可 行 性 研 究 报 告

Feasibility Study Report

Attock Cement Pakistan LTD.

Coal Fired Steam Power Plant Of 2X12MW Project

DESCRIPTIONS

Leda Greenpower (Beijing) Trading & Engineering Co., Ltd.

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CONTENTS

1 INTRODUCTION

1.1 General

The Attock Cement Pakistan Limited introduce ourselves as one of the leading cement manufacturer in Pakistan selling with the brand name of " Falcon " in and outside the country. they have two units namely Line-1 and Line-2 both are located at the same premises at Hub Chowki, Baluchistan. In fulfilling the needs of the company, and they will build a new 2X12MW Coal Fired Steam Power Plant.

The Attock Cement Pakistan LTD. Coal Fired Steam Power Plant will be consisted of two (2) power boiler of 75 t/h and two (2) steam turbine units with total capacity of 2X12MW.

The plant areas will cover around 10 Ha including 6.3 KV switch yard and substation and other auxiliary buildings and also including space for power plant extension.

The Project will consist of major equipment:
- Two new boilers
- Two turbine-generators and condensers
- Condensate and Feed system
- Water and wastewater treatment plant
- Coal and Ash Handling System
- Main control room
- Control and instrumentation equipment
- Fire protection and detection system
- Ventilation and air conditioning system
- Two electrostatic precipitators (or Bag filters)
- Compressed Air system
- Steam and Water Circuit Equipment
- All requires piping and valves
- 6.3kV Substation and terminal substation
- Power and Auxiliary Transformers
- All civil, erection and installation works required for the above supplies
- Other system as necessarily required

1.2 Power plant outline

The Power Plant shall be located Within the Owner's Site.

The boiler will be of semi-outdoor type, of circulating fluidized bed type designed for burning coal, with necessary shelters and platforms for operation and routine maintenance.

The turbine and equipment will be located in turbine building. The buildings will consist of turbine generator, main control room, electronic room, and auxiliary equipment.

1.3 Power plant performance

1.3.1 Startup performance

Cold Starts:

For purpose of this section a Cold Start is defined as:

- A start after 72 continuous shutdown hours – boiler unfired and not drained;
- A start after 150 continuous shutdown hours – boiler continuously fired to maintain temperature and pressure;
- For shutdown periods less than 150 hours boiler may not be drained: if shutdown periods exceeds 150 hours, boiler will be drained:
- Boiler refilling: 8.0 hours / unit:
- Start-up to synchronous speed: 2.0 hours / unit:
- Maximum Cold Starts per year: 6
- Maximum Cold Starts in thirty (30) year: 180

Warm Starts:

For purpose of this section a Warm Start is defined as:

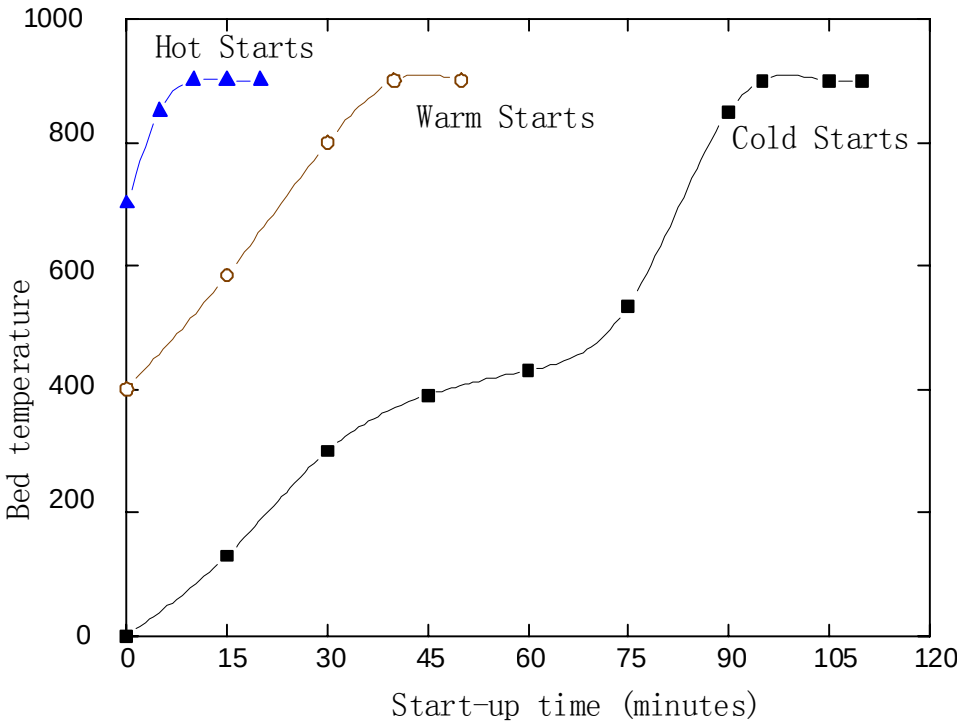
- A start after more than 10 but less than 72 continuous shutdown hours – boiler unfired and not drained;
- A start after more than 72 hours but less than 150 continuous shutdown hours – boiler continuously fired to maintain temperature and pressure;
- Start-up to synchronous speed: 0.75～1.0 hours / unit:
- Maximum Cold Starts per year: 30
- Maximum Cold Starts in thirty (30) year: 900

Hot Starts:

For purpose of this section a Hot Start is defined as:

- A start after not more than 10 continuous shutdown hours – boiler unfired and not drained;
- A start after more than 10 but less than 72 continuous shutdown hours – boiler continuously fired to maintain temperature and pressure;
- Start-up to synchronous speed: 0.5 hours / unit:
- Maximum Cold Starts per year: 50

- Maximum Cold Starts in thirty (30) year: 1500



1.3.2 Plant net heat rate

Plant Net Heat Rate (PNHR) diagram by load condition and based on Project Design Condition (Feed water temperature is 150℃, is not 136℃) is 16513.8 KJ/KW • H.

2 BOILER PLANT

2.1 General

The power plant will consist of 2 boilers which main characteristics, irrespective of the boiler type, will be as follows:

- Medium temperature and medium pressure parameters, single drum type.
- Natural circulation.
- Balance draft with one forced draft fan, one secondary air fan and one induce draft fan.

- Fired with coal as specified Fuel Analytic Data.
- Circulating fluidized bed.
- Semi-outdoor installation.
- Single pass boiler.
- Boiler accessories including safety valves, all small valves for blow-down, vents, chemical feed, drains and sampling fittings, together with all necessary connecting pipes and supports.
- Fly ash resulting from combustion boiler will be used as by products.

The boiler will be equipped with a non-heating drum in horizontal arrangement. The inner diameter of the drum will be 1500 mm, and the wall thickness will be 54 mm. The length of the straight section of the drum will be 7360 mm. The material will be 20g. A man hole of 320 x 425 will be opened at each end of the drum for maintenance purpose. The normal water level of the boiler will be at the centerline of the drum. The heated steam mixture will be separated preliminarily and fed to the drum through the vapor space at the rear part of the drum. The drum will be separated into front part and rear part by a partition board to force the steam mixture to flow to the two ends of the drum. The steam mixture will return at 180° to the middle section of the front part. A corrugated plate separator and a steam equalization orifice will be installed on the top of the middle section of the front part of the drum as the steam purifier to guarantee the quality of steam.

The upper part of the drum will be installed with pressure gauge, safety valve and steam valve. The lower part will be installed with an electrical driven valve for emergency drain. Chemical dosing pipe and surface blow down pipe will be installed inside the drum to guarantee high quality steam and qualified boiler water.

A 2-stage superheater will be supplied. The saturated steam from the drum will pass through the first stage of the superheater from the bottom to the top, and then pass through the second stage up and down through a surface temperature reducer in horizontal arrangement.

The surroundings of the furnace and the partition wall will be of film type water wall full enclosure structure. The film type water wall will be welded with ∅51x5 tubes and flat steel using special welding equipment. The water wall tube pitch will be 90 mm. Inspection door, fire observation door and a checking sleeve for flue gas temperature and negative pressure measurement will be installed at proper locations on the furnace wall.

A steel tube type economizer will be installed at the middle part of the flue shaft at the rear of the boiler. The economizer will consist of ∅32x4 tubes. The tubes will be arranged in row sequence. The flue gas will flow from the top to the bottom, and the feed water in the tube will flow from the bottom to the top to make heat exchange in counter current. The feed water will be fed to the drum through the economizer.

A single stage high temperature air pre-heater will be installed at the lower part of the flue shaft at

the rear of the boiler, and a 2-stage low temperature air pre-heater will be installed at the under part. All the air pre-heaters will be of steel tube type in vertical arrangement. The flue gas will flow from the top to bottom. The air will purge the tube bank horizontally. The tubes of the air pre-heater will be ∅40x1.5. Hot air will come out from the rear part of the last stage and will be fed to the air inlet pipes of the grate from the two sides of the boiler through hot air duct.

When applied to combustion, the circulating fluidized bed technique provides the thermal inertia of a well mixed bed to allow burning at a relatively low temperature. Fuel burns in the furnace where hot non-combustible bed material is held in semi-suspension in an upward flowing gas stream. Primary air is admitted into the bottom of the furnace. Hot bed material makes intimate contact with incoming fuel and quickly heats it to temperatures at which it can burn. Air admitted above the bed supports and completes combustion. The tall hot freeboard of this design enables most combustible material to burn before leaving the furnace.

The furnace is completely water wall enclosed, including the air distribution grid and plenum. Over-fire air is provided at a level above the lower furnace. Flue gas and elutriated solids exiting the furnace pass to the hot cyclones. The primary purpose of the cyclones is to separate solids carried with the flue gas so that they can be re-injected back into the lower portion of the furnace.

