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PROJECT REPORT ON BOP SYSTEM OF 2X270 MW THERMAL POWER PLANT

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Declaration by the Guide

This is to certify that the Mr. Amrinder Singh, a student of (Program), Roll No 500024884 of UPES has successfully completed this dissertation report on "GVK (Goindwal Sahib) ltd. 2*270 MW thermal power plant Punjab" under my supervision.

Further, I certify that the work is based on the investigation made, data collected and analyzed by him and it has not been submitted in any other University or Institution for award of any degree. In my opinion it is fully adequate, in scope and utility, as a dissertation towards partial fulfillment for the award of degree of MBA/BBA/B.Sc.

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ABSTRACT

The detailed project report covers the Power and energy requirements and establishes the need for the installed generation capacity. To establish the power plant the balance of plant & boiler turbine, generator is necessary but in this project we will focus on the balance of plant including Ash handling system, coal handling system & water treatment plant. The project starts with the initial stage of planning for the Erection & commissioning of balance of plant to the final stage of operation & maintenance. To achieve this goal the various sections of balance of plant adopted the methodology including the dense phase ash handling system for AHP, double conveyor system including the wagon triple & stacker recliamer for coal handling system and the pre- treated water plant for water system. All these system is pre designed using the technical consultants for preparing the drawings, schedules, schemes & final write up.

1.0 Introduction

Electricity is the prime mover for growth and is vital for the sustenance of a modern economy. The projected 8% GDP growth of the Indian economy depends rather heavily on the availability of electricity to propel all-round industrial, agricultural and commercial activity.

The increase in India's installed capacity from 1,362 MW to over 120,000 MW since independence and electrification of more than 500,000 villages may be significant in absolute terms. The end consumers of electricity – households, farmers, commercial establishments, and industries are subjected to frequent power cuts - both scheduled and unscheduled.

The Electricity Act 2003 of India entrusts the Central Electricity Authority (CEA), under the Union Ministry of Power, to prepare the National Electricity Plan for the next five years and the prospective plan for the next ten years. The preparation of the National Electricity Plan is based on the electric load forecast for the next ten to fifteen year period. The data and projections in this section are based on the latest published CEA surveys, studies & reports available in the public domain.

Electric Power is one of the most important infrastructural inputs necessary for the fast socio-economic development of the country. The electric power sector of India has registered significant progress since the process of planned development of economy began in 1950. Hydro power and thermal power have been the main sources of generating electricity. Nuclear power development is at slower pace, which was introduced, in late sixties. The concept of operating systems on a regional basis, crossing the political boundaries of the States, was introduced in the early sixties.

Again National Grid, crossing the boundaries of Regions has been implemented in this decade. On all counts the growth of the power sector has been significant.

The Electricity Act - 2003 passed by the Parliament promises to usher in sweeping changes. The Act attempts to provide a legal framework for enabling reforms and restructuring of the Power Sector. It has simplified administrative procedure by integrating the Indian Electricity Act, 1910, the Electricity (Supply) Act, 1948 and the Electricity Regulatory Commissions Act, 1998 into a single Act.

The Electricity Act, 2003 is based on the principle of promoting competition, protecting consumer interests and providing power to all. The salient features of the Act are:-

De-licensing of Thermal Power Generation

Liberalization in Captive Power policy

Open access to Transmission and Distribution network

Stringent penalties for Power thefts

Transparent subsidy management

Constitution of Appellate Tribunal

Thrust on Rural Electrification

The preamble to the Bill put forth to the Parliament says it all. It will consolidate the laws relating to Generation, Transmission, Distribution, Trading and use of electricity; take all measures that are conducive for the development of the sector including rationalization of electricity tariff, ensuring transparent policies regarding subsidies, addresses environmental concerns, and empower the existing Power sector regulators and create new ones.

The new legislation has ushered paradigm shifts in the Power sector. Competition will be possible not just in generation, but also in every facet of the sector including Transmission and Distribution. Private sector investment will be facilitated by greater transparency that will come about.

The conceptual framework underlying the new legislation recognizes that the power sector should be thrown open to the competition. The Act permits free entry into Generation, unless there is overriding safety and Environmental concerns. The Act also promises non-discriminatory open access to the Transmission system. To this end the Central Electricity Regulatory Commission has framed the regulation for the "Open Access in Inter-State Transmission" in January, 2004. This shall facilitate the bulk sale of energy from Generators to the customers and will end the problems of the single buyer model. This has introduced the idea of trading in whole sale electricity.

The private sectors are already showing interest in the distribution sector and are gearing up to enter into the distribution of major consuming centers in the country. These developments promise radical change in the profile of the wholesale electricity customers.

Open access thus would encourage and enable private investors to enter into Power Generation and sell it directly to consumers. This would begin with bulk consumers and gradually extend upto the householders.

1.1 Growth of Power Sector in the Country

In the first 46 years of planned development, electricity generation has increased by well over 74 times which has been made possible by more than 49 fold increase in the installed generating capacity. Installed generating capacity increased from 1,713 MW in 1950 to more than 173,626 MW by March 2014.

India: Installed Capacity (MW) (As On 30.03.14)

(As on 30-03-14)									
S. No.	Region	Thermal				Nuclear	Hydro	R.E.S. @ (MNRE)	Total
		Coal	Gas	DSL	Total		(Renewable)		
1	Northern	24232.50	4134.76	12.99	28380.25	1620.00	13822.75	3165.55	46988.55
2	Western	30995.50	7903.81	17.48	38916.79	1840.00	7447.50	5357.96	53562.25
3	Southern	19882.50	4690.78	939.32	25512.60	1320.00	1299.03	9341.67	47473.30
4	Eastern	18747.88	190.00	17.20	18955.05	0.00	3882.12	359.64	231.96.84
5	N. Eastern	60.00	787.00	142.74	989.74	0.00	1116.00	223.60	2329.34
6	Islands	0.00	0.00	70.02	70.02	0.00	0.00	6.10	76.12
7	All India	93918.38	17706.35	1199.75	112824.45	4780.00	37567.40	18454.52	173624.40
Captive Generating Capacity Connected to the Grid (MW) = 19509									

(Source: CEA Power Sector at a Glance, Report Dt March 2014)

1.2 Demand Analysis

The region wise demand estimation for peak demand and energy requirement for 2015 and 2017 as per latest publication of Electrical Power Survey (EPS-17) published by CEA are presented below in Tables respectively.

Demand Projections up-to 2015

Region	Peak Demand (MU)	Energy Requirement (MU)
	As per 17th EPS	As per 17th EPS
Northern	48137	294841
Western	47108	294860
Southern	40367	253443
Eastern	19088	111802
North Eastern	2537	13329
Islands	88	384
All India - Total	**157325**	**968659**

(Source: Power Scenario at a Glance - April, 2013, CEA)

Demand Projections up-to 2017

Region	Peak Demand (MU)	Energy Requirement (MU)
	As per 17th EPS	As per 17th EPS
Northern	66583	411513
Western	64349	409805
Southern	60433	380068
Eastern	28401	168942
North Eastern	3760	21143
Islands	136	595
All India - Total	**223662**	**1392066**

(Source: Power Scenario at a Glance - April, 2013, CEA)

1.3 Capacity Addition Plan

Region wise addition of generating capacity expected in the country. Plan is shown in the table below. The capacity addition data has been considered based on the recent assessment by CEA on demand projection and generation Planning.

Capacity Addition (Region wise)

Region	Hydro	Thermal				Nuclear	Wind	Total
		Coal	Gas	Diesel	Total Thermal			
Northern	7,488	11,280	1,720	0	13,000	440	0	20928
Western	1,170	16,875	3,335	0	20,210	0	0	21,380
Southern	1,094	9,885	1,001	0	10,886	2,940	0	14920
Eastern	3,151	14,060	0	0	14,060	0	0	17,211
North Eastern	2,724	750	787	0	1,537	0	0	4,261
Islands	0	0	0	0	0	0	0	0
TOTAL	**15,627**	**52,850**	**6,843**	**0**	**59,693**	**3,380**	**0**	**78700**

(Source: Power Scenario at a Glance- April 2013 published by CEA)

Capacity Addition (Sector wise)

Type/Sector	Central	State	Private	Total
Thermal	24840	23301	11552	59693
Hydro	8564	3482	3491	15627
Nuclear	3380	0	0	3380
Total	36874	26783	15043	78700

(Power Scenario at a Glance- April 2013 published by CEA)

1.4 Demand & Supply Scenario during 2010-11

Region wise Demand & Supply Scenario (actual power supply position) during 2013-14 are presented below:

Region Wise Demand & Supply Scenario (Apr13-Mar14)

Region	Peak Demand (MW)	Peak Met (MW)	Peak Deficit (%)	Energy Requirement (MU)	Energy Availability (MU)	Energy Deficit (%)
Northern	37,431	34,101	8.9	259,426	238,782	8
Western	40,798	34,819	14.7	268,452	232,835	13.3
Southern	33,225	31,129	6.3	229,853	217,929	5.2
Eastern	14,528	13,085	9.9	94,515	90,458	4.3
North Eastern	1,913	1,560	18.5	9,879	9,009	8.8

(Source: Power Scenario at a Glance- April 2014 published by CEA)

From the above, it is observed that even after addition of substantial generation capacity and enhanced performance in 11th Plan, Western Region and Northern Region are facing significant energy and peak demand shortages. All other regions are also facing peak demand as well as energy shortages.

