B-R POWERGEN LTD.

TENDER DOCUMENT

FOR

CONSTRUCTION OF SREEPUR 150 MW (±10%) HFO BASED POWER PLANT PROJECT.

VOLUME 2 OF 2 (PART A)

TECHNICAL REQUIREMENTS

Volume - 2 (Part A) Technical Requirements

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Section 1

Description of The Project

Sreepur 150 MW±10% Power Plant (HFO fired engine Generating Set) Project.

TECHNICAL REQUIREMENTS

DESCRIPTION OF THE PROJECT:

A Power Station with HFO based Engine Generator Sets of 150 MW ± 10% total net capacity at site conditions (35^0C, 1.013 bar, 98% R.H.) is intended to be set up by B-R Powergen Ltd. at Barama, Sreepur, Gazipur a district adjacent to Dhaka, the capital of Bangladesh.

The proposed Plant consisting of maximum identical units having capacity not less than 10MW will be installed in the space, as shown at the site layout. The Project will be implemented on turnkey basis with ECA/Buyers`s Credit.

The Power Station will be connected with Sreepur 230/132/33 kV Grid Sub-Station through power plant's own switchyard to be built and other electrical equipment to be provided within this contract. In out from the transmission line and the hook-up to the gantry of power plant switchyard will be done by PGCB. **All the electrical equipment to be supplied with considering its short circuit rating not less than 40 kA.**

Climatic Conditions:	Sub-Tropical Monsoon
[To be considered in	Temperature: 5^0 C to 45^0 C
Plant design]	Relative Humidity: 36% to 100%
	Annual Rainfall: 120 cm to 345 cm
	Wind Velocity: 240 km/hr
	Seismic Horizontal Ground Acceleration: 0.28g

The project may be classified into the following broad areas. Details are however given later in the scope of work.

1. Survey preparation of drawing, land development, landscaping of the proposed site.
2. The supply and construction of the Power plant equipment.
3. Equipping of 132 KV material/equipment at the HV switchyard of the power plant.
4. Supply and Construction of all civil work including control room, administrative building, store, workshop, internal roads, boundary, Dormitory etc.
5. Supply and construction of entire Fuel system for the plant, fire protection system etc.

Section 2

Scope of Work

2. Scope of Work

2. Scope of work

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2.2 132 kV Switchgear, equipment and Transformers

2.2.1 132 kV Switchgear, equipment

2.2.2 Step up Transformers and Associated equipment

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2.20 Office Equipment

2.21 Electrical Workshop Tools

2.22 Machine Shop Equipment & Tools

2.0 Scope of Work.

The work stated in this specification shall cover the complete design, engineering (**including supply of all calculation & settings**), manufacturing, inspection, testing, supply, delivery to the site, construction, erection installation, testing & commissioning, commercial operation and supervision of operation & maintenance for the first twenty four (24) months after satisfactory performance tests of a Generating Unit, and associated equipment at Barama, Sreepur, Gazipur on full turnkey basis.

The equipment provided shall be of proven type and design, having total net rating at site condition (35^0C, 1.013 bar, 98 % relative humidity) of 150 MW $\pm$ 10% power plant consisting of identical units of engine generators (heavy duty, low/medium speed, 4 stroke diesel cycle engine-HFO fired. The Net Power Output shall be measured at HT/Secondary side of Step up transformer excluding auxiliary consumption and transformer loss.

The work shall be carried out in accordance with the conditions of this contract, and shall include but not necessarily be limited to the following major items.

2.0. POWER GENERATION

2.0.1 **GENERATING SETS**

Design, manufacture, supply, installation, testing commissioning of stipulated number of engine generating sets complete with all auxiliary and ancillary equipment and systems (including but not limited heavy and light fuel handling- storage and cleaning system, lubricating system, cooling system, air intake system, exhaust system, heat recovery steam generating system, water treatment system etc.). Some description of these systems is stated in the later part. These description may not be complete in all respect, so, the work have to carried out in such a way that all excluding the mentioned equipment/ system any other equipment/ system deemed to be necessary for prudent engineering practice, those have to be incorporated.

2.0.1.1 ENGINE

2.0.1.2 GENERATOR

2.0.1.3 BASE FRAME including

Common base frame engine part

Common base frame generator part
Fastening equipment (set)

2.0.1.4 ELASTIC MOUNTING
Steel springs (set)

2.0.1.5 COUPLING

Flexible coupling

2.0.1.7 CONNECTIONS

Flexible connections between engine and external piping
- Flexible hoses and gaskets (set)
- Cooling water bellows (set)
- Exhaust gas bellows

- Charge air bellows compensator

2.0.1.8 PLATFORMS

Engine & its auxiliaries maintenance platform prefabricated

2.0.2 MECHANICAL AUXILIARY SYSTEMS

2.0.2.1 AUXILIARY MODULES

Engine auxiliary module with integrated compact booster including
- Fuel oil filter
- Fuel booster pump
- Return fuel pump
- Fuel oil cooler
- Return fuel tank
- Lubricating oil automatic filter
- Lubricating oil cooler
- Pre lubricating oil pump
- Pre heating unit
- Thermostatic valve lubricating oil back-up cooler
- Thermostatic valve high temperature water system
- Thermostatic valve low temperature water system
- Pressure increasing pump
- Steam heater
- Piping and insulation
- Valves and gauges
- Module control panel