Fuel and limestone are feeded into lower furnace where combustion and sulphur capture reactions occur in the furnace. Solid particles entrained in the flue gas leaving the furnace are mostly separated from the gas stream in two cyclones. Oversize particles that cannot circulate are slowly drained from the bed. The quantity of circulating solids is controlled by extracting fine particles from the furnace. Any fine particulate that passes through the hot cyclones with the flue gas, is collected downstream in order to meet the environmental regulations. Hoppers are located wherever the flue gas flow changes directions such as beneath the heat recovery area (HRA) and the air heater to collect any particulate that settles at those points. Final dust collection occurs downstream of all heat recovery equipment, but upstream of the ID fan, in the bag house. Areas which its subjected in to high dust loadings could cause wear, such as in the lower furnace and at the entrance to the cyclone, are protected with abrasion resistant refractory linings.

The cyclones is cooled by hot water that natural circulation from water wall to the steam drum. The cyclones will be installed in vertical arrangement. The inner diameter of the cyclone will be 3000 mm, and the resistant refractory linings over the wall thickness will be 55 mm. The length of the cyclone will be 9700 mm.

Above the fluidized bed, flue gas and solids pass through the upper furnace zone where combustion is completed. Sufficient heat exchange surface (enclosure walls) is provided to maintain the gas temperature at the desired level prior 850~920℃ to exiting the furnace. The gas and solids then enter the cyclones, where solids are separated and returned to the circulating fluidized bed for furnace burn-up and lime utilization. Flue gas is directed to the heat recovery area

(HRA), passing across the super heaters, and to the economizer. The gas then passes through the air heaters, the final dust collector and induced draft fan prior to entering the stack. Air heaters will be provided for further heat recovery and to meet the exit flue gas temperature desired.

The fluidized bed boiler would be able to use other alternate fuels like biomass, baggasse, cow dung etc. as well besides coal.

2.2 Design parameters

2.2.1 Main Steam Condition

The main steam condition at steam boiler outlet will be as follows:

- Main steam pressure: 3.82MPa
- Main steam temperature: 450℃

The main steam condition at steam turbine inlet will be as follows:

- Main steam pressure: 3.43MPa
- Main steam temperature: 435℃

2.2.2 Firing and Feed System

Fuel will be fed to the boiler directly from the fuel handing system. Each boiler silo will be supplied with two outlets at the bottom. Coal will be fed to a screw feeder homogeneously. The boiler furnace will be of open type. The furnace front wall will be provided with two fuel inlets. Each screw feeder will feed one fuel inlets of the furnace. The feed volume will be automatically controlled by changing the speed of the screw feeder.

Some secondary air nozzles will be arranged under each furnace fuel inlet for blowing coal. Some of the coal will fire in laminar on the circulating fluidized bed, and some will fire in suspension.

2.2.3 Combustion Air System

The boiler will be equipped with one secondary air fan and one forced draft fan. Both secondary air fan and forced draft fan will be driven by electric motors and will be designed for capacity of 1.20 times all necessary air requirements to suit any specified fuel.

The primary(fluidizing) air from the blower will firstly pass through the low temperature air pre-heater to be heated up to a temperature of 75.9°C. Then it will pass through the high temperature air pre-heater

to be heated up to a temperature of 145°C. The air will be delivered to the air chamber under the bed from the two sides of the boiler. Then, it will be delivered to the furnace through more groups of louvers. The air control devices will control air flow by valves to meet the demand of air for coal firing.

The secondary air from the blower will firstly pass through the low temperature air pre-heater to be heated up to a temperature of 160°C. Secondary air header will be arranged at the front part of the furnace and the first half of the two sides.

The fan bearings will be horizontally split, oil ring lubricated, complete with dust seals, oil reservoir, oil level indicator and temperature measurement. The bearings will be mounted on fabricated rigid steel pedestals and separate sole plates which will be independent of the fan housing.

2.2.4 Boiler Continuous Blow-Down System

The boiler will be equipped with a complete continuous blow-down system and periodical blow down system.

The contaminated water in the drum and lower collector will be blown down continuously to the continuous blow-down flash tank. The flash steam shall be led to the deaerator. The contaminated water will be discharged to the periodical blow-down flash tank after temperature reducing through a continuous blow-down heat exchanger.

The blow-down pipes of the collectors and start up drainpipes will be connected to the periodical blow-down flash tank. The blow-down flash tank will be cooled with service water to keep an effluent temperature less than 60℃ and discharge to drain trench.

2.2.5 Sootblowing System

Automatically operated steam sootblowers will be supplied to clean the surface of superheater and economizer. Type and location of the sootblowers will suit the requirement of cleaning to guarantee a good cleaning result.

Opening on furnace water wall for future installation of sootblower will furnished.

2.2.6 Service Platforms and Walkways

The boiler operation floor will be at 7.000 meters elevation on the same elevation with the turbine operation floor, which will provide convenience for safety operation. The boiler operation floor will be of platform in open air. Escape stairs will be provided at the two ends of the platform. An open space will be reserved in middle of the boilers to satisfy the requirement of maintenance of boiler.

The boiler will be of frame structure. Multi-floor platforms will be provided for the convenience of operation and maintenance. The platforms will be connected through the stair at the two ends. Both the water level inspection platform and soot-blowing platform can meet the operation requirement.

2.2.7 Thermal Insulation and Cladding

The boiler, air heater, fans, ductwork, flue gas scrubber auxiliary equipment, piping, etc. will be supplied with adequate thermal insulation and lacking material to keep the surface temperature of not more than 55℃. The cladding will be of 1 mm thick aluminum plate.

2.2.8 Others

Pipes

Pipes, elbows, flanges, bolts and auxiliary elements are in the scope of the delivery.
-- Steel piping of 12Cr1MoV to be used for main steam.
-- Steel piping of 20G to be used steam pipe for soot blower.
-- Carbon steel piping: to be used for water, LP-steam, MP-steam, feed water, condensate, warm water, oil, drains and others non or low corrosive fluids.
-- Air ducts will be made of carbon steel plates of 4 mm thick. The flue gas ducts will be made of carbon steel plates of 5 mm thick.
-- Stainless steel pipes will be used for sampling and phosphate solution system.

Valves

The equipment manufactured and delivered as components such as power boiler, deaerator, blowdown tanks, etc. will be delivered with the valves and accessories covered by the applicable design drawings. This will include motor driven valves, water level gauges, local manometers and thermometers.

In the boiler island design, various of valves will be supplied for different fluids, operating pressure and flow rate on the basis of the valve list provided by the contractor.

The materials of involved in valves are:
--The valve body is casting steel or nodular cast iron.
--The valve disks, seal rings and seat are made of stainless steel, teflon or cooper alloys.

Automatic control and adjusting valves will be supplied in accordance with those specified on the control system.

Operating platforms, staircases and handrails

The operating platforms, staircases, guard rails and handrails will be supplied in accordance with the specified material and quantity shown on the final design drawings, This will include all of operating platforms for the whole boiler and the other auxiliary equipment.

2.3 Flue gas system, electrostatic precipitator and stack

2.3.1 Flue gas system

The high temperature flue gas generated through combustion in the furnace will turn 915° at the top and flow to the flue way. The flue way will be provided with two groups of superheaters. Then the flue gas will enter a 2-stage economizer. The flue gas will be emitted from the boiler after passing through the high temperature air pre-heater and a 2-stage low temperature air pre-heater. The temperature of the flue gas emitted will be 151°C. The flue gas will be led to the stack after dedusting through electrostatic precipitator and finally emitted to the atmosphere.

The induced draft fan will be driven by variable speed control motor. For the purpose of stabilizing the combustion, the negative pressure in the furnace will be controlled through the adjustment of air volume by variable speed control. The fan bearings will be horizontally split, oil ring lubricated, complete with dust seals, oil reservoir, oil level indicator and temperature measurement. The bearings shall be mounted on fabricated rigid steel pedestals and separate sole plates which will be independent of the fan housing.

2.3.2 Electrostatic precipitator (ESP)

Fuel gas deduster which will be of electrostatic precipitator will be provided for the boiler to reduce the particulate emissions to the atmosphere and guarantee that the concentration of particulate will not exceed 120 mg/Nm^3 at the outlet of the stack.

The electrostatic precipitator will consist of the following equipment:

- Nozzle type inlet and outlet, collecting plates and rigid-frame emitting electrodes, dust cleaning system. Dust hoppers, steel support structure, casing, weather enclosure, access doors, stair, platform, thermal insulation and all necessary accessories.
- The dust cleaning system will consist of transformer rectifier (T-R), emitting electrode rapper, collecting electrode rapper, HV silicon rectifying equipment and electromagnetic rapping control cabinet.
- Pre-set program and interval automatic control will be provided for periodical cleaning of dust.

2.3.3 Stack

One stack will share for two boiler units. The outlet diameter of the stack will be 2.0 meters. The stack will be 80 meters high. An insulation and lagging will be provided at the base of the stack to a height of 2.5m above grade for personnel protection. The lagging surface temperature shall not exceed 55℃. The exterior surface of the stack will be painted with a heat resistant coating system. The stack will be supplied complete with check lights for aircraft with cabling, platforms and ladders, a drain connection at the base, lightning protection and measuring point for emission measurements.

2.4 Chemical dosing system

In order to prevent from scaling in the boiler and in addition to guarantee the feed water quality, a certain amount of trisodium phosphate will be added into the drum. The phosphate dosing system will be arranged on the 0.000 meters elevation floor of the main production building.

2.5 Sample coolers

The sampling system will be supplied with sample coolers for condensate, feed water, boiler water, saturated steam and superheated steam. The sample coolers consisting of a water-jacket stainless steel cooling coil will be supplied complete with a cooling water inlet regulating valve and a sampling line with outlet connections. The steam sample cooler will be supplied with two outlet connections, one for the automatic analyzer for conductivity, pH, and the other for extraction of water samples for chemical analysis in the laboratories. The temperature of the extracted water samples should not exceed 30℃.