Likely Power Supply Position at the end 2014-15

Expected supply position at the end of 2014-15 is presented in Table below:

Likely Power Supply position at the end of 2014-15

Period	Peak Demand (MW)	Peak Met (MW)	Peak Deficit (%)	Energy Requirement (MU)	Energy Availability (MU)	Energy Deficit (%)
2014-15	152,746	142,765	6.5	968,659	948,836	2

(Source: Power Scenario at a Glance- April 2013 published by CEA)

It can be seen above that during 2014-15, there shall be peak deficit of 6.5% in the country. Also, it is seen that Northern and Western Regions are facing substantial energy and peak power shortages. The National Electricity Policy has set up the goal of adding new generation capacity to not only eliminate energy and peaking shortages but to have adequate spinning reserve in the system.

1.5 Northern Region

The proposed 2x270 MW Plant, to be located in Goindwal Sahib, Tarn Taran District, Punjab, unit will be feeding the Northern Grid consisting of the states of; Chandigarh, Delhi, Uttar Pradesh, Uttarakhand, Himachal Pradesh, Punjab, Haryana, Jammu & Kashmir & Rajasthan. The installed capacity of the Southern Region is shown below:

Northern Region: Sector-wise Installed Capacity, in MW, as on 31-March-14

Ownership Sector	Mode wise Breakup				Nuclear	Hydro Renewable	RES (MNRE)	Grand Total
	Coal	Gas	Diesel	Total Thermal				
State	14112	1719.2	12.99	15844.19	0	7052.55	1005.69	23902.43
Private	870	71.5	0	941.5	0	978	2159.86	4079.36
Central	9250	2344.1	0	11594.56	1620	5792.2	0	19006.76
Grand Total	24232	24233	12.99	28380.25	1620	13822.75	3165.55	46988.55

(Source: CEA Power Sector at a Glance, Report Dt. April 2014)

1.6 Power Sector Scenario in Punjab

The state of Punjab has an installed capacity of 7019.29 MW, as on 31-Mar-14 The sector wise break-up of power generation in Punjab is: State Sector 73%, Central Sector 27% followed by the Private Sector (IPP's).

The installed capacity of Punjab as on 31-Mar-14 is shown in the following Table:

Punjab State: Installed capacity in MW

Region	Hydro	Thermal				Nuclear	RES	Total
		Coal	Gas	Diesel	Total Thermal			
State	2230.23	2630	25	0	2655	0	243.2	5128.43
Private	0	0	0	0	0	0	86.05	86.05
Central	754.66	578.19	263.92	0	842.11	208.04	0	1804.81
Total	2984.89	3208.19	288.92	0	3497.11	208.04	329.25	7019.29

(Source: CEA Power Sector at a Glance, Report Dt. April 2014)

The present power supply situation in Punjab is shown in the following table:

Punjab: Actual Power Supply Position

Region	Peak Demand (MW)	Peak Met (MW)	Peak Deficit (%)	Energy Requirement (MU)	Energy Availability (MU)	Energy Deficit (%)
Punjab	7,729	7,442	3.7	44,594	41,905	6

1.7 Indian Grids & Its Managements

Historically, the Indian power sector was divided into five independent grids, namely; Northern, Eastern, Western, Southern and North-Eastern. Each grid covered several states in the respective region. However, since August 2006, all regional grids, except the Southern Grid, have been integrated and are operating in synchronous mode.

Hence, India presently has two grids. The Southern Grid is also planned to be synchronously operated with the rest of all India Grid.

Presently, the Southern Grid is connected to the Western Grid and Eastern Grid through High Voltage Direct Current Link (HVDC) link and HVDC back-to back systems.

Power generation within a grid is managed by Regional Load Dispatch Centre (RLDC). The Regional Power Committees (RPC's) provide a common platform for discussion and solution to the regional problems relating to the grid. Each state meets its demands with its own generation facilities and also with allocation to each state from the central sector power projects (NTPC, NHPC, NPC, NLC etc). Specific quotas are allocated to each state from the central sector power projects. Depending on the demand and generation there are electricity exports & imports between states in the regional grid.

In the context of the above, the Punjab State Electricity Board (PSEB) had invited bids from private sector firms for setting up a coal based 2 x 270 MW capacity thermal power station near Goindwal Sahib in Tarn Taran District on the western bank of river Beas. GVK Power (Goindwal Sahib) Ltd. (GPL) after having been selected as the Successful bidder by PSEB and Govt of Punjab for setting up coal based thermal power plant near Goindwal Sahib had entered into a Power Purchase Agreement. PSEB and GPL have amended the Power Purchase Agreement to implement the project with a capacity of 2x270 MW. The project highlights the details of the selected site, availability of coal and water, evacuation of power, features of the main plant equipment including raw water and cooling water system, coal and ash handling systems, electrical systems, environmental aspects, estimates of project cost, schedule for project implementation and organization structure for operation and maintenance of the proposed thermal power project.

Land:

PSEB has identified around 1093 acres of land about 700 m away from the river Beas western bank near Goindwal Sahib Village for the installation of the thermal power plant including ash disposal area. 1093 acres of land would be adequate for setting up the proposed power station including future expansion. The site lies adjacent to Amritsar-- Kapurthala Road.

Main Plant Equipment

The steam generators would be 100% coal fired and would be rated to generate about 865 t/hr of superheated steam at 158.6 kg/cm2 (g) pressure and temperature of 540°C. The reheat steam temperature would also be 540°C. The steam generators would be equipped with facilities for fuel oil firing for start-up and for flame stabilization at low loads. The steam turbine would be tandem- compound single reheat, regenerative, condensing, multi cylinder design directly coupled with generator suitable for indoor operation. The steam turbine would be driving a turbo generator at 3000 rpm to produce 270 MW output at 0.85 power factor at the generator terminals under steam turbine generator MCR conditions.

Coal Supply and Requirement

It is envisaged that the requirement of coal for this project would be sourced from Tokisud North Sub-block captive coal mine in the State of Jharkhand. The annual coal requirement for 2x270 MW TPP would be about 2.5 million tones at 80% PLF. The calorific value of the proposed coal from Tokisud North Sub-block coal mine is about 4127 kcal/kg (worst coal). The coal requirement is worked out for a plant load factor of 80%.

Coal Handling System

The coal handling system envisaged would be capable of handling coal at the rate of 1000 tons/hour up to coal stockyard in a single stream of conveyor. The coal handling system (i.e. beyond coal stockyard) would consist of two streams of conveyor, with one stream working and the second stream as standby. It is considered that coal of maximum 100 mm size for coal would be received at the site and single stage crushing would be employed to crush the coal to a size of (-) 25 mm as required by the coal mills of the steam generators.

Ash Handling System

The ash handling system proposed envisages intermittent jet pump system for bottom ash disposal and pneumatic type system for fly ash removal. Dry fly ash collection in ash silos has also been planned with a view to promote fly ash utilization to the maximum extent possible. Unutilized fly ash would be converted into slurry and disposed of along with the bottom ash.

Water System

The source of water for the proposed thermal power plant is from river Beas which is about 700 m away from the plant site. The water from the river is pumped to the reservoir through two (2) no's of pumps each of capacity 3150 m3/hr. The normal peak raw water make-up requirement for the proposed 2x270 MW units would be about 50926 m3/day which would be required only when both the units are running at full and both bottom ash and fly disposal in slurry form. However, since for most part of the unit operation, fly ash would be disposed of to the fly ash silos in dry form. Hence the weighted average monthly consumption would be about 46500 m3/day. Once when the ash water recovery system is in place, the effective raw water requirement for the plant would be about 38926 m3/day which is well within the limits of sanctioned quantity. Water from the reservoir would be drawn by three (3) no's of pumps each of capacity 850 m3/hr with one pump as standby. Closed circuit recirculation system with clarified river water make- up employing natural draught cooling towers (one for each unit) has been proposed for condenser cooling. The makeup water for the condenser cooling would be drawn from the clarifier through gravity filters and would be discharged into the common CW pump house fore bay. From the CW pump house the cooling water would be pumped to the condenser through individual mild steel conduits. The hot water would be led to the cooling tower through similar mild steel conduits. The raw water from the river is pumped to the raw water reservoir within the plant boundary. The water from the reservoir would be further pumped to raw water clarifier and DM water clarifier. The clarified water from the raw water clarifier would be stored in filter water storage tank for further plant use. The clarifier water from DM clarifier would be further processed in DM plant for further use in the boiler.

Power Evacuation

Power evacuation would be at 220 kV level through 4 lines connected to 2 different 8 substations of PSEB. The necessary transmission lines for this purpose would be installed by PSEB. The power generated would be fed to PSEB grid network through these 220 kV outgoing feeders, namely one double circuit (DC) line to Tarn Taran substation, one double circuit (DC) line to Thatha Sahib Substation.

Environmental Aspects

The power plant is proposed to use coal received from Tokisud north sub block captive coal mine in Jharkhand. A multi-steel flue 275 meters high RCC chimney (stack) is proposed to be provided common for two steam generator units to meet the requirements of the environmental regulations. The steam generators would be provided with low NO x burners; hence the emission of oxides of nitrogen from the steam generator would be minimum. The steam generators would be provided with electrostatic precipitators to limit the particulate matter in the flue gas to 100 mg / Nm3 as stipulated by Environmental Regulations. Environmental clearance for the capacity of 2x281 MW has already been obtained. However, same is to be amended for the proposed capacity of 2x270 MW. Rapid environmental impact assessment (REIA) studies have been conducted by M/s. B.S.Envi-Tech (P) Ltd., Hyderabad and the report has been submitted. Adequate provisions are proposed for neutralizing the effluents from the water treatment plant. Effluents from the entire power plant are proposed to be treated and reused in the power plant to maintain zero discharge concepts.

