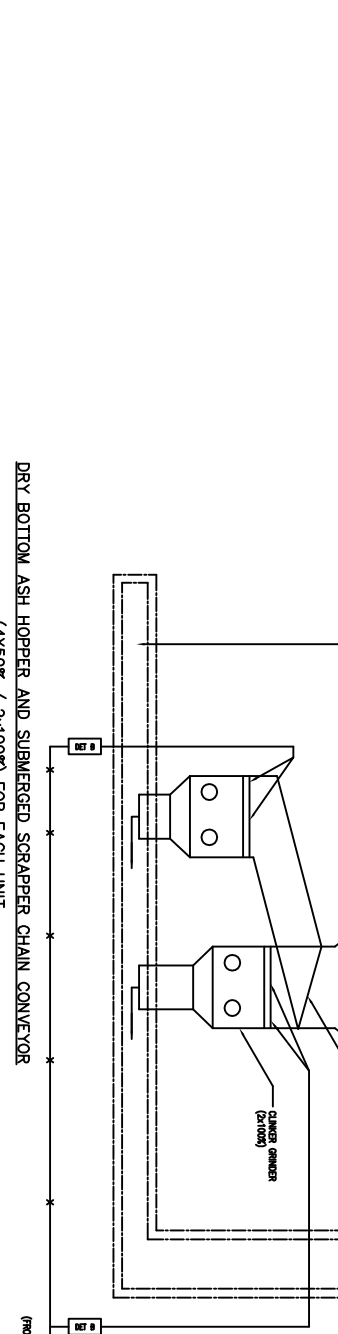
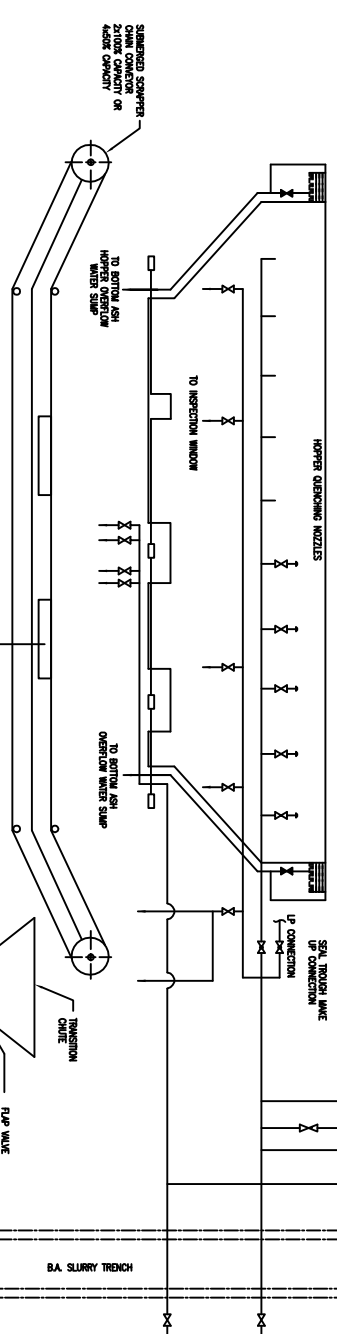
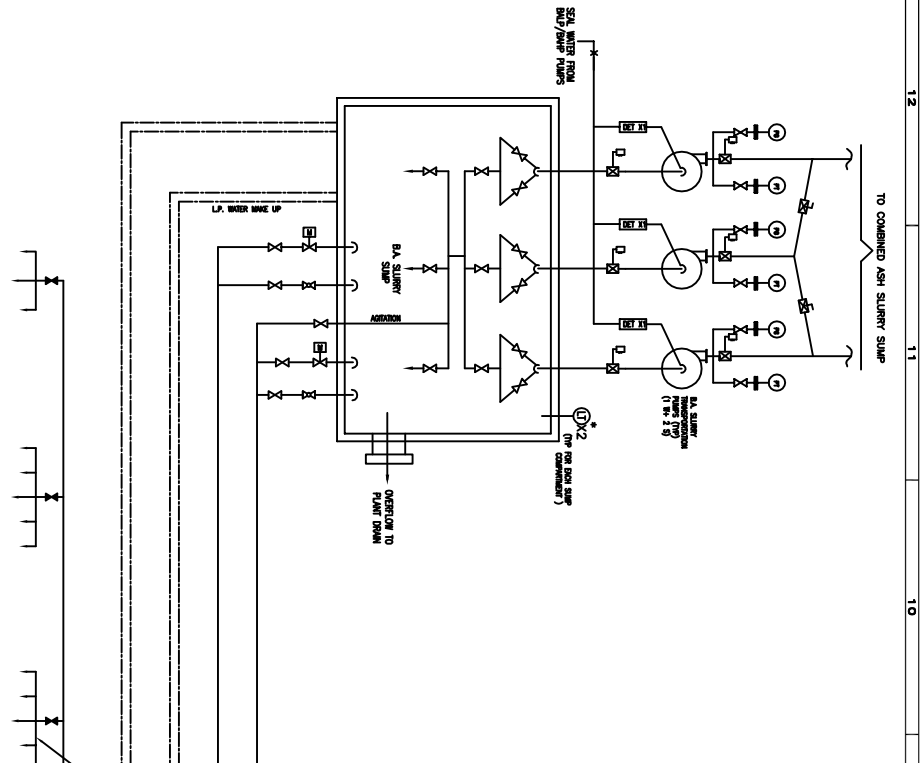
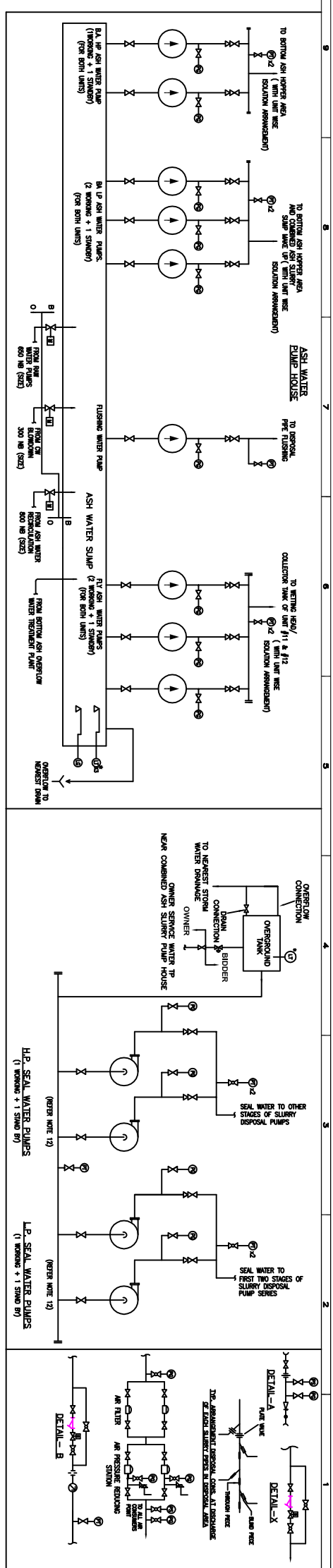