2.6 Chemical cleaning and steam blow out

Chemical cleaning of boiler, pre-boiler equipment and piping shall be carried out before the equipment is placed into initial operation.

The chemical cleaning shall consist of the following stages as a minimum:

- Flushing
- Alkali boil-out
- Acid cleaning
- Hydrazine based passivation

A steam blow out of boiler and the complete steam lines shall be carried out to remove the mild scale, slag, and other foreign materials from boiler and the steam lines prior to initial operation of the steam

turbines.

2.7 Fuel oil system

Light fuel oil or HSD is used for boiler start-up and flame stabilization during low-load operation. The fuel oil is stored in a tank with 150 m^3 capacity.

There is one fuel oil unloading pump and two (2)X100% capacity, light fuel oil supply pumps. The oil filter will be installed.

2.8 Boiler control and instrumentation

The boiler control system will be completely compatible with steam generator design, boiler control system design, and plant system design.

The system shall automatically initiate an MFT (Master Fuel Trip) under any unsafe operating conditions, but not limited to, the following:

Loss of FD fans.
Loss of ID fans.
Drum level too high.
Drum level too low
High bed pressure.
Low bed pressure.
Bed extraction too high.
Bed extraction too low.
Total air flow below minimum.
High furnace pressure.
Low furnace pressure.
All fuel inputs zero.
Manual emergency trip button actuated.
Loss of power to the combustion control and the fuel feeding equipment control system.
All BFP stopped.
Feed water flow low.
Main steam press high.
Condenser protect on.
Turbine trip.

A complete loss of a critical Automatic plant Control System or Burner Management System processor

(BMS) will trip the MFTs immediately. A complete loss shall be defined as the loss of all processing (both primary and redundant processors) at that drop. A critical Automatic Plant Control System processor is defined as any processor drop without which the unit should not be operated for personnel or equipment safety reasons. Processors controlling fuel, air, and draft or performing Unit Protection functions shall be considered critical. A critical Burner Management System processor shall be defined as any processor that is responsible for MFT functions.

The trip logic shall consist of two identical and parallel logic trains each with an MFT relay. The trip signal from the trip relays shall be arranged in a two-out-of-two, deenergize-to-trip scheme.

3 BOTTOM AND FLY ASH HANDLING SYSTEM

3.1 Scope of Work

The scope of work performed under the Ash handling system will consist of bottom ash handling system and fly ash handling system.

3.2 General requirements

The bottom ash silo and fly ash silo will be made of steel. The silos will be equipped with ash dischargers at the bottom. The operation will incorporate with electric clapper and truck loader. The ash will be loaded directly to enclosed truck tank.

3.3 Bottom ash handling system

Each boiler shall be provided with a suitable bottom ash conveyor system and provision for cooling by the bottom ash roller before it is discharged into the scraper conveyor. From the scraper conveyor, bottom ash is raised into the bottom ash silo by the strickle hoist.

3.4 Fly ash handling system

A single fly ash silo is provided for the units. The silo has storage capacity for minimum (24) hours at full load. The fly ash system removes the ash that accumulates in the electrostatic precipitator hoppers using a pneumatic vacuum conveying system sized for approximately twice the expected ash

quantities.

The fly ash silo is provided with a dry unloading bulk machine and a wet unloading mixer with water before it is discharged into the truck. Additional dust suppression equipment will be employed as necessary to further control fugitive dust.

4 COAL HANDLING SYSTEM

4.1 General

Raw coal will be delivered by trucks directly to the mill coal storage area and the indoor coal yard. One (1) grab crane and one (1) loader will be selected for coal unloading, piling and moving. The raw coal will be sent to the coal silo located in the boiler house by the belt conveyor through devices of electromagnetic iron separator, screen and crusher.

4.2 Design basis

The system is designed based on the data given Coal Analysis Data.

SOUTH AFRICAN, LOCAL (WASHED) & INDONESIAN COAL SPECIFICATION

AL SPECIFICATION		SOUTH AFRICAN COAL	LOCAL WASHED COAL (LAKHRA)	LOCAL UNWASHED COAL (LAKHRA)	INDONESIAN COAL
TOTAL MOISTURE	(ARB)	8-10%	17-20.50%	25-35%	14-16%
INHERENT MOISTURE	(ADB)	3-4%	8-12%	10-15%	10-12%
ASH CONTENT	(ADB)	14-15%	17 - 25%	25 - 28%	14-15%
VOLATILE MATTER	(ADB)	21-29%	38 - 42%	33 - 35%	40-44%
SULPHUR	(ADB)	0.80-1.00%	4.50 - 5.25%	5.00 - 7.00%	0.80-1.00%
GCV K.Cal/kg	(ADB)	6400-6600	4800 - 5500	4600 - 4800	6100-6300
NCV K.Cal/kg	(ADB)	-	-	-	5743-5931
HGI	-	50-52	-	-	40-45
SIZE	-	0-50 mm 95% min	0-50 mm 95% min	0-50 mm 95% min	0-50 mm 90% min
NCV K.Cal/kg	(ARB)	6000-6100	-	-	-
GCV K.Cal/kg	(ARB)	6250-6350	-	-	-

Local unwashed coal (LAKHRA) is high ash, high sulphur, low heating value. but Indonesian coal is low ash, low sulphur, high heating value. If Local unwashed coal (LAKHRA) mixed with Indonesian coal according to 1:1 scale, then the CFB boiler will is best burning. Designed fuel analysis as follows.

Coal Analysis Data

Ash (adb)	21 %
Volatile matter	40 %
Fixed carbon (minimum)	27 %
Sulphur content	＜3.0 %
Moisture content total max.	35 %
Gross Calorific value (adb)	5350~5550 kcal/kg

4.3 Coal consumption

Consumption with the rated output (75t/h): 10.5 t/h
Total coal consumption for two boilers with rated output: 21 t/h
The daily coal consumption for two boilers: 504 t/h

4.4 System functions

For the power plant, coal transportation will be designed using belt conveying system.

A belt scale and automatic as-received sampling system is provided for certification of coal quantity and quality. The belt scale is installed on the receiving conveyor. The as-received sampling system and stockyard feed conveyor transfer chutes are located in a transfer house designed to accommodate the equipment and provide adequate space for maintenance.

Coal from the live stockpile is moved by mobile equipment to and from the adjacent dead coal stockpile for use if coal supply is disrupted. There is a reclaim hopper beneath the live coal stockpile with variable speed vibrating feeder. One reclaim conveyor supplies adequate coal to the silos via a crushing house. The crushing house supplies coal of suitable size as required by the CFB boiler. From the silos, the crushed coal is fed the boiler by the CFB boilers fuel feed system. The Vendor/manufacturer may also propose other alternative system for the coal feeding.

A self cleaning magnetic separator is installed over the head pulley of the conveyor to prevent damage to the downstream equipment. The magnetic separator and coal transfer chutes are sized to accommodate the equipment and provide adequate space around the equipment for maintenance. To verify the type and quantity of coal being fed to the boilers, the conveyor is equipped with belt scales and an as-fired automatic sampling system, magnetic separator, and transfer chutes from the reclaim conveyor to the silo distribution tripper conveyors are housed from the reclaim conveyor to the silo distribution tripper conveyors are housed in a transfer house. Coal is transferred to the silos by belt conveyor.

The coal handling system is controlled from the coal handling control room adjacent to the transfer house. The overall control is programmable by a logic controller system. The control board is including the controls, graphic display, and annunciator sections to allow remote operation of the coal handling system. The central coal handling building also houses the necessary electrical equipment to distribute power to the coal handling equipment.

Transfer points in transfer house are provided with bag filter to keep dust to a minimum.

The belt conveyors will be supported with the steel structure. There will be covered the painted plate on the top of the belt conveyors.

Coal is conveyed by the one-way belt conveying system to be operated in two shifts. The belt is 650mm wide, and the output of the system is 100t/h.

5 FEED WATER SYSTEM

5.1 General

The feed water system shall consist of the following systems for flow of feed water from the condenser hot well to the boiler inlet:

Boiler feed system
- Condensate system
Cycle makeup and storage system

Boiler feed water standard:

Hardness	≤3 μe/L
Dissolved oxygen	≤15μg/L
Iron	≤50μg/L
Copper	≤10μg/L
pH (25°C)	8.5~9.2

5.2 Boiler feed system

The boiler feed system provides for flow of feedwater from the deaerator storage to the economizer inlet of boiler. It also provides for desuperheating spray to the boi1er attemperator.

During normal condition, the outlet water from deaerator will flow to economizer by means of water pump. The outlet water temperature from deaerator is 104℃. Then the water will be heated by high pressure heater. The outlet water temperature from HP heater is 150℃.

The boiler feed system typically contains three (3)×100% capacity electric motor driven boiler feed pumps as its major components. In order to meet different loads of boiler, two of them shall be in operation and one shall be stand by. The boiler feed pump shall be a multi- stage horizontal centrifugal pump driven by electric motor.

The design duty of feedwater pump shall be based on the ability to deliver a water flow corresponding to 115% of the maximum output capacity when operation design ambient air temperature plus spray water requirements for superheater attemporators and when operating at this flow boiler feed pump discharge

pressure shall be able to overcome a system resistance equal to the sum of the drum pressure, the pressure loss through the economizer feed regulation/control valves, feed pipe work up to economizer inlet and static pressure difference between the pump and the boiler drum center line, minus the net positive suction head.

Each pump shall be provided with a suction and discharge isolating valve of gate type and a separate discharge non-return valve.

The pumps shall be designed to provide the feedwater requirements consistent with the turbine-generator design for normal operating conditions.

The desuperheating spray water requirement will depend on the boiler manufacturer's design as well as the boiler rate. The desuperheating water quantity is controlled by regulating valve.

Feedwater from the deaerator storage tank will flow to the boiler feed pumps suction. The deaerator is located at the height of 13m in order to overcome cavitation in the inlet of water pump.