Project Cost and Tariff

Total project cost including the interest during construction for the proposed 2 x 270 MW project is estimated to be Rs.2940.35 Crores (Rs. 5.445 Crores / MW) and the levelised tariff at 80% PLF would be Rs. 2.71 / kWh. The cost of generation for the first year, works out to Rs. 3.01/ kWh.

2.0 PROJECT LITERATURE

The project is divided in to the three major areas of BOP system which are as follows;

Water system

Coal Handling System

Ash handling System

2.1 WATER SYSTEMS

The water will be used for condenser cooling, cooling of SG, and TG auxiliaries and various other requirements like SG makeup, miscellaneous services and potable water. The water systems consist of various sub-systems listed below;

(a) Raw water system

(b) Condenser cooling water (CW) system

(c) Make up water system

(d) Auxiliary cooling water (ACW) system

(e) Water treatment (WT) system

(f) Service & potable water system

(g) Fire protection system

(h) Effluent Treatment system

2.1.1 RAW WATER SUPPLY SYSTEM

The raw water requirement for proposed power plant of capacity 2x270 MW varies between 37000 to 50000 m3/day depending upon the number of units in operation, unit load and method of ash disposal. Department of irrigation and Power, Government of Punjab has transferred in favor of GVK (Goindwal Sahib) power Ltd., an allocation of 20 cusecs of water from the river Beas for phase-I of the project comprising 2x270 MW. It may be noted that the peak raw water requirement would be about 50926 m3/day (20.8 Cusecs) which would be required only when both the units are at full load and both bottom ash and fly ash to be disposed of in slurry form. However since for most part of unit operation fly ash will be disposed of in dry form, the weighted average monthly consumption will be about 46500 m3/day (19 Cusecs). Also with the ash water recovery system becoming effective the raw water requirement per day would be about 38926 m3/day (15.9 Cusecs). Hence the plant raw water consumption would be well within the sanctioned allocation. The required quantity of raw water is proposed to be drawn from the perennial Beas river which flows on the eastern side of the plant area. Drawl of raw water from the river would be through the intake pump house located in the river. Accordingly, a circular intake well of 8m internal diameter in the river bed along with pump house is located close to the existing road bridge At this location, the river section is expected to be deep and stable and the pump house will be near the bridge facilitating easy accessibility for maintenance and operation. The intake well is proposed to be sunk to sufficient depth below the river bed at EL 214.0 m for satisfactory performance of pumps even at the lowest water level during lean flow periods. The well will have sufficient openings in the wall along with trash racks to arrest the debris for drawl of clear water. Two pumps (1W+1S) with a capacity of 3150 m3/hr based on two shift operation are proposed with the motor located at floor level of EL 224.5 m which is above the highest flood level of EL 222.2 m. Suitable provision for pump handling is made by providing a monorail with hoist of required capacity. The pumps will be vertical turbine type. The raw water is pumped to the power plant premises into a raw water reservoir having about 1 day water storage capacity(about 60000 M3) to take care of any interruption of water flow through pipeline due to unforeseen maintenance, power supply failure etc. Pumping of water directly to the clarifier, bypassing the reservoir would be examined and worked out during detailed engineering stage. The water from the well is conveyed to the reservoir through an MS conduit of around 760 mm internal diameter and an approximate length of 1.6 kms. The bottom elevation of superstructure will be kept above the high flood level. The pipe line inside the plant area will be either buried or over ground supported on RC pedestals depending on the ground profile. Buried pipeline will be protected externally against corrosion by concrete encasement. The diameter of the pipeline will be finalised during detailed engineering after carrying out the optimization studies. Necessary provision would be made for the installation of protective devices in the pipeline such as air release valves. The fresh water requirement for the proposed power plant is estimated to be about 50926 m3/day (2122 m3/hour) without the ash water recovery system. However, with the recovery system coming into operation, the same will be reduced to 38926 m3/day (1622 m3/hour). The plant raw water storage reservoir capacity would be about 60000 m3. The plant raw water reservoir would be divided in to two equal compartments to facilitate cleaning and maintenance. The raw water would be pumped from the plant reservoir by 3 Nos (2 working + 1 standby) raw water supply pumps, each of capacity 850 m3/hr. These raw water supply pumps will be located in a raw water supply pump house near the plant reservoir. The pumps will be vertical turbine type. The raw water will be supplied to the pre-treatment plant located in the plant.

2.1.2 RAW WATER TREATMENT

Since river water is expected to have high turbidity / suspended solids during monsoon and the quality of influent water required for the various systems in the plant is clarified water (with turbidity and suspended solids less than 20 ppm), it is proposed to provide 1 x 100 % capacity clariflocculator type clarifier of capacity 1500 m3/hr. for CW makeup and general services. To counteract the problems of organics and colloidal silica which will deter the satisfactory operation of DM plant if not eliminated, it is proposed to install a separate clarifier of solids contact type to treat the DM plant influent. The capacity of this clarifier will be 70 m3/hr. Provision will be made to separately store the clarified water from the main clarifiers and the DM plant clarifier. Clarified water from the main clarifier will be led to the gravity sand filter. The filtered water from the gravity sand filter shall be stored in the filtered water storage tank. The filter water storage tank will be in two compartments feeding to a common sump to facilitate cleaning and maintenance. The filtered water storage tank will be closed and above ground structure.. This tank will cater to CW make up, HVAC make up, filter backwash requirements, plant washing & cleaning, seal water for ash handling system and plant service water requirements. The tank capacity will be 3000 Cu.m with reserve storage of 1640 Cu.m for fire protection system. The filtration plant will be six (6) sections (5 operating + 1 standby) rapid gravity dual media type each of capacity 300 m3/hr. The filters will be of RCC material of construction. Filter media will be graded sand supported on graded gravel and anthracite. Two (2) nos. 100% capacity filter air blowers will be used for loosening filter airbed before filter back washing. Filtered water will be stored in a below ground filtered water storage tank (RCC).

Back washing of filters will be done by means of 2 x 100% filter backwash pumps taking suction from the filtered water storage tank. Clarified water storage from the DM plant clarifier will be in only one compartment.

2.1.3 FILTERED WATER PUMP HOUSE

The following pumps will be located adjacent to the filtered water storage tank under a top covered enclosure.

(a) WT plant supply pumps.
(b) Service water pumps
(c) Fire water pumps

Chlorination equipment and alum dosing equipment for the clarifier will be housed in this pump house. WT plant supply pumps will take suction from the DM plant clarifier storage tank while the other pumps will take suction from the main plant filtered storage tank.

2.1.4 CONDENSER COOLING WATER (CW) SYSTEM

A recirculation type system is proposed for meeting the cooling water requirement of condenser and TG/SG auxiliaries. It is proposed to install two natural draught cooling towers (NDCT) each of capacity 37700 m3/hr with a cooling range of 100C and an approach of 50C for the power plant. The design wet bulb temperature would be about 280C. The design hot and cold water temperatures of the cooling towers would be 430C and 330C respectively. Tower construction would be of RCC material with PVC film type fill.

RC CHANNELS

The cooled water from the two cooling tower basins is proposed to be conveyed by 50 gravity to the CW fore-bay and pump house through a system of RC rectangular open channels. The channels are designed to resist maximum pressures expected under transient flow condition.

COOLING WATER (CW) PUMPS

Three 3 x 331/3% capacity CW pumps each of capacity 12560 cu.m/hr are proposed for each unit without standby. The total head of CW pumps would be around 26 mWC. The same will be finalized during detailed engineering. Vertical, wet pit, mixed flow, non-pullout, self-lubricated type of pumps with cast iron bowl, steel (IS 2602) column with epoxy painting, stainless steel (SS 410) shaft and stainless steel (SS 410) / bronze impeller are proposed. These pumps will be installed in individual chambers connected to the CW fore-bay. Each pump chamber will have provision for installing coarse screens and stop logs. The pumps will be located indoors. Handling of pumps would be through E.O.T crane provided in the pump house. For handling stop logs and coarse screen a separate gantry crane will be provided.

CW FORE BAY AND PUMP HOUSE

The total CW flow from the cooling tower basin will be discharged from the open channel to a common fore bay and pump house. The fore bay is designed to ensure equal distribution of flow to the CW pumps as well as to limit the entrance velocity at the CW pump house. The top level of the fore bay walls is fixed on the basis of maximum upsurge expected in the fore bay when all the CW pumps trip under normal water level condition. The sump level of the pump house is fixed so as to ensure adequate submergence to the CW pumps. Necessary provision will be made in the pump house for installation of stop logs and coarse screens in the individual pump chambers.

MILD STEEL CONDUITS

From the CW pump house, the CW discharge for the power plant is proposed to be conveyed to the condensers located in the station building, through two mild steel conduits. The hot water from the condensers is proposed to be conveyed back to the cooling tower through two mild steel outlets.

VALVES AND SPECIALTIES

Motor operated butterfly valves will be provided at the discharge of the CW pumps and the condenser inlet / outlet piping, cooling tower inlet piping to facilitate isolation and control. Expansion joints are proposed in the CW pump discharge lines and condenser inlet and outlet lines to take care of any misalignment, thermal expansion, etc., and to facilitate erection and maintenance. The CW pumps and their discharge valves would be suitably interlocked to result in a coordinated operation.

ON-LOAD TUBE CLEANING SYSTEM (OLTCS)

An on-load tube cleaning system (OLTCS) using sponge balls is proposed to be provided.