- NOTES :**
1. FLY ASH CONVEYING SYSTEM FOR ESP HOPPERS SHOWN IS FOR ONE UNIT ONLY AND THE SAME SHALL BE IDENTICAL FOR OTHER UNIT.
 2. NO. OF ESP FIELDS IS INDICATIVE, MAY VARY WITH ESP DESIGN.
 3. INSTRUMENT AIR PIPING IS NOT SHOWN IN THE DIAGRAM. IT SHALL BE PROVIDED TO DIFFERENTIAL VALVES, BLENDED ETC. IN FLY ASH HANDLING SYSTEM AS PER SYSTEM DESIGN AND REQUIREMENTS.
 4. EACH INSTRUMENT AIR COMPRESSOR SHALL BE PROVIDED WITH INDEPENDENT AIR DRIVING PLANT AND AIR RECEIVER.
 5. EACH TRANSPORT AIR COMPRESSOR & CAC SHALL BE PROVIDED WITH INDEPENDENT AIR DRIVING PLANT (GENERATOR/TURBO) AND AIR RECEIVER.
 6. EACH OF SOLID ASHLINE BLOWERS & BATTERY HOPPER ASHLINE BLOWERS SHALL BE PROVIDED WITH INDEPENDENT AIR RECEIVERS AND ACCESSORIES.
 7. NOT AIR LINE FROM RECEIVERS OF BATTERY HOPPER ASHLINE BLOWERS UP TO BATTERY HOPPER & FROM RECEIVERS OF SOLID ASHLINE BLOWERS UP TO SOLID LINE BLOWERS/RECEIVERS. THE SOLID LINE HANDLING SYSTEM SHALL BE PROVIDED FOR BOTH THE WORKING AND OTHER (STANDBY) UNITS/BLINDS.
 8. COOLING OF WINDING EQUIPMENTS SHALL BE MET BY COOLING WATER SUPPLY PROVIDED AT WORKERS'S TERMINAL. THE WINDING COMPRESSORS FOR SUPPLY OF COOLING WATER SHALL BE PROVIDED WITH INDEPENDENT WATER RECEIVERS (FOR FURTHER NECESSARY WATER CONNECTION BY THE BIDDERS) WITH FOLLOWING PARAMETERS :
 INLET HEADS PRESSURE OF WATER : 2.5kg/cm²
 FLOW RATE : 300 LPM
 MILET TEMP. : 30°C
 WAT. PRESSURE DROP ALLOWED IN COOLING CIRCUIT (4 BETWEEN SUPPLY AND RETURN) : 1.5kg/cm²
 9. BOTH SOLID ASHLINE AND BATTERY HOPPER ASHLINE BLOWERS SHALL BE AIR COOLED.
 10. OPERATIONAL, PRESSURE GAUGES AND INSTRUMENT, PRESSURE GAUGES ARE TO BE PROVIDED ACROSS EACH END OF INSTRUMENT AIR LINE FOR EACH UNIT.
 11. ALL BATTERY HOPPER ASHLINE AIR SHALL BE PROVIDED WITH MANUAL ISOLATION VALVE IN A LINE. THIS IS APPLICABLE FOR BATTERY HOPPER ASHLINE SYSTEM.
 12. INSTRUMENT AIR LINE SHALL BE PROVIDED FOR MANUAL VALVES AS PER SYSTEM REQUIREMENT & CONTROL PRESSURE.
 13. SHOWER SHALL BE PROVIDED IN FAHP MAIN LINE TO EACH LINE FOR PROTECTING OPERATOR OF WINDING HEAD RECEIVERS AND AIR WINDING RECEIVERS (TYPICAL DETAIL INDICATED). 10% DPG SHALL BE PROVIDED ACROSS SHOWER.