5.3 Condensate system

The condensate system condenses backpressure exhaust steam from turbine generator and provides a flow path to the deaerator.

The condensate system contains the following major components:

Two pumps (2)×100% capacity, in order to meet different loads of boiler, one of them shall be in operation and one shall be stand by.

The condensate system shall be designed to provide deaeration system consistent with the turbine generator design conditions.

During normal operation, condensate shall be supplied to deaerator by one condensate pump (One pump for standby) shall suck condensate from condenser hotwell into the deaerator through condensate pump, two stage ejection extractor, steam sealing heater and low pressure heater.

Mechanical seal flush sleeve and vent sleeve of the condensate pumps shall be provided for prevent air in-leakage into the system.

Each pump shall be provided with a suction and discharge isolating valve of gate type and a separate discharge non-return valve.

The deaerator shall be the direct-contact tray type consisting of a vertical cylindrical shell deaerating section

supported on a horizontal cylindrical shell water storage tank section. The capacity of deaerator is 75t/h; the volume of deaerator water tank: 30m^3; working pressure:1.2 ata; water outlet temperature:104° C.

The deaerator shall be located at elevation of 13m in order to provide sufficient head margin for the boiler feed pumps and shall guarantee reduction of the oxygen content in the feedwater to not greater than 0.007ppm as measured by the HEI method at the storage tank outlet. The deaertor unit shall consist of a deaerator heater, water storage tank, deaerating spray nozzles and/or spray nests, vent condenser, and all necessary pipes, valves and auxiliaries. The equipment shall be provided to maintain the deaerator pressure even when the steam turbine is operated at low load.

The deaereated water storage tank shall have a capacity of 30 m^3, even at normal water level, sufficient to provide for at least 10 minutes running at maximum output capability.

Equipment shall be provided to supply the deaerator with sufficient steam from the main steam during start-up, and low load operation.

5.4 Boiler makeup water and storage system

The boiler makeup water and storage system provides makeup water necessary for the boiler.

The boiler makeup water and storage system consists of the following major components:

One demineralized water storage tank 20 m3 (it is located at chemical water treatment room).

Two(2)X100%capacity demineralized water pump, one is in operation and other one is stand by (they are located at chemical water treatment room).

Alarms are provided for low-low and high-high water levels in the demineralized water storage tank. The water level in the tank shall be displayed in the control room.

The demineralized water is pumped from demineralized water storage tank then discharged by a pipe into a deaerator.

The demineralized water storage tank shall be a vertical, cylindrical, atmospheric, field erected water tank of welded steel construction. The storage tank shall be constructed of carbon steel,. The exterior wall of storage tank shall be coated with epoxy resin and interior wall shall be coated with anti-rust and mixed paint.

Two demineralized water pumps, one is in operation and other one is stand by. It feeds water continuously and driven by electric motor, safety and reliable. The pump materials shall be stainless steel.

6 CHEMICAL WATER TREATMENT

6.1 Service water treatment system

6.1.1 Water quantity

The water quantity of circulation cooled is 8908m^3/h. The production and domestic water quantity Q=21.4 m^3/h, total consumption of fire fighting water Q=468 m^3. The water consumption of every department is shown in the table of water consumption.

The table of water consumption

SN.	Water consumption unit	Daily used (m^3/d)	Max. water consumption (m^3/h)	Remark
1	Circulation cooling water	223392	4654X2	
2	Boiler makeup water	96	4	
3	Cooling water for ID fan	24	1	
4	Cooling water for grate	72	3	
5	Makeup water for feed water pump	24	1	
6	Makeup water for sample	24	1	
7	Consumption water for water treatment	153.6	6.4	
8	Others	72	3	
9	Invisible water quantity	48	2	
10	Total	223905.6	9329.4	

6.1.2 Water quality

Raw water quality from the raw water supplied by the user:

TOTAL HARDNESS (TH)	180
CALCIUM HARDNESS (CAH)	120
MAGNESIUM HARDNESS (MGH)	60
METHYL ALKALINITY (M)	130
TOTAL DISSOLVED SOLID (TDS)	530

pH VALUE (pH)	8-8.3
CHLORIDE	130

6.2 Chemical water treatment system

6.2.1 Function

The function of the Demineralization System is to provide high quality demineralized water for use as makeup to the thermal plant steam cycles. The Demineralization System also supplies the water for various uses for start-up of power plant, test and chemical cleaning.

To meet up the feed water for power boilers requirement, a new single stage demineralized by ion exchange followed with mixed bed exchange demineralized water plant will be supplied for make-up water to the boilers. The water treatment plant shall be of capacity of 40t/h water.

6.2.2 Capacity of system

First fill chemicals for Boiler feed water treatment plant

001 x 7 strong acid resin 18.85 m3
201 x 7 strong alkali resin 18.85 m3

The raw water quality after filtration shall meet the following standard required by the boiler:

Suspension solids	≤2mg/l
Free chlorine	≤0.1mg/l
Oxygen demand	≤2mg/l

The demineralized water quality after treatment is as follows:

Silica, as SiO2	<0.01mg/kg
Conductivity (25°C)	<0.05μs/m
Total Sodium + Potassium	<0.02mg/kg
Hardness	0 μe/l

6.2.3 Process description

According to the requirement on the make-up water quality of the boiler, single stage demineralization ion exchanger added mixed bed exchanger system shall be supplied for the make up water treatment. The coming filtered water shall first pass through a cation exchanger and enter into a CO_2 remover and an intermediate water tank and then flow into an anion exchanger. The demineralized water shall then pass through a mixed bed and flow to a demineralized water tank and from which it shall be delivered to the deaerator by a demineralized water pump.

The demineralization consists of two streams; anion and cation exchangers followed with two mixed bed filters. The streams can be operated in parallel. The exchangers are regenerated with sodium hydroxide and sulfuric acid. The regeneration effluents are mixed in a neutralization tank for pre-neutralisation and led to the effluent treatment plant.

H_2SO_4 shall be used as cation regeneration agent and NaOH shall be used as anion regeneration agent. One complete set of regeneration equipment will be installed.

In order to reduce the corrosion in feed water pipeline and steam & water system, one ammonia adding device shall be installed.

6.3 Equipment list for water chemical treatment

S.N	Item No.	Qty	Specification	
1	74101	2	Bi-flow Mechanical Filter (1 stand – by)	
			Diameter:	Φ2000mm
			Height of filter layer:	2500mm
2	74102	2	Raw Water Booster Pump (1 stand – by)	
			Flow:	65m^3/h
			Head.	0.2MPa
		2	Power:	7.5kW
3	74103	2	Upflow Regeneration Cation Exchanger (1 stand – by)	
			Diameter:	Φ2000mm
			Height of resin layer:	2000mm
4	74104	2	Upflow Regeneration Anion Exchanger(1 stand – by)	
			Diameter:	Φ2000mm
			Height of resin layer:	2000mm
5	74105	1	CO_2 Remover	
			Diameter:	Φ1200mm
6	74106	1	Centrifugal Fan for Ventilation	
			Capacity:	1500~3000 m^3/h
			Full pressure:	1.76kPa
		1	Power:	2.2kW 2900 rpm
7	74107	1	Intermediate Water Tank	
			Volume:	30 m^3

8	74108	2	Intermediate Water Pump (1 stand – by)	
			Flow:	$50m^3/h$
			Head.	0.45MPa
		2	Power:	11kW
9	74109	2	Mixed Bed Exchanger (1 stand – by)	
			Diameter:	Φ2000mm
			Height of resin layer:	2000mm
10	74110	2	Demineralized Water Tank	
			Volume:	100 m^3
11	74111	2	Demineralized Water Pump (1 stand – by)	
			Flow:	$65m^3/h$,
			Head.	0.8MPa
		2	Power:	30kW
12	74112	1	Back Wash Pump	
			Flow:	$50m^3/h$,
			Head.	0.3MPa
		1	Power:	7.5kW
13	74113	1	H_2SO_4 Storage Tank	
			Volume:	$20m^3$
14	74114	1	Acid Metering Tank	
			Volume:	1.5 m^3
15	74115	1	Acid Ejector	
16	74116	1	Acid Mist Absorber	
			Diameter:	Φ500mm
17	74117	1	NaOH Storage Tank	
			Volume:	20 m^3
18	74118	1	Alkali Metering Tank	
			Volume:	1 m^3
19	74119	1	Alkali Ejector	
20	74120	6	Resin Filter	
			Diameter:	Φ125mm
21	74121	2	Ammonia Tank	
			Diameter:	Φ600mm

			Volume.	0.3 m^3
		2	Power:	0.55 kW
22	74122	2	Ammonia Pump	
			Flow:	20 l/h
			Head.	0.5MPa
		2	Power:	0.37 kW

7 STEAM TURBINE AND TURBINE AUXILIARY

7.1 General

The steam turbine and turbine auxiliary will consist of:

- Steam turbine
- Condenser
- Condenser air extraction
- Process steam system
- Turbine room crane

Steam quality:

Silica	Max. 0.10 ppm as SiO_2
TDS	Max. 0.10 ppm
Conductivity	Max. 2 micromhos per cm at 25°C

7.2 Steam turbine

The function of the steam turbine is to accomplish conversion of the thermal energy of steam produced by the boiler to mechanical energy required to drive the generator. The generator converts the mechanical energy to electrical energy, which is transmitted through, the generator breaker to the generator step-up transformer.

The two steam turbines will be medium-temperature, medium-pressure, condensing type, arranged longitudinally and installed indoors.