CW BLOWDOWN AND MAKE-UP WATER REQUIREMENTS

Make-up water requirement of CW system is obtained as the sum of drift and evaporation losses from the cooling tower and blow down from the CW system (by way of water drained from the hot water conduit of the CW system). In order to conserve water, the blow down would be utilized to meet the water requirement of the ash handling system and coal handling system dust suppression. The CW blow down/ make-up water requirements, for the cooling water system. Based on this water analysis and ash handling system requirement the cooling water system is proposed to operate with a cycle of concentration (COC), of around At a later date when dry fly ash collection becomes fully operative waste requirement for ash handling system will considerably reduce further in CW blow 52 down which may lead to COC as high at 8-10. In view of this filtered water makeup is envisaged.

Suitable chemical dosing system will be provided for control of water chemistry in the CW system. Chemicals will possess anti scaling, anti-corrosive and dispersant properties. The blow down water from the CW system will be utilized for the ash handling & coal handling system. The ash water will also be recovered and re-circulated for use. During initial stages of plant operation when the ash recovery system is not operational, water required for ash handling system in addition to the CW blow down will be met from the raw water reservoir.

2.1.5 MAKE UP WATER SYSTEM

Filtered water from the filtered water storage tank will flow by gravity to the cooling tower fore bay as CW system make up through a carbon steel pipeline of about 500 mm diameter. The pipe will be externally protected by coating and wrapping. Individual pump chambers also have provisions for installing stop logs and coarse screens. Likewise individual pump chambers of raw water pumps and raw water supply pumps shall have provision for installing coarse screens and stop logs.

CW / RW WATER SYSTEM CHLORINATION

In order to prevent/minimize the growth of algae in the CW system and raw water system, chlorine dosing is proposed. Provision will be made for shock dosing at 3 ppm and continuous dosing of up to 1 ppm. However, the continuous dosing rate would be adjusted during operation phase to meet the chlorine demand. For these purpose chlorinators with evaporators and adequate numbers of chlorine cylinders to meet about 10 days requirement would be stored. Alternatively chlorine-di-oxide or biocide dosing system will be reviewed during detailed engineering stage. For protection against chlorine leakage, chlorine leak detectors and chlorine gas absorption system would be provided for CW chlorination system. The CW chlorination plant would be located in the area close to the CW fore bay. The raw water chlorination plant will be located in the raw water pump house.

2.1.6 AUXILIARY COOLING WATER (ACW) SYSTEM

The ACW system meets the cooling water requirements of all the auxiliary equipment of the TG and SG units such as turbine lube oil coolers, seal oil coolers, stator water coolers, ID/FD/PA fan bearing oil coolers, mill lube oil coolers, BFP auxiliaries such as lube and working oil coolers, seal water coolers, drive motors, condensate pump bearings, air preheater bearings, sample coolers, air compressors and ash handling system compressors. Passivized DM water will be used for auxiliary cooling. The total estimated cooling water (passivated DM water) requirement for the above auxiliaries for one unit is 2378 cu.m/hr. A closed loop system is proposed for the ACW system. The DM water is circulated through the auxiliary coolers by three 50% capacity (2 working + 1 standby) Auxiliary cooling water (ACW) pumps, each of 1310 cu.m/hr capacity. The hot water from these auxiliaries is cooled in the plate type ACW heat exchangers by the circulating water tapped from the main CW circuit and pumped by secondary cooling water (SCW) pumps. Three 50% capacity secondary cooling water (SCW) pumps (2 working +1 standby), each of 1405 m3/hr capacity, would be provided for each unit of the power plant. An ACW overhead tank of 10 cu.m capacity is proposed to ensure positive suction to the ACW pumps and also serve as the source of make-up to the ACW system. Normal make-up to the ACW overhead tank is provided from the condensate extraction pump discharge. Initial fill for the tank will be provided from the boiler fill pumps discharge.

2.1.7 WATER TREATMENT PLANT

The water treatment plant broadly consists of pre-treatment plant, filtration and DM plant.

The pre-treatment consists of:

Chlorination system to destroy organic matter and algae.

Alum - For the purpose of coagulation.

Coagulation aid – To improve the settling characteristics and reduction in consumption of alum. The filtration plant consists of two (2) x 50 % vertical dual media filters, each of capacity 45 cu.m/hr, to remove turbidity and suspended solids. The pressure sand filters will be of mild steel construction with five (5) mil thick epoxy painted internally. Filter media will be graded sand supported on graded gravel. Two (2) nos., 100% capacity filter air blowers will be used for loosening filter air bed before filter back-washing. Back-washing of filters will be done by means of gravity flow from filtered water storage tank. Part of the filtered water will be stored in filtered water storage of capacity of 50 cu.m which will be located on the roof of DM plant building. This tank will supply water for filter backwash and plant and colony potable water system. Water will be supplied to the filtration plant by means of three (3) nos. (two working + one standby) WT plant supply pumps each of capacity 50 m3/hr. The material of construction of these pumps will be in cast iron casing, bronze impeller and stainless steel (410) shaft. The WT plant supply pumps will take suction from the clarified water storage of DM plant clarifier and will be located in the filtered water pump house.

DE CHLORINATION EQUIPMENT

2 Nos. activated carbon filters each of capacity 39 m^3/hr are used for DE chlorination purposes and also used for removing traces of oil and grease present in the effluent water.

DM PLANT

The DM plant meets the requirement of steam generator (SG) feed water make up, and ACW system and designed for a total productive output of 1400 m3/day of DM water based on SG feed water make up at 3% MCR. It is proposed to provide two (2) streams DM plant, each stream designed for an output of 39 m3/hr. Each stream of the DM plant will consist of a strong acid cation unit, degasser system, strong base anion unit and a mixed bed unit. Weak base anions units are not resorted to as the equivalent mineral acidity (sulphate + chlorides) are not substantial as compared to silica contents:

DEGASSER SYSTEM

The effluent from SAC units will then pass through a forced draft degasser towers (one for each stream) to limit the CO_2 to 5 ppm as CO_2. For the degasser tower three (3) nos., 50% capacity degasser air blower will be provided. The degassed water will be stored in degassed water storage tank. Three (3) nos., degassed water transfer pumps, two (2) working, with

one standby pump will be provided for transferring the degassed water. The degassed water storage tank will be of mild steel construction with five (5) mm thick rubber lining. The materials of construction of degassed water transfer pumps will be SS.

MIX BED SYSTEM

The final polishing of DM water will be done in MB unit. The MB unit will be designed to limit the silica less than 0.02 ppm as SiO_2 and conductivity will be restricted to 0.1 micro mho/cm at 250C. All the above Ion Exchange units will be of mild steel construction with five (5) mm thick rubber lining internally and 3 mil thick chlorinated rubber painting externally and all associated piping / valves of Ion Exchange Units will be either rubber lined or SS. The DM water from the mixed bed units will be led to the two D.M water storage tanks each of capacity 500 m3. 3 x 50 % D.M water transfer pumps each of capacity 28 m3/hr will be used to transfer D.M water upto condensate storage tanks (one for each unit). The condensate storage tanks will be sized to meet maximum requirement of DM water when one unit is under startup.

REGENERATION SYSTEM

30% hydrochloric acid and 48% sodium hydroxide will be used as regenerates for the purpose of regeneration of cation and anion resins respectively. The equipment of regeneration system shall comprise bulk acid and alkali storage tanks (the tanks will be sized for storing 30% hydrochloric acid and 48% sodium hydroxide for regeneration requirements of cation, anion and MB for fifteen (15) days), acid / alkali transfer pumps, acid / alkali solution preparation and measuring etc. Two (2) nos., of bulk acid and one (1) alkali storage tank will be provided to meet the requirement of both the streams. The bulk acid storage tank capacities shall be 15 days chemicals requirement of the plant.

NEUTRILIZATION SYSTEM

The acidic and alkaline effluents from DM plant and the filter backwash will be led to the neutralizing pit of WT plant, which is in two (2) compartments (each of capacity 100 cu.m) to facilitate maintenance and cleaning. Acid or alkali will be added to the neutralizing pit depending on nature of effluents from DM plant. Two (2) nos., waste disposal pumps, (one working + one standby) each of 47 m3/hr capacity, SS 316 material of construction are proposed to dispose the neutralized effluents to the Ash water sump.

2.1.8 SERVICE AND POTABLE WATER SYSTEMS

The service water system supplies water required for seal water for ash slurry pumps, HVAC and Plant washing & cleaning etc. Two (1 working + 1 standby) horizontal, centrifugal pumps, each of 65 cu.m/hr capacity, would pump water from the filtered water storage tank to meet this requirement. For coal dust suppression and ash handling, C.W blow down will be utilized. Requirements of the plant potable water system would be met from the filtered water storage tank of 50 cu.m capacity located on the roof of the DM plant building. Two (1 working + 1 standby) horizontal, centrifugal plant potable water pumps, each of 5 cu.m/hr capacity would take suction from the filtered water tank for further distribution of potable water to various consumer points in the plant . Two (1 working + 1 standby) horizontal, centrifugal colony potable water pumps, each of 45 cu.m/hr capacity would take suction from the filtered water tank for further distribution of potable water to various consumer points in the colony.

2.1.10 FIRE PROTECTION SYSTEM

This system will consist of the following sub-systems:

a) Hydrant system covering all areas of the plant.

b) High velocity water spray (HVWS) system for the protection of generator transformers, turbine oil tanks, lube oil system equipment, unit auxiliary transformers inside the steam turbine building.

c) Automatic deluge (medium velocity water spray) system for the protection of cable vaults / cable galleries and underground coal conveyors. The system would be designed to conform generally to the rules and regulations of the National Fire Protection Association (NFPA). Four Fire water pumps (two 58 motor-driven and two diesel engine-driven) of horizontal, centrifugal type, each with 273 cu.m/hr capacity would be provided for the hydrant and spray system together. Two jockey pumps (both motor-driven) of horizontal, centrifugal type, each with 35 cu.m/hr capacity would be provided to keep the system pressurized. All the above pumps would be located in the filtered water pump house. The filtered water storage tank would have a dead storage of 1640 cu.m of water for the fire protection systems in line with the regulations of the NFPA.