FOR REFERENCE ONLY

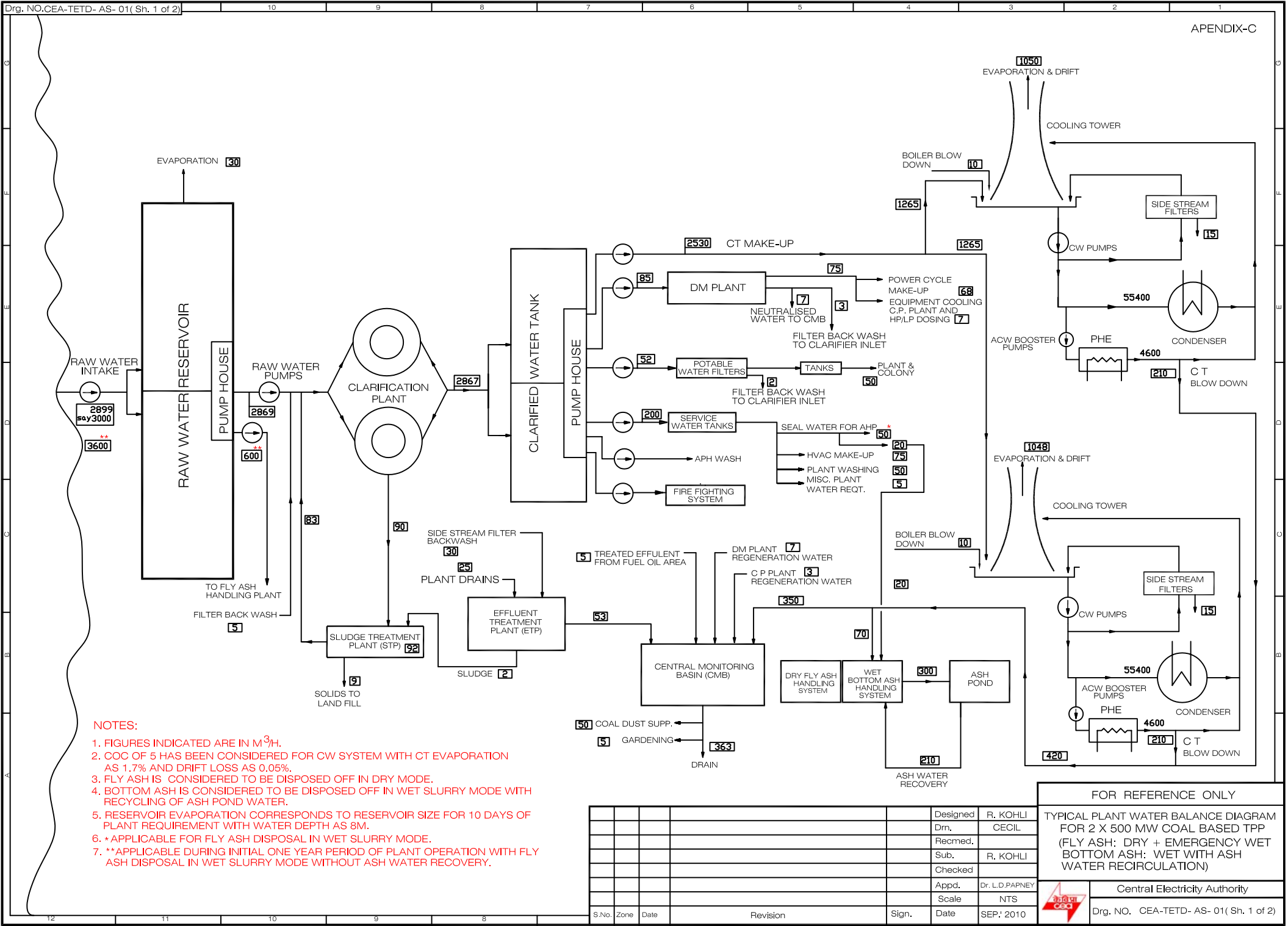
TYPICAL FLOW DIAGRAM FOR ASH HANDLING PLANT-2x500MW COAL BASED THERMAL POWER PLANT (PRESSURE SYSTEM)