7.2.1 Main data of steam turbine

Type of steam turbine	Medium temperature, medium temperature, single extraction, condensing type
Model of steam turbine	N12-3.43/0.3
Rated power	12 MW
Pressure before main steam valve	$3.43^{+0.2}_{-0.3}$ MPa (a)
Temperature before main steam valve	435^{+10}_{-15} °C
Rated steam inlet flow	56 t/h
Rated feed water temperature	150 °C
Design cooling water temperature	≤ 26 °C
Rated extraction pressure	0.052 ata
Rotation direction	Clockwise, looking to the generator from the end of steam turbine
Height of turbine center line (to platform on operation floor)	750 mm
Weight of the largest piece of turbine	13.5 t
Weight of turbine rotor	6.9 t
Max. dimension of steam turbine	5500x3150x3265
Stages of steam turbine	1 regulating stage + 10 pressure stage

7.2.2 Major features of steam turbine

The two steam turbines will be condensing units, including a three-stage extraction heating system. The first stage is for steam supply to the high pressure heater, the second stage is for steam supply to the deaerator, and the third stage is for steam supply to the low pressure heater.

The turbine shaft and generator couplings are amply strong to withstand shocks during operation, including generator short circuit conditions and synchronizing out of phase. The couplings will be designed so as to permit easy and rapid disconnection, re-assembly and alignment.

The steam turbine can operate under idling condition after trip-out not less than 15 minutes.

The rear part of the cylinder is equipped with the vent valve for low vacuum protection.

The shaft amplitude, shaft displacement and revolution rate at the main bearing are with 4-20mA standard output for connection to the PLC monitoring interface.

The turbine will be designed with sufficient drainports for moisture removal particularly during start up. The design will include passage ways and interstage drainage where appropriate to avoid erosion damage of low pressure blading in the wet region. The steam turbine will be equipped with one drain flash tank for maximum removal of water and the drain is let into the condenser through the drain flash tank.

The automatic main steam valve and foundation will be fixed by hangers. The steam turbine will be equipped with electric driven turning gears in power of 3kW. The turning gears can be automatically retreated and it will be equipped with manual operating device.

The steam turbine will be equipped with steam lock pressure automatic regulating device and steam lock air extraction device. The steam supply system for steam lock can automatically regulate its pressure under any working condition of the turbine. The steam lock system will be equipped with surge tank.

The steam turbine will be supplied with complete lubricating and control oil system. The oil system is for supply of oil to the regulation and security system, and for bearing lubrication and turning gears. The oil system will consist of reliable main oil supply equipment and auxiliary oil supply equipment. The oil tank in volume of 5 cubic meters will be equipped with exhaust fan and explosion-proof motor. The oil tank will be installed with emergency drain valve. Oil piping will be installed with exposed stem cast steel valves. Two oil coolers in volume of 2x100% will be supplied and the outlet piping of oil coolers will be installed with strainers.

Steam from the boiler will be sent to the steam turbine via the main steam piping. The main steam will pass through pneumatic stop valves before entering the steam turbine.

The steam turbine extraction piping will be equipped with check valves.

The steam turbine will be equipped with automatic main steam valve, which is kept in open position by the oil pressure of turbine. Once the pressure is lost, the valve is tripped and closed,

The condenser neck and the turbine low pressure cylinder will be connected by expansion joints, and be rigidly supported at the bottom. The expansion joints will compensate the downward expansion of the condenser and the rear cylinder.

The thrust force of steam piping beyond the allowed range by the manufacturers will not be applied onto the turbine casing.

7.2.3 Major auxiliary equipment of steam turbine

1	Automatic main steam valve	
1	Double-stage steam jet ejector	
1	Start up air ejector	
1	Drain flash tank	
1	Low pressure heater	F=40 m^2
1	Oil tank	V=3 m^3

2	Oil cooler	F=20 m^2
1	Centrifugal auxiliary oil pump	Q=40 m^3/h, H=1.25 MPa
1	AC gear oil pump	Q=20.5 m^3/h, H=0.353 MPa
1	DC gear oil pump	Q=20.5 m^3/h, H=0.353 MPa
1	Gland heater	F=20 m^2
1	Turning motor	N=3 kW
1	Condenser	F=1000 m^2
1	Oil filter	

All the equipment covered in this section are in conformity to ASME and IEC standards or equivalent.

7.2.4 Steam turbine control, regulation and security system

Steam turbine monitoring: One set of monitoring instruments in 8000 series, to be supplied with steam turbine.

Steam turbine control: EHC electrical/hydraulic regulation system. The controller will be model 505 from WOODWORD USA. The turbine vendor will supply one WOODWORD 505 and one CPC, and perform configuration and one site commissioning.

Steam turbine security: An emergency security system for over speed prevention will be supplied. It will immediately close the main steam valve and control valves to cut off the steam source in case of failure. Additional over speed protection devices and standby assistant emergency stop devices will be supplied.

Automatic protection devices to close the main steam valve and governor valve under the following emergency conditions:

- Over speed
- High bearing return oil temperature
- Low lubrication oil pressure
- Big thermal expansion
- High bearing metal temperature
- High bearing vibration
- Trip from electric remote signals
- Low condenser vacuum
- Big axial displacement of rotor
- Electric control devices stop

<u>Turbine protection devices (ETS)</u>
Functions

The governing system is modularly assembled and can therefore be adjusted according to the industrial demands. The proposed control system contains:
--Over speed protection
--Turbine protection
--Turbine open loop control (control of turbine auxiliaries)
--Interface to the low-voltage switchgear and distribution (MCC)
--Automatic functional groups (sequential automatics)
--Operation and control station with visualization software
-– desktop PC operator station with LCD, keyboard and printer
--Communication interface to the plant control system (DCS) - RS 422,
--Generator control panel interface
--Turboset vibration monitoring (shaft vibration measuring on turbine, bearing vibration measuring on generator and gearbox)

The following protective devices, automatically trip the emergency stop valve when operated:
--Overspeed trip, when turbine speed exceeds rated speed by approx. 10%.
--Thrust bearing trip
--Upon axial displacement of rotor.
--Oil pressure trip
--Upon falling oil pressure in system
--Generator protection
--Manual shut-down
The emergency stop valve can be tripped by hand or from the control room.

7.3 Condenser

One steam condenser of the surface type will be supplied and it is installed with a horizontal single shell and divided water boxes. The steam surface condensers will incorporate two tube bundles transverse to the turbine generator axis and will be arranged to match the turbine exhaust. The condenser has two waterside passes and will incorporate a deaerating hot well and air removal arrangement.

The condenser is designed for maximum continuous operation conditions of the steam turbine. The steam turbine exhaust pressure will be 0.052ata, the circulation cooling water temperature will be 26°C at the operation condition of maximum exhaust.

The condenser will be designed to receive the following exhaust steam, drain and return water, and with good performance of deaerating.

a. Exhaust steam from steam turbine
b. Condensate from steam turbine

c. Drain from steam lock cooler
d. Low pressure heater emergency drain and normal drain in gravity flow stage by stage
e. Warming pipe drain of the main steam piping at start and stop of turbine
f. Drain of trunk drain flash tank
g. Drain of steam turbine and etc.

The cooling area of condenser F=1000m^2. The cleanliness factor of condenser is 85%. The condenser neck and the low pressure cylinder of the steam turbine will be connected by expansion joint, and rigidly supported at the bottom.

Main technical data of condenser:

Model	N1000
Area	1000 m^2
Pressure	0.052 ata
Cooling water inlet temperature	26 °C
Cooling water flow	4460 m^3/h
Mean water velocity in piping	2 m/s
Water resistance	≤ 60 KPa
Weight	23 t

7.4 Condenser air extraction

The condenser air extraction system provides for the venting of the condenser steam space for removal of noncondensable gases during turbine generator operation. It also provides the capacity to rapidly reduce the condenser pressure from atmospheric before unit startup, allowing admission of steam to the condenser. The vacuum breaker valve allows air to be vented into the condenser to reduce the rolldown time of the turbine generator.

The condenser will be installed with two steam-jet air ejectors of 100% volume.

The condenser air extraction system includes:

- Main condenser vent line
- Steam-jet air ejector
- One condenser vacuum breaker
- Piping and valves

The vacuum breaker installed is to break condenser vacuum and reduce the turbine roll down time.

7.5 Main steam system

Main steam system will ensure a safe and reliable operation of the steam turbine and boiler for a continuous heat supply.

Take the emergency into account, one bypass will be installed in the middle of two main steam piping connected with the main steam pipeline.

7.6 Turbine room crane

The turbine room crane will be provided for maintenance and overhaul of the steam turbine, generator and auxiliary equipment.

The crane will be an overhead, double girder bridge type with motor operated main and auxiliary hoists, trolley and bridge. Control of the crane will be performed from a crane supported operating cab.

Technical data of crane:

Span:		16.5 m
Lifting weight:	Main hoist	20 t
	Auxiliary hoist	5 t
Lifting height:	Main hoist	18 m
	Auxiliary hoist	18 m
Lifting speed:	Main hoist	3.5 m/min
	Auxiliary hoist	8 m/min
	Crane bridge	20 m/min
	Trolley	20 m/min

7.7 Generator

The plant will run parallel with the public grid. The plant shall be able to run also in island mode. The turbogenerators will be connected through a block transformer to the 6.3 kV distribution. The insulation method of the stator windings shall be vacuum impregnation. The alternator is to be equipped with proper closed circuit cooling systems (air/water) with (n-1) elements for 100 % capacity. That means that it shall be possible to operate the generator with nominal power with one cooler element out of operation. The coolers shall be in material SS 2343 or AISI 316. All necessary drain, vents and local indications shall be included. Bearing currents to be prevented and provision to be made for indication.

7.7.1 Stator

The stator is a separate unit. The end plates are bolted to the side beams of the lower casing part to achieve maximum stiffness. All dynamic and static loads are thus transmitted direct to the foundation.

7.7.2 Rotor

The rotor shaft is a one-piece forging made of high quality steel. Each pole is surrounded by a single layer copper bar winding. The coils are compressed and cured under heat and pressure. They are insulated from the pole plates and rotor hub by a collar of laminated glass fibre. The interconnections and terminal leads are insulated and braced. The connection leads to the brushless exciter are arranged inside the shaft and insulated against it by a casting of silicone rubber.