2.1.11 EFFLUENT DISPOSAL SYSTEM

A Guard Pond of capacity 200 cu.m and two (one working + one standby) effluent disposal pumps each of capacity 75 m3/hr have been provided as a part of effluent disposal system. Fuel oil handling area waste will be handled using API type oil water separators /retention pit with skimmers. Separators shall treat oily water runoff from fuel oil dyke area and clear water will be discharged to storm water drain and separated 59 oil will be collected separately in the oil collection tank. Oil water mixture emerging from service water system (due to floor washing of TG, Boiler, ESP area and workshop) will be collected and treated before leading to the guard pond. Retention pit and treatment facility will be provided. Oil waste collected in retention pit will be treated in Tiltable plate Interceptor (TPI). After treatment recovered oil is collected separately. Power cycle blow down will be cooled and recycled to raw water storage tank. The drains from the coal handling area run off (especially during rainy season) will be led to coal settling pond and clear water shall be dispersed to storm water drains. Water from Neutralizing Pit, Seal water, CW blow down is collected in separate ash water tank which is then led to the Ash slurry sump. Sludge from Main clarifiers& DM plant clarifier is led to the Ash handling system slurry sump which after recovery is reused to meet ash handling system requirements. The treated effluents collected in the guard pond after pH correction by addition of acid/alkali (if required) will be pumped by the effluent disposal pumps and reused for gardening & horticulture. Clarifier blowdown and filter back wash will be treated in a sludge handling system and recovered water will be returned to raw water reservoir. The concentrated reject from sludge handling system will be disposed of manually.

2.2 COAL HANDLING PLANT

2.2.1 GENERAL

This chapter covers the provisions that will be made in the coal handling system for the proposed 2 x 270 MW thermal power plant. It covers proposed facilities for receipt of coal by railway wagons, unloading through wagon tipplers, screening, crushing, conveying coal upto the steam generator bunkers or stacking in the stockyard, reclaiming from the stockyard, and conveying same to steam generator bunkers.

2.2.2 DESIGN CRITERIA AND ASSUMPTIONS

The design criteria for coal receipt by BoxN wagons, stacking, reclaiming, crushing and conveying is based on the following functional requirements and assumptions:

a) Coal handling system would be designed for proposed 2 x 270 MW unit only.

b) Coal required for each unit at MCR condition based on Indian coal having a gross calorific value of 4127 kcal/kg is 162 t/hr.

c) The maximum lump size of the coal received at power plant will be (-) 100mm.

d) A coal stockyard for stacking of crushed coal required for a minimum of forty five (45) days (at 80% PLF) has been considered. The stock pile will have live stock of about forty (40) days and dead stock pile of about five (5) days requirement. Coal in the dead stockpile needs to be dozed nearer to the reach of the reclaimer for reclaiming the same.

e) For conveying coal from wagon tippler to the stockpile, single stream of belt conveyor, will be provided. However, two sets of screens, crushers and two (2) numbers (1 operating + 1 standby) of wagon tipplers will be provided. From stockpile to the SG coal bunkers, two (2) (1 operating + 1 standby) streams of belt conveyors and equipment will be provided.

2.2.3 TRANSPORTATION OF COAL FROM MINES TO THE POWER PLANT AND SOURCE OF COAL

Coal will be received from Tokisud, on Barkakana Garhwa Road section of Dhanbad 61 division of East Central Railway of North Sub block captive coal mine in Jharkhand. Coal will be transported by rail to the Power Station. Box N wagons will be used for transporting coal.

In motion weighing system would be provided to weigh the loaded and empty wagons with an arrangement to record the total weight of coal received by each rake at the plant.

2.2.4 WAGON UNLOADING SYSTEM AT POWER STATION

Two (2) Nos. (1 operating + 1 standby) wagon tipplers will be provided. Side Arm Charger (SAC) will be provided for positioning the wagons on the tippler table. Apron feeder and dribble feeder will be provided below each wagon tippler hopper to feed coal from the tippler hopper to the belt conveyor.

2.2.5 RAILWAY TRACK LAYOUT

a) The proposed railway track layout is furnished in the plot plan. The railway track layout will be suitable to handle three rakes of coal per day as per MCR requirement of proposed 2 x 270 MW power plant.

b) The railway siding into the plant would be taken from the existing Khadur Sahib station..

c) Two (2) wagon tipplers (WT) will be provided. There would be totally seven tracks as shown in the plot plan. Four tracks (including two tracks of wagon tippler) would cater to the receipt of loaded wagon rakes while two tracks would be meant for empty wagon rake. Remaining one track would serve as an engine escape track.

2.2.6 MARSHALLING OF WAGONS

The loaded wagon rakes would be received on any of the wagon tippler tracks or loaded wagon track depending on availability. After leaving the loaded wagons, the main line loco would escape. The plant loco would be used for marshalling the loaded wagons. Loaded rake standing on the inhaul side of the WT track will be hauled by the side arm charger (SAC). Each wagon will be uncoupled and positioned on the WT table with the help of SAC. The empty wagon after unloading of coal will be pushed by the SAC to the outhaul side. The outhaul track will be provided with downward gradient for an easy movement of empty wagons. The empty wagon rake formed on the outhaul side, will be 62 hauled out by the main line loco. The loaded wagon rake standing on the other track will be divided into three sections of twenty (20) wagons each. The plant loco will bring 20 wagons to the inhaul of WT. SAC will be used for positioning each wagon on the WT table for unloading. 17 to 20 tipplings per hour shall be done and a total of 8 to 9 hrs of operation per rake. The empty wagon rake will be formed on the outhaul side.

2.2.7 SYSTEM CAPACITY

The maximum daily requirement of coal for the proposed two Units of 2 x 270 MW would be about 7780 tones. Coal handling system capacity would be 1000 tones per hour and would be working for 12 hours in a day to meet the boiler requirement. The coal unloading system will be working for 14 hours in a day to unload the daily requirement of coal.

2.2.8 SYSTEM DESCRIPTION

The system description furnished below is to be read with reference to Plot Plan (Exhibit-3) and Coal Handling System (CHS) flow diagram.

2.2.9 COAL CONVEYING FROM WAGON TIPPLER TO STEAM-GENERATOR BUNKERS

Coal received in railway wagons would be unloaded into wagon tippler hopper using wagon tipplers. The coal in turn will be fed to the belt conveyors by apron feeders and will be further conveyed to crusher house through a series of belt conveyors. Screens provided above the crushers will screen out (-) 25mm coal from the feed and only (+) 25mm coal would be fed to the crushers where the same will be crushed to (-) 25mm size. The crushed coal of (-) 25mm size would either be stored in the crushed coal stockyard or fed to steam generator bunkers through a series of belt conveyors and travelling trippers. As coal of (-) 100 mm size will be received, only single stage crushing is envisaged. Two screens (1 working + 1 standby) and two crushers (1 working +1 standby) are considered. Capacity of each screen and crusher will be 1000 TPH.

2.2.10 COAL STORAGE

Coal storage adequate for 45 days requirement of the proposed 2 x 270 MW units 63 considering 80% plant load factor would be provided. To enable stacking and reclaiming of crushed coal, one (1) reversible stacker cum re-claimer is considered. The height of the stockpile is about 8.75 m. The cross section of the stockpile would be trapezoidal. Out of forty five (45) days coal requirement, coal adequate for 40 days will be in live pile and rest will be in dead pile. Dead stockpile will be utilized using dozers to spread the coal. When required the coal from the dead stockpile will be dozed within the reach of the re-claimer and then reclaimed.

Two (2) stock piles would be provided with a total storage of about 2, 81,000 tones of crushed coal. The stacker on the trunk conveyor would stack coal on both sides of the track. The rated capacity of the stacker would be 1000 TPH and the average reclaiming\ capacity would be 780 TPH with a peak reclaiming capacity of 1000 TPH. The bucket wheel on the boom conveyor of the stacker cum re-claimer would reclaim the coal from the stockyard and feed on to the trunk conveyor for onward conveying to bunkers through a series of conveyors and travelling trippers. During emergency when the stacker-cum-reclaimer is under maintenance, emergency stockpile will be formed using the emergency stack out belt conveyor and telescopic chute. Coal will be reclaimed from the stockpile by dozing coal into the emergency reclaim hopper.

2.2.11 SALIENT FEATURES OF THE SYSTEM

The following are the salient features of the coal handling system:

Belt Conveyors from Wagon Tippler (W.T) hopper to Coal Stockyard / Coal

Bunkers the rated capacity of all belt conveyors would be 1000 TPH. All belt conveyors would be provided with Nylon-Nylon belting with fire retardant grade covers of 5mm thickness at top and 3mm thickness at bottom. The belt width would be 1200 mm with a toughing angle of 350. The belt speed would be about 3.0 m/sec.

Conveyor Galleries

All above-ground conveyors would be provided with galleries with sheeting on side and top. Seal plates at required locations like road & rail track crossings, above buildings, etc. will be provided. Above ground conveyors near the station 64 building area would be provided with completely enclosed galleries with Perspex sheets spaced at appropriate intervals to provide natural lighting. The bottom run of these galleries would be provided with seal plates to avoid coal falling on personnel walking in the area. Ventilation opening for a height of 250 mm at the top and bottom side sheeting of the gallery would be provided for natural ventilation.