Central Electricity Authority



- NOTES:**
1. BOTTOM ASH HANDLING SYSTEM SHOWN IS FOR ONE UNIT ONLY AND THE SAME WILL BE IDENTICAL FOR OTHER UNIT ALSO.
 2. THE BOTTOM ASH HOPPER OVERFLOW WATER SHALL BE LED TO AN OVERFLOW TANK BOTTOM OF THE HOPPER. THE OVERFLOW WATER SHALL BE PUMPED TO THE REQUIRED TREATMENT FACILITIES. STRAIGHT CHANNELS, BENDS, VALVES, ETC. SHALL BE PROVIDED SO THAT 10% OF OUTPUT BEFORE THE WATER IS BEING DISCHARGED TO THE SHAP OF ASH WATER PUMP HOUSE BY GRAVITY FLOW.
 3. H.P. & L.P. SEAL WATER PUMPS SHALL BE LOCATED IN BOTTOM ASH SLURRY PUMP HOUSE.
 4. THE SCHEME SHOWN FOR ECONOMIZER ASH HANDLING SYSTEM IS FOR ONE UNIT. SIMILAR ARRANGEMENT SHALL BE PROVIDED FOR OTHER UNIT ALSO.
 5. FOR SEALING OF BA COOLING WATER OVERFLOW PUMPS, COOLING OF BA OVERFLOW PUMP TANK (1 WORKING + 1 STAND BY) SEAL WATER PUMPS FOR ALL THE UNITS. THESE PUMPS SHALL BE PROVIDED FOR THE BOTTOM ASH HOPPER FOR THESE PUMPS SHALL BE PROVIDED AS 0.3 m³/min (a).
 6. TWO (2) NOS. WORKING AND ONE (1) NO. STANDBY SHAP ASH WATER PUMPS SHALL BE PROVIDED FOR BOTH UNITS.
 7. IN PLACE OF BA SLURRY PUMPS, GRAVITY FLOW MAY BE USED TO THE EXTENT POSSIBLE.
- LEGEND:**
- FLUID VALVE
 - GLOBE VALVE
 - NON RETURN VALVE
 - SOLUTION VALVE
 - (PREMOUNTEDLY ORIENTED)
 - RELIEF VALVE
 - PUMP
 - SHOWER
 - SOLID VALVE
 - (PREMOUNTEDLY ORIENTED)
 - ASH SLURRY VALVE
 - OVERFLOW SEAL TANK
 - PRESSURE GAUGE
 - TEMP. GAUGE
 - DIFFERENTIAL PRESS. GAUGE
 - OVERFLOW SEAL TANK
 - BALL VALVE
 - GATE VALVE
 - PRESSURE TRANSDUCERS
 - LEVEL TRANSDUCER (AUTOMATIC TYPE)
 - TEMP. GAUGE
 - TEMP. SWITCH
 - SOLUTION VALVE
 - LEVEL SWITCH
 - DIFFERENTIAL PRESS. GAUGE
 - TEMP. GAUGE
 - OVERFLOW SEAL TANK
 - BALL VALVE
 - GATE VALVE
- FOR REFERENCE ONLY**
- TYPICAL FLOW DIAGRAM FOR BOTTOM ASH HANDLING, ASH DISPOSAL - 25500MW COAL BASED THERMAL POWER PLANT (SUBMERGED SCRAPER CHAIN CONVEYOR SYSTEM)

DO NOT SCALE, IF IN DOUBT PLEASE ASK



NOTES:

1. FIGURES INDICATED ARE IN M³/H.
2. COC OF 5 HAS BEEN CONSIDERED FOR CW SYSTEM WITH CT EVAPORATION AS 1.7% AND DRIFT LOSS AS 0.05%.
3. FLY ASH IS CONSIDERED TO BE DISPOSED OFF IN DRY MODE.
4. BOTTOM ASH IS CONSIDERED TO BE DISPOSED OFF IN WET SLURRY MODE WITH RECYCLING OF ASH POND WATER.
5. RESERVOIR EVAPORATION CORRESPONDS TO RESERVOIR SIZE FOR 10 DAYS OF PLANT REQUIREMENT WITH WATER DEPTH AS 8M.
6. * APPLICABLE FOR FLY ASH DISPOSAL IN WET SLURRY MODE.
7. **APPLICABLE DURING INITIAL ONE YEAR PERIOD OF PLANT OPERATION WITH FLY ASH DISPOSAL IN WET SLURRY MODE WITHOUT ASH WATER RECOVERY.