Two axial flow fans supply cooling air to the stator and rotor from both sides. The hot air is discharged radial at the centre of the machine and is re-cooled in the air/water heat exchangers mounted on top.

7.7.3 Line side and neutral side equipment

Instrument transformers, Cu strips, supports, bus bar holders are part of MTB or the Generator's enclosure.

7.7.4 Excitation

The generator shall have a directly coupled AC exciter with rotating solid state rectifiers. The max. allowed voltage of the excitation system for 10 s shall be at least 200 %.The system shall be equipped with power system stabiliser to be tuned to improve via the voltage regulator the damping of oscillations of generator and power system.The excitation cubicle shall include local controls, indications and supervisory equipment. Local operations shall be possible. It shall also be equipped with transducers and parallel in- and outputs for control and indications in the mill DCS or with a connection for a bus between the turbine control system and the DCS.

7.7.5 AVR

Automatic Voltage Regulator (AVR) is designed for the excitation control of generators with rota-ting diodes. It is designed with double channel excitation system and can be operated with a generator isolated operation and parallel with a network.

The excitation system consists of two separate control systems, the automatic and manual channel. The automatic channel consists of the automatic voltage regulator AVR, the power factor and reactive power control and all limiters. The manual channel controls the excitation current (excitation current regulator ECR).

The whole system offers comprehensive solution to all technical duties in this special field with modern, highly automatic and yet proven means.

7.7.6 Generator Protection System

Complete control and indication system to be tendered including relay or equal protection for the generator. Digital type microprocessor based relays shall be used in the protection system. The system shall be redundant with two tripping channels, so that a single failure does not render protection in

operation. The generator protection shall be divided into two groups so that the primary protection function and its reserve function are supplied from separate batteries and the tripping circuits and tripping coils shall be doubled to get their supply from separate batteries. Sufficient additional alarm contacts for the mill DCS shall be included or bus connection to the mill DCS through the turbine control system.

7.7.7 Main data of generator

Description	Unit	Data
(1) Type		QF2-15-2
(2) Rated capacity SN	MVA	18.75
(3) Rated output PN	MW	15
(4) Rated power factor COS ϕ N		0.80
(5) Rated stator voltage UN	kV	6.3
(6) Rated stator current IN	A	1718
(7) Rated frequency fN	Hz	50
(8) Rated speed Nn	r/min	3000
(9) Rated exciting voltage UFn	V	152
(10) Rated exciting current IfN	A	364
(11) Stator winding connecting type		Y
(12) Short circuit ratio SCR		0.60
(13) Steady negative sequence current I2/IN	%	8
(14) Transient negative sequence current capability $(I2/IN)^2t$	s	8
(15) Allowed frequency deviation	±%	2
(16) Allowed stator voltage deviation	±%	5
(17) Capability of operating on sub-excited	MW	15(at rated leading power factor cos ϕ =0.95)

7.8 Spare parts

The seller will supply necessary spare parts related to equipment for two years normal operation. The necessary spare parts are mainly listed as follows.

1	Tilting pads of thrusting bearing	1 set
2	Radial bearings	1 set
3	Rotor sealing strips	1 set
4	Lube oil sealing strips	1 set
5	Steam chamber /nozzle box sealing strips	1 set
6	Connecting pieces of front / rear pedestal	1 set

7	Connecting pieces for stationary blade carriers with casing	1 set
8	Connecting pieces for steam chamber / nozzle box with casing	1 set
9	Connecting pieces for main oil pump gear box with front pedestal	1 set
10	“L “ type sealing rings of control valve	1 set
11	Springs, bolts, etc. of barring device	1 set
12	Spring and rods of main stop valve	1 set
13	Cones of control valves	1 set
14	Piston rings and sealing of power oil cylinder	1 set
15	Piston of servo-valve	1 set
16	Axle sleeves of main oil pump gear box	1 set
17	Springs of overspeed trip bolt	1 set
18	Piston of overspeed trip device	1 set
19	Springs, piston ,bolts, thimble etc. of governor	1 set
20	Springs bolts, sleeves etc. of amplifier	1 set
21	Condenser tubes	1 set
22	Nozzles of start-up ejector	1 set
23	Nozzles and tubes of ejector	1 set
24	Axle sleeves and sealing of condensate pump	1 set
25	Axle sleeves and sealing of auxiliary oil pump	1 set

Pumps

-- Spare parts for pumps	for each same size and purpose pump
Mechanical sealing	2sets
Impeller	1
Shaft	1
bearing	1
Shaft sleeve	1
Bolts and nuts	1set
Sealing element or packing material	1set

7.9 Special tools

- For handling of rotors
  - 2 slings
  - 2 collars
  - necessary complementary fittings
  - supports and devices for removing rotors
- For journal bearings removal and change

  - 4 jackscrews
  - collars
- For handling of upper half casing
  - 1 set of adequate slings
  - 1 set of guide rods
- For team blowing
  - 2 special devices for stop valves
- For valve seats removal
  - 1 special extraction tool
- For valves and casing studs tightening and elongation measurement
  - 1 set of stud heating resistant
  - 1 transformer
  - 4 single phase flexible cables
  - 1 set of length calibrated rods for bolts
  - 1 micrometer
- For coupling studs tightening
  - 1 hand operated hydraulic pump
  - 1 flexible hydraulic connection
  - 1 special hydraulic jack
- For rotor transportation
  - Rotor locking sheets
- For hydraulic accumulator
  - Nitrogen/air pressure checking device
- A complete Baroscope set

8 COOLING SYSTEM

8.1 General

The cooling system consists of the following systems:

- Steam condenser system
- Air cooler system
- Oil cooler system

Basic design information for circulating cooling water

Circulating cooling water volume:

Q=4654 m^3/h, including

Condenser	4454 m^3/h
Air cooler	120 m^3/h
Oil cooler	80 m^3/h

8.2 Cooling water system

8.2.1 Main design information

Water circulation system is used for cooling the condenser of steam turbine and air cooler & oil cooler of power station. After heat exchanging with the equipments, temperature of cooling water rises about 9~12℃. The hot water will flows to hyperbolic cooling tower. After exchanged with air in the tower, the hot water is cooled down to 15~26℃ and then flown to the cooling water basin then will be sent back to the condenser by cooling water pumps. There is about 2-4% of the water will be lost during the operation and it will be maker up by service water piping in the mill.

The model of hyperbolic cooling tower is: Diameter at top level: 24m; Inside diameter of foundation: 38m; Outside diameter of foundation: 44m; Height: 60m.

One side filtrater is set in this system, so a portion of the circulation water can be filtrated, in this case the water quality can be reached.

Chlorination or sodium hypochlorite in certain proportion of cooling water will be injected into the circulating water system stream to reduce the microorganism/ biological attaching effect in the cooling water pipes & tunnel. Chemical treatment of the cooling water shall be applied.

8.2.2 Equipment selection and structures

The cooling tower is of a natural counter-flow hyperbolic type. The material of tower main structure is concrete in stead of wood usually applied. In case of wood structure, fire fighting system is not required and skilled carpenters are not required.

1) The circulating water requires bypass filtering treatment for removal of impurities and sludge generated during circulation. Operation and backwash of the valveless filter is fully automatic.

2) The cooling water pump will be model Q=4860 m^3/h, H=24 m. The pump will take water from the basin and transfer to the condenser, air cooler and oil cooler for heat exchanging and finally back to the hyperbolic cooling tower. The water inlet piping of air cooler and the water outlet piping of oil

cooler will be installed with pipe strainers.

The cooling water pump will be provided four sets. In winter two cooling water pumps are running, in other seasons three cooling water pumps are running, this is rational efficiency sensitive method. One cooling water pump is usually standby, this is reliable choice.

3) The chemical liquor will be added into the system to adjust the quality of water, the device includes two solution tanks and two chemical pumps. The volume of tank is $2m^3$, the model of pump is: Q=4-40l/h, H=20 m.

9 OTHER WATER SYSTEM

9.1 Water Fire Fighting Pump

The plant is protected against fire by any one or combination of the following systems.

- Hydrant system
- Automatic sprinkler system
- Portable and mobile chemical extinguisher

The system is designed in accordance with the requirements of the U.S. National Fire Prevention Association codes and standards. Special fire protection provisions are made for the following areas, which are particularly susceptible to fires:

- Cable galleries
- Coal handling areas
- Transformers
- Turbine lubricating oil tank
- Fuel oil storage tanks
- Chemical storage tank
- Etc.

Service water is used for fire protection. One electric, motor driven, fire water pump is provided and tank suction from the fresh water storage tank. One diesel engine-driven pump is installed as a backup system.

9.2 Service Water

The new service water from the turbine building and cooling tower will be provided from existing service water system.

9.3 Sanitary

The sanitary wastes from the plant are managed in a sanitary sewage treatment plant. There will be some septic tanks. The discharge of the plant is monitored to ensure that it is within acceptable limits.

9.4 Waster water treatment system

Wastewater from plant will be collected and treated in the wastewater treatment system, for control of pH, suspended solids and heavy metals. This system will included a waste water pond to receive and store intermittent flows from neutralization basin and partition oil pond.

Chemical water treatment is ion exchanger treatment. There is a few water discharged from filters and ion exchangers. The water contains colloidal substances and salt. The pH value of water in neutralization basin is neutral and meets the requirement of irrigation in local place.

Oil contaminated wastewater from power plant equipment wash and drain shall be routed through a oil-water separator prior to being routed to a partition oil pond. Oil-water separator is set in open ditch in the building, and oil-water separating pond is installed in the site.

The water discharged from the boiler shall enter into blowdown tank after cooled by water.

Storm water from coal pile and ash disposal will include a lined impoundment to collect and store of the storm runoff which is contaminated.