Brakes for Conveyors

All inclined conveyors, wherever necessary, would be provided with electro thruster brakes of fail-safe design type in addition to hold backs to prevent the belt from rolling back in the event of trip/power failure.

Wagon tippler

Two (2) Nos. (1 operating + 1 standby) wagon tippler with associated side arm charger, apron feeders, dribble feeders, etc. will be provided for unloading coal from railway wagons into the WT hopper.

Crushers

The crushers would be of the ring granulator type and would have the capacity to reduce coal from (-) 100mm size to (-) 25mm size as required at the mills. There will be two (2) crushers, one (1) operating + one (1) standby, each having a capacity of 1050 TPH.

Screens

There will be two (2) screens, one (1) associated with each crusher (one (1) operating + one (1) standby). Screens will be of vibrating type with a capacity of 1000 TPH each.

Crusher House

All the floors, roof and side cladding of the crusher house would be of structural steel construction. A partition wall would be provided in the crusher house in between operating and standby crushers to reduce the dust nuisance and also to enable maintenance of the standby crusher while the other crusher is operating. Crushers would be mounted on springs to minimize vibration in the crusher house.

Junction Towers
All junction towers would be of structural steel with chequered plate covered 65 floors. Side cladding and roof would be provided with corrugated GI sheets.

Feeding of Coal to Bunkers and Bunker Ventilation System
Coal would be fed to the bunkers from conveyors through motorized travelling trippers. The coalbunkers are of circular type and the openings on the top would be covered with bunker sealing belt to avoid dust nuisance. The bunkers would be adequately ventilated so as to keep the bunkers free from accumulation of volatile gases, thereby eliminating fire hazard and also avoiding dust nuisance in the tripper floor. The ventilation air would be passed through bag filters before being let out into atmosphere.

Stacker cum Reclaimer
One (1) travelling and slewing type reversible stacker cum reclaimer would be provided for stacking and reclaiming of coal in the stockyard. The rated stacking capacity would be 1000 TPH & peak-reclaiming capacity would be 1000 TPH.

Metering of Coal
Adequate number of electronic belt scales would be provided on conveyors at appropriate places to monitor the inflow of coal quantity into the plant and the coal feed to the bunkers.

Coal Sampling Unit
Coal sampler would be provided at the discharge end of conveyors in JNT –1 to take coal samples automatically.

Fire Protection

Fire hydrants will be provided at all tunnel entry points, junction towers/crusher house, and bunker gallery and along the overhead conveyors. Fire hydrants would also be placed along the periphery of the coal stock pile for firefighting.

Controls

Operation of the complete conveying and crushing system, except traveling trippers on bunkers, wagon tipplers and stacker cum reclaimer would be monitored from the central control room of the coal handling system. Traveling trippers, wagon tipplers and stacker cum reclaimer would be controlled locally. The control and protection system would be microprocessor based with redundant CPU and colour monitor. Telemeter integrated readings would be provided for accounting of coal consumed by the steam generators. Also, annunciation would be provided to indicate low level of each bunker, in the unit control room.

2.3 ASH HANDLING SYSTEM

2.3.1 GENERAL

This chapter covers the provisions, which will be made for the ash handling system of the proposed 2 x 270 MW thermal power plant. The following data has been considered for design of ash handling system:

a) Hourly coal firing rate at SGMCR condition per unit for indigenous coal : 162 tonnes

b) Total ash content in coal considered (%) : 34 %

c) Design Distribution of total ash produced as

- Bottom ash (%) : 20%

- Fly ash (%): 90%

4.0 Volume occupied by one tonne of ash in storage area: 1 cu.m. The system adopted for bottom ash removal would be an intermittent jet pump system and for fly ash removal, pressure type pneumatic system. The ash disposal would be in slurry form using pumps and transport piping.

The water used for the ash handling system would be drawn from the CW blow down.

2.3.2 CAPACITY

Bottom ash removal from the bottom ash hopper would be carried out intermittently at the rate of about 60 TPH per unit to the sump. Similarly, the fly ash formed in one shift would be evacuated from the fly ash hoppers of the steam generator unit up to ash storage silo with a system capacity of 75 TPH per unit. Thus, it would take about 6.5 hrs to dispose the total ash generated in a shift of 8 hours for each of the two units considering that bottom ash slurry and fly ash slurry will be disposed one after the other. Two series of pumps will operate simultaneously, one for each unit. One more series of pumps will be provided as common standby.

2.3.3 SYSTEM DESCRIPTION

Bottom Ash Handling

A maximum of 20% of the total ash produced by each steam generator would be collected in the water impounded, refractory lined furnace hopper as bottom ash. The bottom ash hopper would have a capacity to store about eight hours collection of bottom ash and would be in the shape of `W' to enable free flow of bottom ash. The hopper would have four outlets fitted with hydraulically operated feed gates. A double roll type heavy duty clinker grinder and a jet pump would be mounted at each of the hopper outlets to crush the ash clinkers to (-) 25mm size and convey the same to the slurry sump. Out of the four clinker grinders and four jet pumps, two clinker grinders and two jet pumps would operate, leaving the other sets as standby. Main equipment's of bottom ash handling system are:

Bottom Ash Hopper

a) The bottom ash hopper would be of 'W' type having four (4) outlets. Bottom ash slurry would be discharged from two outlets leaving the other two outlets as standby. Each outlet will be provided with hydraulically operated feed gates.

b) The bottom ash hopper would be of MS welded construction having external supports.

c) A seal trough would be provided around the top periphery of the ash hopper, for furnace sealing and to prevent ingress of air into the furnace.

d) The hopper would be lined with a monolithic refractory.

Clinker Grinders

A double roll type clinker grinder housed in steel enclosure with suitable liners would be provided below each outlet. The grinders would crush the ash clinkers to (-) 25mm size.

Jet Pumps

a) One jet pump complete with water piping, valves, etc. would be provided below each clinker grinder.

b) Two jet pumps complete with wetting head, feed sump, water piping, valves, etc. would be provided below each fly ash silo.

Fly Ash Handling System

The fly ash system will be designed to collect fly ash in dry form in RCC silos using dense phase pressure system which is described below: The fly ash collected at the air preheater hoppers, ESP hoppers and stack hopper will be gravity fed into individual transmitter vessels provided below each hopper. On initiation of fly ash removal cycle, fly ash will be fed into the transmitter vessel upto the predetermined level after which the inlet valve will close. Afterwards, the conveying compressed air will be allowed to flow into the transmitter vessel by opening the air inlet valve. Once the desired conveying pressure is reached inside the vessel, ash discharge valve will open automatically allowing the ash to be conveyed in dense phase to the silo with the help of compressed air through transport piping. The conveying air will be vented through the bag filters mounted on top of the silo(s) in order to limit the dust concentration in the vented air below 100 mg/Nm3. The fly ash transmitter vessels connected to ESP hoppers in a particular row will be connected to common fly ash conveying pipeline as shown in the flow diagram.

If the hoppers in each field are connected to common conveying line, fly ash removal from all hoppers in that field will be done one after other. The clearance from any hopper will continue cycle after cycle till the level in the hoppers reaches low level. The removal of fly ash from any particular hopper will be initiated whenever the level in the hopper reaches predetermined level. Therefore, the removal and transfer of the fly ash to the silo will be done in cyclic manner on a continuous basis. Generally, the fly ash conveying system will operate continuously but with time gaps between cycles. The vessel sizes are selected in such a way that when they are operated without any gap, the ash collected in 8 hours will be cleared in about maximum 6.0 hours' time. Further, about 0.5 hours would be utilized for flushing of pipelines. The fly ash removal system will be designed on a continuous basis with 20 cycles per hour and during emergency with maximum 30 cycles per hour. The level probe will be provided in each hopper in such a way that the ash collected in the hopper will be equal to the volume of the ash transmitter vessel. There will be one manually operated isolation valve (knife gate type) below each fly ash hopper, which will be used during maintenance of the ash transmitter vessel. Major equipment's of Fly Ash handling system are:

Conveying Air Compressors

The requirement of compressed air for conveying fly ash from ESP hoppers, APH hoppers and Economizer hoppers to fly ash storage silo would be met by three (3) screw compressors (one for each unit and common standby) of suitable capacity with adequately sized air receivers. The requirement of compressed air for instruments, operation of pneumatic valves, cleaning of bag filters, etc., would be met by two (2) separate compressors (1 w+ 1s) with air receiver, air dryers etc.

ESP Hopper fluidizing Blowers & Silo Fluidizing Blowers

The requirement of fly ash hopper fluidizing air is met by three air blowers (2w + 1s), one working for each unit. Similarly, silo aeration is met by three (3) (2w + 1s) blowers and two (2) heaters.

Fly Ash and Bottom Ash Piping and Valves

The piping for conveying mixture of fly ash and air from fly ash hoppers to the respective storage silos would be of mild steel ERW pipes. The ash branch isolation valves would be of knife gate type, made of stainless steel (ANSI 410) gate hard faced by nitrating to get a minimum hardness of 450 BHN while the seat and body will be made of alloy C.I. with 2.5% Ni, minimum hardness 340 BHN.

High Pressure Water Pumps

Three (3) high pressure (HP) water pumps would be provided, out of which one (1) pump would operate for each unit and supply HP water to respective jet pumps, bottom ash hopper flushing, seal trough flushing, feeder ejector below fly ash silo etc. leaving the third pump as standby. The pumps would be of horizontal centrifugal type.