Designed	R. KOHLI
Drn.	CECIL
Recmed.	
Sub.	R. KOHLI
Checked	
Appd.	Dr. L.D.PAPNEY
Scale	NTS
Sign.	
Date	SEP, 2010

FOR REFERENCE ONLY

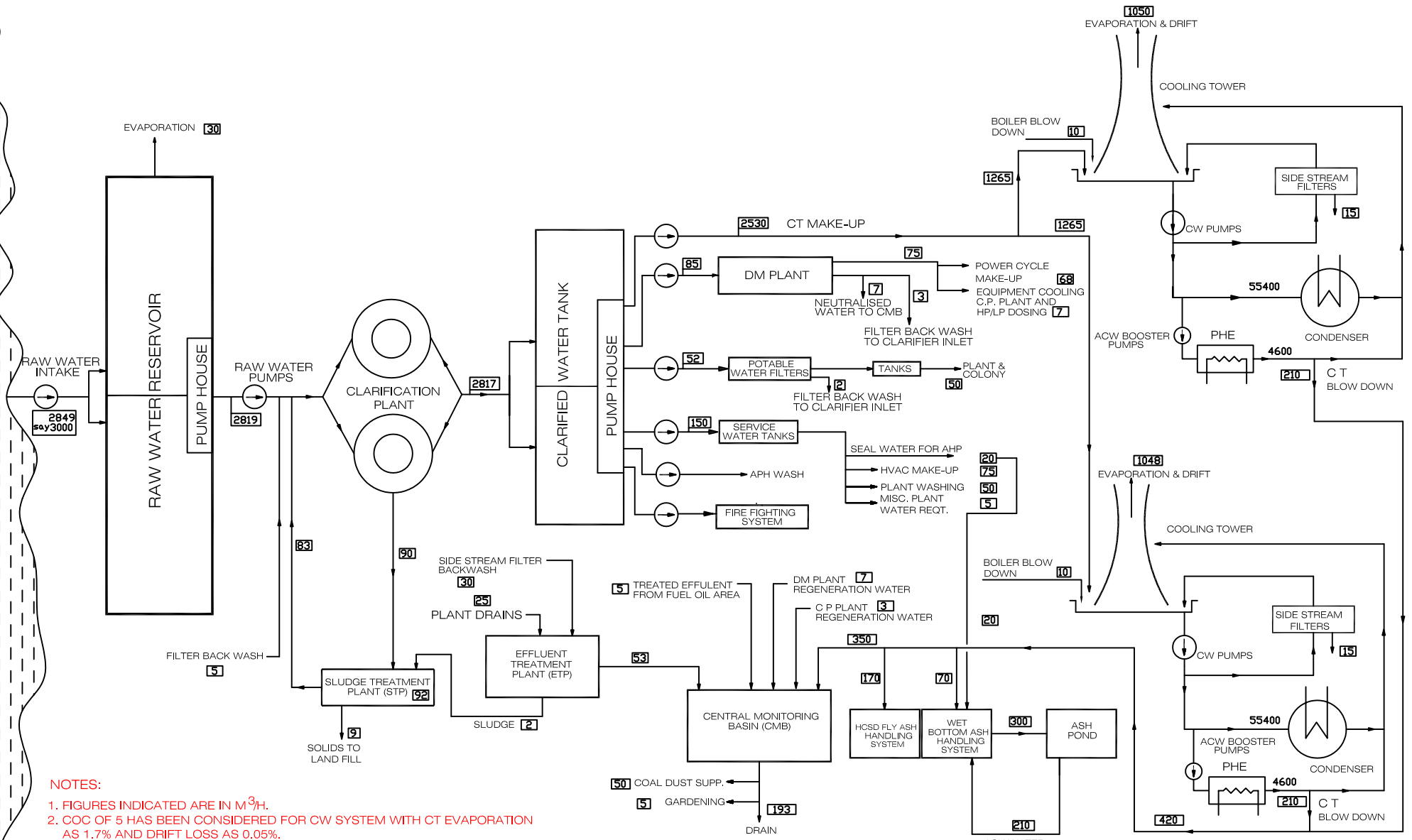
TYPICAL PLANT WATER BALANCE DIAGRAM FOR 2 X 500 MW COAL BASED TPP (FLY ASH: DRY + EMERGENCY WET BOTTOM ASH: WET WITH ASH WATER RECIRCULATION)

Central Electricity Authority

Drg. NO. CEA-TETD- AS- 01(Sh. 1 of 2)

S.No.	Zone	Date	Revision	Sign.	Date

DO NOT SCALE, IF IN DOUBT PLEASE ASK



- NOTES:**
1. FIGURES INDICATED ARE IN M³H.
 2. COC OF 5 HAS BEEN CONSIDERED FOR CW SYSTEM WITH CT EVAPORATION AS 1.7% AND DRIFT LOSS AS 0.05%.
 3. FLY ASH IS CONSIDERED TO BE DISPOSED OFF IN DRY MODE.
 4. BOTTOM ASH IS CONSIDERED TO BE DISPOSED OFF IN WET SLURRY MODE WITH RECYCLING OF ASH POND WATER.
 5. RESERVOIR EVAPORATION CORRESPONDS TO RESERVOIR SIZE FOR 10 DAYS OF PLANT REQUIREMENT WITH WATER DEPTH AS 8M.