10 COMPRESSED AIR STATION

10.1 General

There will be one air compressor station installed for this project. The compressed air system consists of two parts of the compressed air for boiler area, steam turbine area, chemical water treatment and etc. and the compressed air for instrument control.

10.2 Compressed air demand and parameters

Demand and parameters of compressed air used for power plant boiler area, steam turbine area and chemical water treatment:
Compressed air demand: 360 Nm^3/h; Pressure: 0.7 MPa

Demand and parameters of compressed air used for instrument control:
Compressed air demand: 120 Nm^3/h; Pressure: 0.7 MPa

10.3 Process flow and layout

10.3.1 The air compressor station will be located in the building to the right side of the water chemical treatment plant. The air compressor station consists of screw air compressor, air dryers, filters, air tanks, piping, valves and etc. A part of the compressed air from the air compressor will be sent directly to an air storage tank and then to the power plant through piping for use in systems of dust removing and etc. and the other part will be sent to another storage tank, after drying in air dryers, and then sent through piping for use in the instrument control system. For details of process flow, refer to Flowsheet of Air Compressor Station.

10.3.2 Equipment selection

Two air cooling screw air compressors are selected for the air compressor station. The rated capacity for each air compressor is 8 Nm^3/min, input power of motor is 45kW and outlet pressure is P=0.75MPa. Two sets of micro-heating regeneration air drying device and two air storage tanks are selected. The rated capacity of each air drying device is 3.6 Nm^3/min and the storage volume of each air tank is 7.7 m^3. The air compressors and air drying devices will be one in operation and one standby. There will be no standby for air tank.

11 VENTILATION AND AIR CONDITIONING SYSTEMS

11.1 Ventilation Systems

Ventilation systems are provided in the turbine generator building, pump house, control building, workshop, warehouse and other areas such as diesel oil pump room, air conditioning plant room, demineralizer building and various pump houses.

The electrical room should be equipped with emergency ventilation system, and the emergency ventilation system should also be used to discharge heat generated by the electrical devices.

11.2 Air conditioning Systems

Air conditioning is required in various areas in the plant (including the main control room and administration building) that house control equipment. Air conditioning is provided by individual air conditioning units.

The central monitoring control room should be conditioned by split air conditioner, The operation and installation should be depend upon the requirement of the manufactory.

11.3 Heating Systems

Indoor design conditions

Room	Temperature	Relative humidity	Remarks
Office, Control room	19-21 °C	-	
Electrical board room	17-19 °C	40-60%	
Toilet, Workshop	16 °C		
Meeting room	17-19 °C		
Plant, Pump house	10 °C		

Heating systems are provided in the main building, pump house, workshop, warehouse, office, meeting room and other areas such as toilet. There will be serviced radiator made of cast iron.

Heating systems are provided in the distribution board room and central monitoring control room. There will be serviced radiator made of cast steel in order to prevented the aleak water.

12 INSTRUMENT & AUTOMATION

12.1 General description

The Power plant (including power boilers and turbine generator) will be monitored and controlled by

DCS. The chemical water treatment will be monitored and controlled by PLC.

The instrumentation and system for the project is a microprocessor-based distributed control system. The distributed control system is designed to provide:
- High reliability
- Failsafe operation
- Capability of being upgraded
- High productivity
- Safety for equipment and personnel
- Minimum number of discrete display and recording instruments

The distributed control system includes the following functionally distributed subsystem:
- Distributed digital control for closed loops
- Programmable logic controller for open-loop controls
- Operator console (unit control board)
- Process data acquisition
- Supervision subsystem(engineer console)
- Programming subsystem
- Historical data storage, retrieval, and calculation subsystem

These subsystem are designed to ensure:
- One to two-second response time
- 100 ms data update rate
- 1 ms data resolution for sequence of events points

The distributed control system includes adequate redundancy at various levels. The system is designed for “fail-safe” operation and is in full conformity with the specifications and recommendations of codes and standards of recognized international technical bodies and institutes.

12.2 Scope of supply

- All necessary field instruments, transmitters, control valves, on-off valves, motor valves, auxiliary equipment, wire and cables, installation materials.
- DCS system, include necessary hardware and software.
- PLC system, include necessary hardware and software.
- All instrumentation engineering documents.

12.3 Engineering standard of instrumentation

- Standard signal
  - Electronic standard signal: 4~20 mADC
  - Pneumatic standard signal: 0.02~0.1 Mpa
- All materials will be suitable for process requirement.

- Standard power supply is 220VAC, 50Hz, single phase, or 380VAC 50Hz, three phases.
- Signal cable will be shield cable, 1.0mm^2.
- Air supply tube will be nylon, D6x1 or D8x1.
- Instrument pulse pipe will be stainless steel, D14x1.

12.4 Process Measurements

- Temperature measurement
  - Up to 300℃, resistance temperature detector Pt100 or bimetallic thermometer.
  - Over 300℃, thermocouple will be used
  - Normally integrated temperature transmitter will be used.
- Pressure measurement
  - Pressure gauges
  - Normally pressure transmitter
  - Pressure transmitters with diaphragm
  - Diaphragm pressure transmitter with capillary
- Level measurement
  - Float level indicator
  - Level switch
  - Level transmitter with diaphragm
  - DP transmitter
- Flow measurement
  - Water flow meter
  - Throttling device and DP transmitter
  - Magnetic flow meter
  - Flow switch
  - Vortex flow meter

12.5 DCS system specification

The DCS system is standardized and of rigid design for location in industrial control room. The system includes necessary display for operation and dynamic process information, and also safety interlocking, alarms. “Trends” display can be used for easy process check-up; alarms and report can be printed via printers in control room.

The DCS includes 3 operator stations (OS), one of OS will be also use as engineering station, and also include 2 printers.

Main feature of DCS control system:

- Open system structure, easily expanding in future.
- Use of only one engineering tool for configuring the automation functions and the operator

interface with displays and logs.

- Automatic generation of the entire communication between process and operator stations.
- Lower cost and time investment for data input due to a system uniform database for process and operator stations, leading to data consistency within the entire system.
- The operating system for DCS will be based on Microsoft Windows NT, it is convenience for operator training and operating, and also easily for engineering configuration.
- The engineer station located in each control room will do the configuration of DCS system.

The operator and engineer station will be at least P4/2.0GHz, and 256M RAM, 19”CRT.

12.6 PLC for chemical water treatment

One set of PLC system will be applied to the chemical water treatment, include one operator station and one printer. The operator station will be control room.

12.7 Power boiler instrument list

Item	Tag	Application	QTY
1	FIRCQ	Super heated steam flow of 1/2# boiler	2
2	PRA	1/2# Boiler steam pressure	2
3	TRA	1/2# Main temp.	2
4	HS	1/2# Super heater outlet valve	2
5	TIC	1/2# SH outlet header temp.	2
6	PI	1/2# SH outlet header press.	2
7	HS	Start up vent motor valve	2
8	PI	1/2# Boiler drum pressure	2
9	FIRCQ	Feedwater flow of 1/2# boiler	2
10	PIA	1/2# Boiler FW pressure	2
11	TI	FW temp. of 1/2# boiler	2
12	PI	1/2# ECO inlet water pressure	2
13	LICA	1/2# Drum level	2
14	LIS	1/2# Drum level	2
15	HS	1/2# Drum emerg. Drain valve	2
16	FRQ	1/2# Temp. reducer water flow	2
17	TI	Temp. reducer inlet steam temp	2
18	TIC	Temp. reducer outlet steam temp	2
19	HIC	Reduced temp. water motor valve	2
20	AIC	O2 of 1/2# boiler FG	2

21	PI	1/2# DF outlet air pressure	2
22	TI	1/2# Air heater outlet air temp.	2
23	PI	1/2# Air heater outlet air press.	2
24	PI	1/2# SH outlet FG pressure	2
25	TI	1/2# SH outlet FG temp.	2
26	TI	1/2# ECO outlet FG temp.	2
27	PI	1/2# ECO outlet FG pressure	2
28	PICA	1/2# Furnace pressure	2
29	TI	1/2# Air heater outlet FG temp.	2
30	PI	1/2# Air heater outlet FG press.	2
31	PICA	1/2# Bed pressure	8
32	PISA	Main feed water pressure	1
33	PISA	1/2/3# Feed water outlet press.	3
34	PICA	Dearator pressure	1
35	LICA	Dearator level	1
36	TI	Dearator water temp.	1
37	TI	Continuous blowdown heater inlet	1
38	TI	Continuous blowdown heater outlet	1
39	TI	Make-up water preheater outlet	1
40	LISA	Flash vessel	1

12.8 Turbine generator instrument list

Item	Tag	Application	Qty
1	FIRQ	Turbine main steam flow	2
2	PI	Before motor main stop valve pressure	2
3	TIA	Before motor main stop valve temp.	2
4	HS	Main steam motor valve	2
5	PIA	Before auto main stop valve pressure	2
6	PIA	After auto main stop valve pressure	2
7	TIA	After auto main stop valve temp.	2
8	PI	After regulating steam pressure	2
9	TI	Exhaust champer temperature	2
10	PI	Exhaust champer pressure	2
11	FIRQ	Steam flow	2
12	PRSA	Main steam pressure	2
13	TI	Main steam temp	2
14	HS	Steam motor valve	2