Low Pressure Water Pumps

Three (3) low pressure (LP) water pumps would be provided, out of which one pump would operate to meet the water requirement of the refractory cooling, seal trough makeup, wetting units, bottom ash hopper filling and makeup and fly ash conditioners etc. for each unit leaving the third pump as standby. The pumps would be of horizontal centrifugal type.

Seal Water Pumps

To meet the high pressure filtered water requirement, two (2) seal water horizontal pumps would be provided. One pump would operate to meet the seal water requirement of slurry pumps, sump pumps, clinker grinders, etc. of both units leaving the other pump as standby. These seal water pumps would take suction from the service water system.

Compressor Cooling

These will be horizontal, centrifugal type pumps and will supply required quantity of water for compressor cooling purpose. Two pumps common to both units will be provided for these services, out of which one will be operating to meet the requirements of both units while other will serve as standby. Service water will be used for these purposes.

Ash Slurry Pumps

For pumping the bottom ash or fly ash slurry from the slurry sump to the disposal area, three sets-one working for each unit and one common standby of slurry pumps for two units would be provided. Each set would comprise of two horizontal hydro-seal ash slurry pumps operating in series. The ash slurry pumps would be provided with V-belt drives with vari-pitch sheaves to vary the pump speed in future, as required, depending upon the disposal distance and/or wear of the impeller. Each set of pumps would be connected to one ash slurry disposal line.

Disposal Piping

There would be three ash slurry disposal pipelines one operating for each unit and one common standby pipeline. Beyond the pump house these pipelines will be interconnected and will ultimately dispose of ash slurry to the disposal area. The pipelines would be of MS ERW with minimum 9.3 mm pipe thickness. Bends would be of Alloy CI.

Fly Ash Conditioners

The fly ash from fly ash silos will be disposed into open trucks through fly ash conditioners. There will be two fly ash conditioners of suitable capacity below each fly ash silo. Provision will be made so that both conditioners can be operated simultaneously.

Automatic Sequential Controls for Ash Removal System

The operation of complete ash handling system (bottom ash as well as fly ash) will be\ controlled from main control panel located in ash handling system pump house. Two (2) numbers of PLC with one (1) working and one (1) hot standby will be provided. In case of failure of working processor, the standby will take over the operation automatically and necessary failure alarm will be provided. For control/ sequential operation and monitoring of ash handling system, a field proven PLC with all related equipment will be provided in the main control panel. Provision will be made for necessary adjustment of timings, selection etc. with appropriate checks before command initiation. Manual intervention for collection from a particular group of hoppers will also be provided in control room. The compressor selected for base duty operation will run continuously and the standby compressor will start automatically whenever the air pressure in the system reaches the preset lower limit. All water and slurry pumps will be operated manually from main control panel located in control room. Operating status of pumps will be reflected in the mimic diagram of ash handling system plant. Local push button stations will also be provided near each drive.

2.3.4 DISPOSAL OF FLY ASH FROM SILO

Dry fly ash from the air pre-heater, economizer and ESP hoppers would be collected in the fly ash storage silos. There would be two fly ash storage silos, one for each unit. Each storage silo will be designed to have a storage capacity of 900 tons. The dry fly ash collected in the storage silo will either be disposed in the dry conditioned form or in wet slurry form. The fly ash will be unloaded in dry form through rotary feeder and double shaft paddle type dust conditioners to open trucks for utilization of fly ash. There will also be two wet disposal arrangements, (one working + one standby) consisting of rotary feeder, wetting unit and jet pump/feeder ejector to dispose of fly ash in wet slurry form to the ash slurry sump whenever there is no demand for fly ash in dry form.

2.3.5 ASH SLURRY DISPOSAL

Ash slurry from both the units will be discharged into the respective slurry sump from where it will be disposed to ash disposal area by means of slurry pumps and associated piping. There will be three (3) series of slurry pumps for two units, out of which one series will be operating normally for each unit and the third series will serve as common standby. One pipeline will be associated with each series of pumps. In each series there will be two (2) pumps. The slurry pumps of each unit are expected to operate for 70 about 6.5 hours in a shift of 8 hours. First the bottom ash slurry and then fly ash slurry will be pumped for each unit. Each time at the end of disposal of ash slurry in a shift, complete disposal line will be flushed with water in order to prevent settling of ash inside the slurry pipe lines.

2.3.6 MAJOR STRUCTURES

a) Ash Slurry Sumps and Pump house

Ash slurry sump would have an optimum capacity to hold the ash slurry formed and the bottom ash hopper overflow. The sump would be provided with suitable alloy cast iron liners, agitating nozzles overflow connections, etc. Ash slurry pump house would be provided adjoining this sump. The pump house will be complete with EOT crane, drainage facilities, sump pumps, etc.

b) Ash Water Tanks and Pump house

Ash water tank would be located above ground. The HP & LP water pumps would take suction from this tank. Tank would have a capacity of about 30 minutes water requirement of the ash handling system. The pump house would be provided with suitable handling facilities for the maintenance of the pumps.

2.3.7 ASH DISPOSAL AREA

Ash slurry from the slurry sumps would be dumped into the ash disposal area. The proposed ash disposal area for the proposed power plant is by the side of the plant. The fly ash and bottom ash slurry from both the units will be pumped to ash pond. The disposal area is estimated based on the following assumptions.

Ash Pond - I Ash Pond - II

a) Total area of ash pond available 48.75 hectares 20.25 hectares

b) Elevation of top of the bund (To be constructed in phases up to ultimate bund height) 11.0 m 11.

c) Average ash fill height considering a free board of 1 m 10.0 m 10.0 m.

d) Ash produced out of 2 x 270 MW Units in one year based on coal consumption of 142.4 TPH and PLF 80% (7008 hrs. per year) and average ash content of 34% 7,72,000 T

e) With the above ash generation rate the life of ash pond will be 9 years.

The disposal area is estimated considering disposal of both bottom ash and fly ash in slurry form to the disposal area. As indicated above, the proposed disposal area will serve for the ash disposal from two units for about 9 years. In case the fly ash is disposed through closed trucks in conditioned form for utilization, then the life of ash pond will increase accordingly. Ash slurry dumped into the disposal area would be contained in the ash dyke by constructing bunds around the periphery of the disposal area. Adjacent to ash pond, a stilling pond would be provided which would occupy about 10% of area of ash pond. The ash slurry would be pumped to the ash pond where most of the ash would settle down and water with fine ash would flow into the stilling pond. In the stilling pond, all the fine ash is expected to settle down. The most important characteristic of ash slurry from the water pollution point of view is the suspended solids content in the effluent. The two stage settling arrangement described above is expected to limit the suspended solids to within acceptable limits. Additionally sedimentation facility and pumping system will also be introduced. The recovered water will be pumped to ash water tank in the plant area and it will be used for ash handling service. As indicated above, a stilling pond is proposed in order to ensure fairly clear effluent water. This pond also helps to suppress any wave action in the decanted ash water. To allow ash water to flow from the settling pond to the stilling pond and from the stilling pond to the sedimentation facility it is proposed to construct collecting wells (spill way) of RCC, as close to the bund as possible. On two opposite sides of the collecting well, openings will be provided at about 3000 mm centre-to-centre in a staggered pattern such that, at any particular elevation, the collecting well would have only one opening. These openings would be progressively blocked as the depth of ash fill increases so that only clear water flows into the well. The top most opening would be kept at about 600 mm below the full pond level. From the well, the clear water would be led away through RCC pipes laid through the ash bund. The collecting wells would be provided with access bridges to the ash bunds and rung ladders on the internal walls. The exact number, size and constructional details of the wells would be decided during the detailed engineering stage. The collecting wells would be operated to maintain a free board of atleast 1 m for the bunds. The water depth in the pond would be minimum but adequate to effectively remove any suspended solids. The complete ash disposal area would be covered with impervious liner to prevent water seepage. The ash water from the stilling pond would be recovered fro reuse in ash handling system. Also, the ash pond would be provided with LDPE lining to prevent pollution of ground water sources.

Ash Water Recovery Pump House

Ash water recovery pump house is located near sedimentation facility in the disposal area. The pump house will have adequate space to provide recovery water pumps, chemical dosing system. Space provision will be made for the storage of chemicals in, the pump house. There will be separate relay based control panel for controlling all equipment's. The pump house would be provided with adequate space equipment for maintenance. It will be also provided with suitable handling facilities for maintenance of the pumps. Other Constituents of the Effluent The feedback obtained from the ash pond effluent of some of the power stations indicates that metals, such as arsenic, mercury, lead, cadmium, etc. are found only in traces and they are well within acceptable limits.

Ash Bund

The ash bund would have sufficient width to accommodate three slurry disposal pipelines and service road adjacent to it at the top to enable jeeps to move for inspection and maintenance. The bund would be constructed of homogeneous earth fill. Side slope of 2.5 horizontal to 1 vertical would be provided on both sides. The outer side of the bund would be protected with turfing and inner faces provided with HDPE lining. A berm of 1.5m width would be provided at every 3.5 to 4m height of the bund in line with good engineering practice. Exact cross sections and details of construction of the bund would, however, be finalised during detail engineering.