				Designed	R. KOHLI
				Drn.	CECIL
				Recmed.	
				Sub.	
				Checked	R. KOHLI
				Appd.	Dr. L.D.PAPNEY
				Scale	NTS
S.No.	Zone	Date	Revision	Sign.	Date
					SEP,' 2010

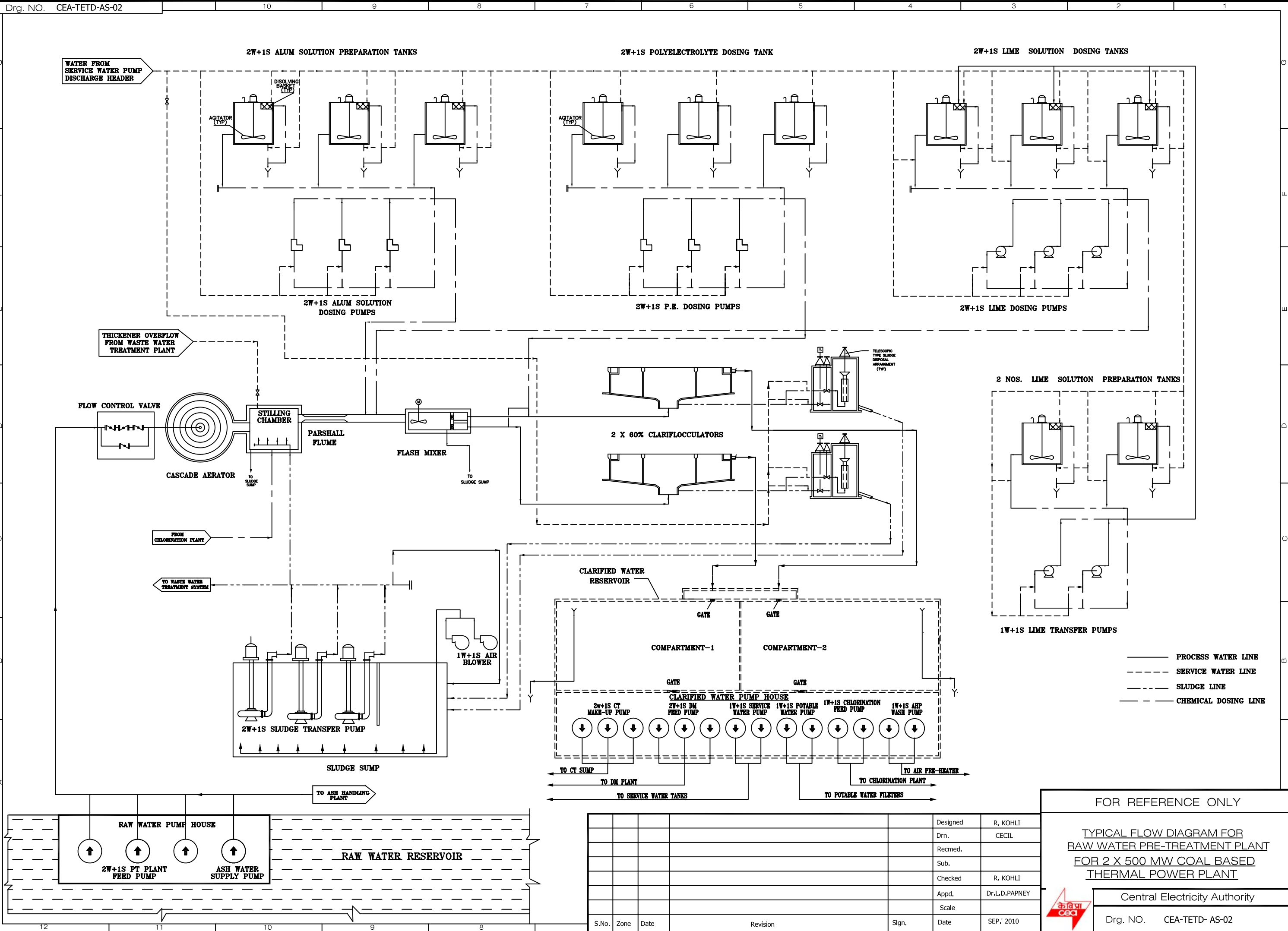
FOR REFERENCE ONLY

TYPICAL PLANT WATER BALANCE DIAGRAM
FOR 2 X 500 MW COAL BASED TPP
(FLY ASH: HCSD
BOTTOM ASH: WET WITH ASH
WATER RECIRCULATION)