15	TI	Condenser inlet Temp.	2
16	LIA	Condenser hot well level.	2
17	PI	Condensate pump outlet main press.	2
18	TI	Condensate pump outlet main Temp.	2
19	FIRQ	Turbine condensate flow	2
20	TI	Turbine condensate Temp.	2
21	CI	Turbine condensate conductivity	2
22	PISA	Vacuum inside condenser	2
23	PI	Condenser cooling water inlet press.	4
24	HS	Condenser cooling water inlet valve	4
25	PI	Condenser cooling water outlet press.	4
26	HS	Condenser cooling water outlet valve	4
27	PI	Water ejection pump outlet press.	2
28	TI	Air cooler inlet air temp.	2
29	TI	Air cooler inlet water temp.	2
30	TI	Air cooler outlet water temp.	2
31	PIA	Main oil pump outlet pressure	2
32	LIA	Turbine oil tank level	2
33	PISA	Lube oil pressure	2
34	PI	1st pulsating oil pressure	2
35	PI	2nd pulsating oil pressure	2
36	PI	Governor oil pressure	2
37	TI	Oil cooler inlet oil Temp.	4
38	TI	Oil cooler outlet oil Temp.	4
39	PI	Oil pressure for axial displacement	2
40	TISA	Temp. of main thrust pad	20
41	TISA	Return oil temp. of thrust bearing	4
42	TISA	Temp. of thrust journal bearing bush	4
43	TISA	Return oil temp. of turbine front bearing	2
44	XIA	Rotor (front bearing) vibration	2
45	TISA	Temp. of turbine rear bearing bush	4
46	TISA	Return oil temp. of turbine rear bearing	2
47	XIA	Rotor (exhaust casing) vibration	2
48	ZIA	Axial displace of turbine rotor	2
49	SIA	Turbine speed	2
50	SI	Generator frequency	2
51	JI	Generator power	2
52	TISA	Temp. of Gen. front bearing bush	4
53	TISA	Return oil temp. of Gen. front bearing	2

54	TI	Temp. of Gen. rear bearing bush	2
55	TI	Generator stator coil temp.	12
56	TI	Generator stator iron temp.	12
57	TIS	Lube oil temp. of Generator	2

13 ELECTRIFICATION

13.1 General

13.1.1 All electrical equipment and materials shall be of high quality and reliable.

13.1.2 All electrical equipment shall, if not otherwise specified ,comply with the applicable following codes, standards and recommendations:
- IEC International Electrotechnic Commission
-GB China National Standard

13.2 Scope of Supply

The coal fired steam power plant shall comprise two identical 12MW BTG units; 6.3kV substation and common auxiliaries.

These electrical equipment will be supplied:
- Generator
- Diesel generator
- Step up transformer
- Unit auxiliary transformer
- 6.3kV switchgear
- 0.4kVMCC
- Control and relaying
- SCADA system
- Uninterruptible power supply system(UPS)
- Plant DC system
- Communication system
- Power cable and control cable
- Cable tray
- Lighting system
- Lightning protection and grounding
- Spare
- etc.

13.3 Power system

13.3.1 Two 6.3kV busbars will be built in the mill extension. The bus-tie switchgear will build between two 6.3kV busbars. Two outgoing lines connected to the PLN gird on overhead. Two incoming lines connect the step up transformers. The transformers are 6.3/0.4kV 16MVA.

13.3.2 Two unit auxiliary transformers will be build for the power plant service motors.

13.3.3 One spare unit auxiliary transformer will be build.

13.3.4 Grounding system

High voltage	6.3kV	Neutral isolated
Low voltage	400/230V	Neuter grounding solid

Detail see electrical single line drawing

13.4 Design documentation and diagram of the electrical engineering

The design documentation and diagram of the electrical engineering shall be following:

- Document schedules.
- Main electrical single line diagrams.
- Single line diagrams for switchgears.
- Cable tray layouts.
- Cable layouts and elevations for power, control and signal cables.
- Cable schedules and connection lists.
- Electrical room equipment, transformer arrangement and hole openings.
- Motor control center (MCC) schematic diagrams.
- Switchgear interconnection diagrams.
- MCC interconnection diagrams.
- Interlocking logic diagrams.
- Motor lists.
- Electrical bill of materials.
- Operation, maintenance and installation instruction manuals.
- The setting values and calculation for protection relays.
- Calculation for short circuit and voltage drop.
- Test report for all electrical equipment. Detail specification for each and ndividual equipment.
- Grounding system engineering.
- Lightning protection design.
- Lighting design engineering.
- Battery and battery capacity design.
- Fire alarm system design
- Lighting layout design.
- Emergency lighting layout design.
- All drawings, data, calculations and manuals will be written in English.

13.5 Power consumption of plant motors

The estimate installed power of the project will be 3980kW, the estimate demand power will be 2540kW.

13.6 Protection relay and automatism equipment

The protection relays and automatism set shall be the microcomputer protection device. The following Protection relay and automatism equipment will be installed:

13.6.1 Generator

- Differential
- Earthing fault(one site grounding for stator)
- Over voltage
- Over temperature
- Over current
- Excitation fault
- Under voltage
- Over load
- Automatic manual synchronizing system
- Automatic adjust excitation
- Others

13.6.2 6.3kV outgoing line

- Current and voltage fast protection 3ph
- Time-delay current protection 3ph
- Over current protection 3ph
- Earthing fault
- Auto reclosing relay
- Automatic and manual synchronizing system

13.6.3 6.3/0.4kV transformer

- current fast protection 3ph
- Over current protection 3ph
- Earthing fault
- Over temperature (over 800kVA)

13.6.4 Plant 0.38kV motor

The main plant motors will install microcomputer motor protection device.
—current fast protection 3ph
— Over current protection 3ph
—Over load protection
— Long starting time protection
— Earthing fault
— Low voltage
— Others

13.7 SCADA system

Supervisory, substation protection and monitoring system (SCADA System) concept:
Scope of supply will consist the following:

13.7.1 Power Management System :

(1) All the required hardware (CPU, PLC, Desk Top PC's, printers) and software (operating system, drivers, monitoring/metering/protection and etc.)
(2) All the interface (connectors, cables, converters and etc.).
(3) Communication with the PLN dispatch centre.
(4) All communication cables will be designed with redundancy.
(5) Design detail shall be discussed with purchaser.

13.7.2 Control Building Equipment :

(1) One large animated mimic panel with display meters and LED's .
(2) Digital display meters for A, V, KW, KWH, KVAR, KVARH, PF, Frequency, CB position, Fault alarm (for each incoming and distribution feeders 6.3kV VCB system and generators) and etc.
(3) Manual load shedding capability (On/Off switches, selector switches for each incoming and distribution feeders and etc.).
(4) Design details shall be discussed with purchaser

13.7.3 Data acquisition, monitoring, reporting and database functions.

13.7.4 Event and alarm monitoring functions.

13.7.5 Maintenance, operation guide functions.

13.7.6 Load shedding and other safety features.

13.7.7 Power price calculation and other features.

13.7.8 Other functions and features.

13.7.9 All the required materials for installation works for the above system.

13.8 DC system

DC system will comprise of the following:
- Stationary batteries (220V DC)
- Battery charger connected to the LT switchboard
- 230V DC distribution switchboard
- Other accessories

The battery shall be Nickled-Cadmium type.
The battery charger shall be monitor mode and automatic charging mode.

13.9 Lighting

13.9.1 Lighting voltage shall be 220V, single phase, 50Hz

13.9.2 Illumination levels

- 300 lux in control rooms and offices
- 200 lux in switchgear room and MCC room
- 200 lux in generator room and loading areas
- 50 lux on stairs and platforms
- 25 lux in the yard

13.9.3 Luminaire

Fluorescent lamp for control room, offices and some indoor working areas.
Incandescent lamp for some emergency lighting, small room, etc.
Color-improved mercury or similar types with low energy lights for high building or structure, large working areas, flood lights. etc.

13.9.4 Emergency lighting

The emergency lighting unit incorporated with battery-rectifier, normally will be used in process departments and other buildings.
The emergency lighting for control room and other important places within the power plant shall consists of incandescent lamps fed from the 220V DC battery unit.

13.10 Grounding

1. The 20kV and 6.3kV system normally will be neutral isolated.
2. The low voltage power distribution system normally will be neutral solid grounded (TN system).
3. The overall resistance shall not exceed 1 ohm for any path to grounding.
4. Conductors may be bare copper wire or galvanized steel.

13.10.1 Communication and Uninterruptible power supply system (UPS)

Any required equipment and communication service will be provided.
One set of uninterruptible power supply system (UPS) (30kVA) will be provided

13.10.2 Technical specification for electrical equipment

All enclosure and equipment shall be tropicalized.

Detail see technical Schedules

13.11 6.3kV switchgears

Switchgear shall be complete with protection and other necessary metering, testing, operating devices and special tools.
The space heater shall be installed

13.12 6.3kV circuit breaker

The circuit breaker consist of spring charging of manual and motor driven. The control voltage of the circuit breaker is 220DC.
The space heater shall be installed

13.13 380V switchboard

The circuit breakers in the switchboard shall be of draw out or fixation type. The Cubicles shall be arranged in free standing vertical assemblies with ten small size starters at most in a single stack. The bottom enclosure of each stack should not contain a starter, it may be used for connections and fittings. The center itself be sized for future expansion. The starter and all controls for each motor shall be in single enclosure.
An automatic space heater shall be installed.

13.14 Ransformers

The step up transformers will be oil immersed type.
The unit auxiliary transformers and emergency unit auxiliary transformer will be try type.
Detail see technical Schedules.

13.15 Motor

Low voltage AC Motor
Most of the motors will be squirrel cage induction type, and normally started directly on line. Star-delta starter will be supplied as necessary. Motors from 0.37 to 200kW shall be 380V.

—Type
—Rated voltage 380V
—Frequency 50Hz
—Insulation class F
—Protection class IP54

13.16 Cables and Wiring

All conductors shall be copper.
Armored cable shall be used except where specific applications require conduits.

1. Low voltage power cable
   —Type Series VV or YJV
   —Rated voltage 1kV
   —Insulation PVC or XLPE

2. High voltage power cable
   —Type Series VV or YJV
   —Rated voltage 6kV
   —Insulation PVC or XLPE

3. Control cable
   —Type Series KVV
   —Rated voltage 0.5kV
   —Insulation PVC

13.17 Spare parts

The Vender shall supply spare parts for two years operation.