2.3.8 DUST CONTROL IN THE ASH DISPOSAL AREA

To minimize the dust carry over due to wind, the easiest and most economical way is to ensure that ash is not exposed but covered with ash water of at least 600 mm to 1000 mm depth all over the ash disposal area. Since the ash disposal area is nearly level i.e. the gradient from one end to the other end is not very high, the ash water is likely to cover the ash all over the area.

a) The collecting wells will be operated to have a minimum free board of 1000mm above ash level. In case the free board gets reduced and the suspended solids content in water being let out exceeds 100 ppm, the opening in the collecting well nearest to the water level will be blocked.

b) The collecting wells and drain pipes from the collecting wells located in the stilling pond will be maintained free from any choking/build-up.

c) The effluent water from the stilling pond will be analyzed regularly, to take necessary action well in time. Since the ash disposal area is long, ash build-up will take place near the disposal point itself. Hence, the disposal point would have to be shifted for further slurry disposal. When the ash disposal point is shifted by extending the pipeline, the exposed ash near the previous disposal point will be covered with a layer of earth to prevent ash carry over by wind. Where the ash layer gets exposed, one or more of the following measures would be adopted as dust control measures : After disposing of ash for a specific period (say 6 months or one year), in case ash gets exposed (when it is slightly damp) it would be covered with a layer of earth. Disposal would then be continued for a further period of 6 to 12 months. When the ash in a particular area is being covered by earth, the ash slurry disposal would be carried out in a different area. This process will continue throughout the life of the ash disposal area.

2.3.9 FLY ASH UTILISATION

As stated earlier, the fly ash is proposed to be collected in silos and most of it would be utilized/ marketed in dry form. The fly ash which cannot be utilized/ marketed would be mixed with water in a hymixer /jet pump and the slurry thus formed would be led to the slurry sump. The fly ash generated in thermal power stations has commercial value because of its usage in cement and construction industries. Fly ash generated from the proposed power plant would be commercially utilized in one or more of the following industries, to the extent possible:

Cement Industry

Fly ash is used in the production of Pozzolona cement by intergrading Portland cement clinkers and fly ash or by blending intimately and uniformly Portland cement and fly ash. Indian Standard specifications limit the Pozzolona (fly ash or similar material) component upto 25% by weight whereas in other countries it varies from 15 to 50%. The advantages of fly ash in the manufacture of Portland

Pozzolona Cement (PPC) as compared to other common Pozzolonic materials are two-fold

a) Better hydraulic properties of fly ash.

b) Cement retains its natural and accepted grey colour instead of becoming mud-red in case bricks/tiles are used as Pozzolonic materials. Brick Industry

Fly ash produced in modern thermal power stations can be used in making bricks. The Cement Association of India has conducted research and experiments for making hollow bricks using fly ash. The Central Building Research Institute (CBRI), Roorkee has also conducted experiments in making bricks by using fly ash as an admixture with black cotton soil. In this project, bricks of minimum 105 kg/sq.cm strength were produced by CBRI. Concrete/Building Industry

Fly ash is used in the building industry largely as a concrete additive. Fly ash can also be sintered into pellets for use as light weight aggregate. Laboratory and pilot plant trials carried out at CBRI, Roorkee have established that sintered light weight aggregate can be successfully produced from Indian fly ash and used for producing plain concrete as well as reinforced concrete beams and slabs. Laboratory investigations and factory trials have shown the technical feasibility of manufacture of cellular concrete from lime and fly ash. It is more economical to produce this cellular concrete than the cement-sand cellular concrete which is being produced in the country at present. Fly ash can also be used as masonry mortar. The work done at CBRI suggests that mixtures will be thicker than 1:6 (by volume) to enable them to be used as mortar. As a masonry mortar, fly ash is used in place of Surkhi and prepared in a way similar to Lime- Surkhi mortar. Lime fly ash mortars are cheaper and better in performance and strength than Lime-Sand mortars. Roads/Paving It has been reported from the laboratory tests conducted by the Cement Association of India that fly ash with other ingredients can be used for paving roads and airport runways. Fly ash mixed with sand and hydrated lime is used as a base course of asphalt pavement. The breaking strength of such a pavement is calculated to be as high as 68 kg/sq.cm (1000 psi). As a result of a series of experiments, the mixtures ofingredients added in the following recommended proportions gave a good paving material with adequate strength and reasonable setting time: Ingredients Composition by Weight (%)

Fly ash 12 - 14

Lime 2.8 - 3.6

Portland Cement 0.7 - 0.9

Sand 80 - 84.5

The above mixture developed strength from 54 to 95 kg/sq.cm (800 - 1400 psi) in about 90 days at a temperature of 18 deg.C to 21 deg.C. Further, the experiments have, shown that 30% of crushed stones (instead of sand) established a strength of 102-136 kg/sq.cm (1500-2000 psi). The total cost of manufacturing the paving mixture comes to about one half that of ordinary road stone which has much less strength and to less than one third the cost of lime concrete which has good strength. Even with the extra strength obtained by using 30% crushed stones as a substitute for sand, the cost is not expected to exceed that of conventional materials.

Fly Ash Aggregate

The fly ash can be converted to light weight aggregate which can substitute the presently used conventional aggregate, in concrete blocks, flooring and non-load bearing structures such as compound walls, canals, pavements, etc. The main components of the process are fly ash, calcium oxide, fresh water quenched bottom ash (optional), sand, water and chemically bonding additives. The calcium from lime reacts with silica and alumina in fly ash to produce calcium/ aluminium materials in a reaction similar to that of Portland cement. These minerals bond the flyash particles tightly so that hard, strong and practically unleachable pellets are formed. These pellets are heated at low temperature to cure them. It may be noted that proportions of different ingredients to make bricks/cellular concrete/briquettes with fly ash chiefly depends on the constituents of the particular fly ash. Therefore, the particular type of fly ash is to be analysed for the properties of its constituents and checked for suitability or otherwise and suitable proportions of ingredients are to be determined by laboratory tests/pilot plant tests.

3.0 RISK ASSESMENT & DISASTER MANAGEMENT PLAN

3.0.1RISK ASSESMENT

Environmental risks are inherent in design and operation of any power plant. Risk involves the occurrence or potential occurrence of an accident consisting of an event or sequence of events.

The main objectives of risk assessment are as follows:

a) Identification of hazard prone area and estimation of damage distance for the maximum credible accident scenario visualized for storage.

b) Computation of frequency of occurrence of hazards and evaluation of risks

c) Recommendation of risk mitigation measures and arriving at a Disaster Management and Emergency Preparedness Plan.

Identification of hazards in a power plant is of primary significance in the analysis, quantification and cost effective control of accidents involving chemicals and process. Hence all the components of a process/system/plant need to be thoroughly examined to assess their potential for initiating or propagating an unplanned event/sequence of events, which can be termed as an accident.

As coal is subject to spontaneous combustion, it may catch fire given the slightest opportunity. This fire hazard is greatly influenced by the amount of airflow through the mass of coal.

Thus, storage of coal will be designed in such a way that the air content in the coal pile is minimized. Dimension of the coal stack, particularly the height, is a very important parameter for making storage of coal safe.

Fuel oils (LDO/HFO) will be used in small quantity for initial start-up. Chlorine and other chemicals are used in the water treatment & DM Plant. The hazards associated with the use of these materials need careful consideration and it is necessary to take due precaution for safe handling at various stages of usage.

3.0.2 Disaster Management Plan

A major emergency in a plant is one that has the potential to cause serious injury or loss of life. It may cause damage to property and serious disruption, both inside and outside of the plant. The disasters identified as most likely to occur in the power plant are:

a) Fire at oil storage area

b) Fire at coal storage area

c) Toxic release of chemical

Hazard analysis has revealed that the damage distance is mainly confined to plant boundary only.

The main objective of the disaster management plan is to prevent or at least reduce the risk of accidents through design, operation, maintenance and inspection. An important element of accident mitigation is emergency planning, which would consist of:

a) Recognizing the possibilities and probabilities of each kind of accident.

b) Assessing the on-site and off-site implications of such incidents and deciding the emergency procedures that would need to be carried out.

c) A number of elements make-up a good and workable disaster management plan. They are briefly discussed below:

Identification and assessment of hazards

Experience has shown that for every occasion that the full potential of an accident is realized, there are many other occasions when some lesser event occurs or when a developing incident is made safe before reaching full damage potential.

Procedure for personnel and equipment

This involves setting up of an emergency communication system, formation of an emergency response team and setting up of an emergency control centre.

It is essential that the emergency plan be regularly tested so that any defect may be corrected. The plan should be reviewed and updated and any changes made should be disseminated to all concerned.

Emergency plan needs to consider emergency shutdown procedure so that phased and orderly shutdown of the plant & systems can take place when necessary.

Depending upon the methodology adopted for the co-ordination of various aspects of disaster management, specific responsibilities should be fixed for civil and government agencies. Outside agencies support is required for the emergency responses such as:

- Augmenting the firefighting service and firewater.
- Emergency medical help for the injured personnel of the plant.
- Evacuation of personnel.
- Law enforcement, traffic control and crime prevention.
- Co-ordination with other nearby industrial establishments.

- Communication facilities.
- Procuring fire-fighting consumables such as foam compound, fire hose etc.

Maintenance and Monitoring

The safety of a plant and function of safety related systems could only be as good as the maintenance and monitoring of these systems. It is of great importance to establish plant maintenance & monitoring schedule, which includes the following tasks;

- Checking of safety related operating conditions in the control room and at site / on the field.
- Checking of safety related parts of the plant on site by visual inspection or by remote monitoring.
- Monitoring of safety related utilities such as electricity, steam, coolant and compressed air.
- Preparation of maintenance plan and documentation of maintenance work specifying the different interval and type of works to be performed.

In addition, the maintenance and monitoring schedule will specify the qualifications and experience required by the personnel to perform their tasks.

REFERENCES

a) Analytical Reports by the central electricity authority, Ministry of Power and other Govt. bodies, available in the public domain.

b) In house data resources of GVK

c) Data from Lahmeyer International India.