Central Electricity Authority

Drg. NO. CEA-TETD- AS- 01(Sh. 2 of 2)

DO NOT SCALE, IF IN DOUBT PLEASE ASK



FOR REFERENCE ONLY

TYPICAL FLOW DIAGRAM FOR
RAW WATER PRE-TREATMENT PLANT
FOR 2 X 500 MW COAL BASED
THERMAL POWER PLANT

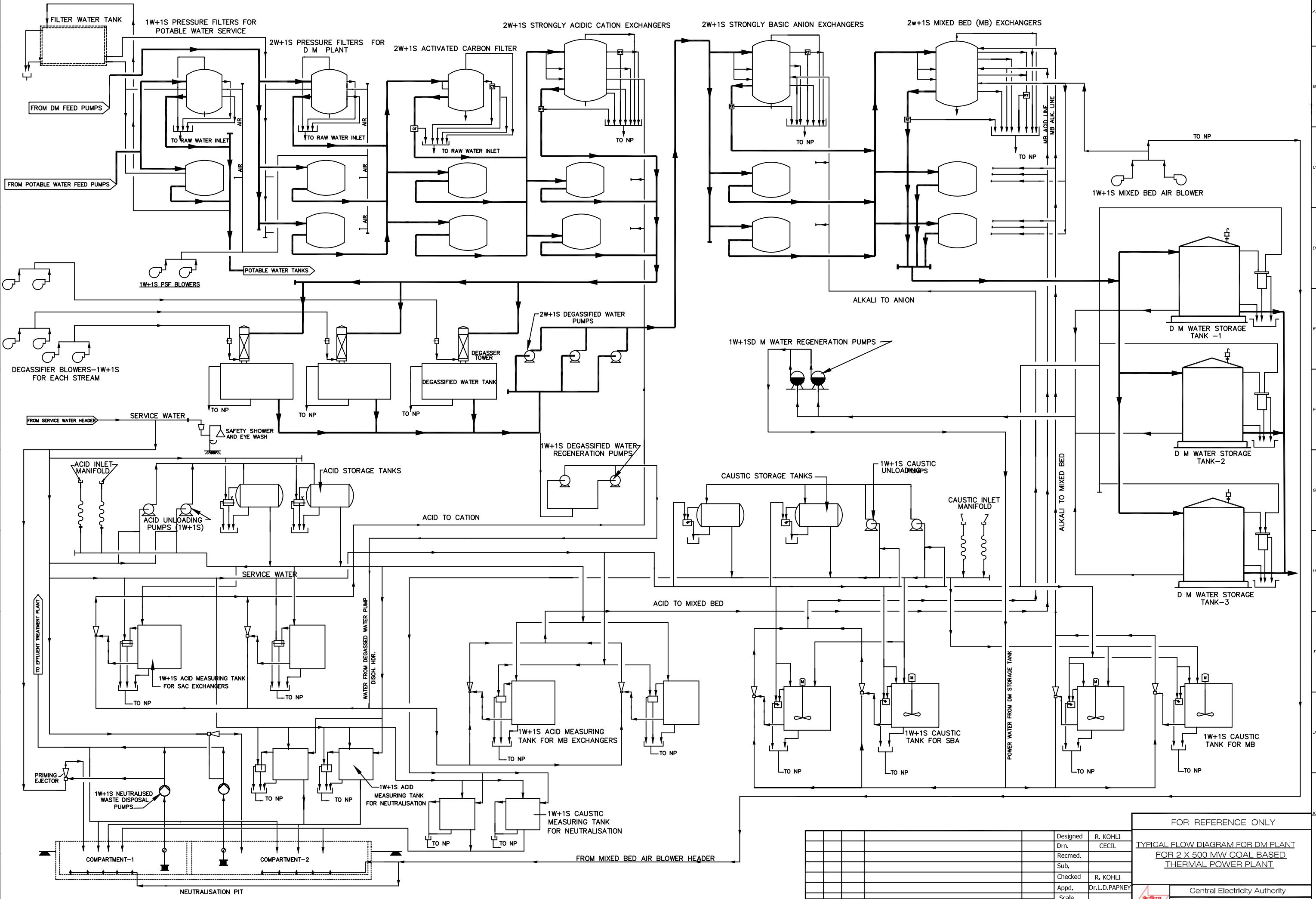


Central Electricity Authority

Drg. NO. CEA-TETD- AS-02

S.No.	Zone	Date	Revision	Slgn.	Date

Designed	R. KOHLI
Drn.	CECIL
Recmed.	
Sub.	
Checked	R. KOHLI
Appd.	Dr.L.D.PAPNEY
Scale	
Date	SEP.' 2010



FOR REFERENCE ONLY

TYPICAL FLOW DIAGRAM FOR DM PLANT FOR 2 X 500 MW COAL BASED THERMAL POWER PLANT

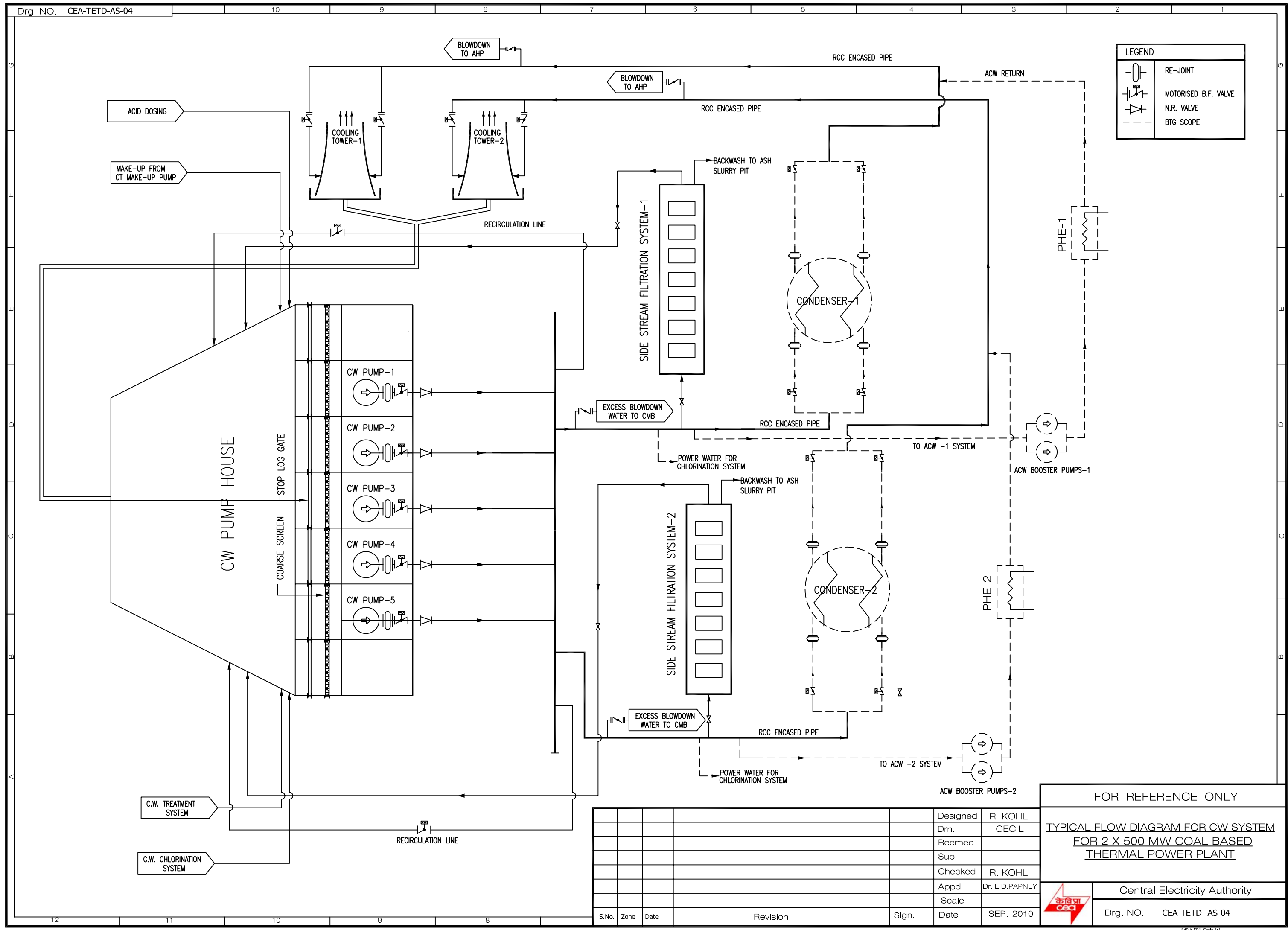
Central Electricity Authority

Drg. NO. CEA-TETD- AS-03

Designed	R. KOHLI
Dwn.	CECIL
Recmed.	
Sub.	
Checked	R. KOHLI
Appd.	Dr.L.D.PAPNEY
Scale	
Date	SEP.' 2010

S.No.	Zone	Date	Revision	Sign.

DO NOT SCALE, IF IN DOUBT PLEASE ASK



LEGEND	
	RE-JOINT
	MOTORISED B.F. VALVE
	N.R. VALVE
	BTG SCOPE

S.No.	Zone	Date	Revision	Sign.	Date

Designed	R. KOHLI
Drn.	CECIL
Recmed.	
Sub.	
Checked	R. KOHLI
Appd.	Dr. L.D.PAPNEY
Scale	
Date	SEP.' 2010

FOR REFERENCE ONLY

**TYPICAL FLOW DIAGRAM FOR CW SYSTEM
FOR 2 X 500 MW COAL BASED
THERMAL POWER PLANT**

Central Electricity Authority

Drg. NO. CEA-TETD- AS-04