Exhaust gas module
- Low temperature expansion tank
- Charge air silencer
- Exhaust gas branch pipe
- Piping and insulation
- Oil mist separator

Pipe rack

2.0.2.1 FUEL SYSTEM

2.0.2.1.1 -LIGHT FUEL OIL SYSTEM including
-Light fuel oil unloading pump unit
-Light fuel oil unloading measuring unit
-Light fuel oil tank
-Light fuel oil tank equipment
-Light fuel oil transfer pump unit
-Light fuel oil day tank
-Light fuel oil day tank equipment
-Light fuel oil feeder unit
-Light fuel oil feeder pump with Variable Frequency Driver (VFD) for steady su pply pressure to Engine
- Automatic filter

- Manual by-pass filter
-Piping and valves light fuel oil system inside engine hall
-Piping and valves light fuel oil system outside engine hall

2.0.2.1.3 HEAVY FUEL OIL SYSTEM including
Heavy fuel oil unloading pump unit
Heavy fuel oil unloading measuring unit
Heavy fuel oil storage tank
Heavy fuel oil storage tank equipment
Heavy fuel oil transfer pump unit
Heavy fuel oil storage tank suction heater
Heavy fuel oil buffer tank
Heavy fuel oil buffer tank insulation
Heavy fuel oil buffer tank equipment
Heavy fuel oil separator unit
- Separator
- Delivery pump
- Strainer
- Steam heater
- Sludge tank
- Sludge pump
- Steel frame
- Control panel
- Interconnection pipes, flanges, seals and valves
Heavy fuel oil day tank
Heavy fuel oil day tank insulation
Heavy fuel oil day tank equipment
Heavy fuel oil feeder unit
- Heavy fuel oil feeder pump with Variable Frequency Driver(VFD) for steady supply pressure to Engine
- Automatic filter
- Manual by-pass filter
- Viscosity control system
Piping and valves heavy fuel oil system inside engine hall
Heavy fuel oil trace heating material inside engine hall
Heavy fuel oil pipe insulation inside engine hall
Piping and valves heavy fuel oil system outside engine hall
Heavy fuel oil trace heating material outside engine hall
Heavy fuel oil pipe insulation outside engine hall

2.0.2.2 LUBRICATING OIL SYSTEM including
Lubricating oil separator unit
Lubricating oil unloading pump unit: fresh oil
Lubricating oil storage tank: fresh oil
Equipment for lubricating oil storage tank: fresh oil
Lubricating oil service tank
Lubricating oil service tank equipment
Lubricating oil transfer pump unit (mobile)
Lubricating oil transfer pump unit (stationary)
Lubricating oil storage tank: used oil
Lubricating oil unloading pump unit: used oil
Equipment for lubricating oil storage tank: used oil
Piping and valves lubricating oil system inside engine hall
Lubricating oil system pipe insulation inside engine hall

Piping and valves lubricating oil system outside engine hall
Lubricating oil system pipe insulation outside engine hall

2.0.2.3 COMPRESSED AIR SYSTEM including
Starting air bottle
Starting air compressor unit – consists of two units each two stage type
Starting air compressor unit – consists of one units each two stage type
Instrument air compressor unit
Instrument air bottle
Piping and valves compressed air system (set)

2.0.2.4 COOLING SYSTEM
Cooling radiator/ tower
Cooling radiator/ tower legs (set)
Cooling radiator/ tower ladder and railings
Maintenance water tank units (fresh water)
Piping and valves maintenance water system (set)
Piping and valves cooling system inside engine hall
Piping and valves cooling system outside engine hall

2.0.2.5 CHARGE AIR SYSTEM including
Charge air filter
Charge air silencer
Ducting charge air system (set)

2.0.2.6 EXHAUST SYSTEM (with stack height not less than 50m) including
Exhaust gas silencer
Bellows for exhaust gas silencer
Ducting exhaust gas system (set)
Bellows for exhaust gas ducting
Insulation exhaust gas ducting (set)
Exhaust gas stack pipe with drain

2.0.2.7 STATION SUPPORT SYSTEM

2.0.2.7.1 OILY WATER SYSTEM including
Oily water transfer pump units
Oily water buffer tank with heating and gravity separation compartments
Oily water feed pump unit
Automatic oily water treatment unit
Sludge tank with heating
Sludge loading pump unit
Piping and valves with heat tracing
Sludge disposal

2.0.2.7.2 WATER TREATMENT SYSTEM including
Water treatment unit
Treated water storage tank
Water booster unit
Piping and valves treated water system (set)

2.0.2.7.3 FIRE FIGHTING SYSTEM associated with the Engine and other systems

2.0.2.8 HEAT RECOVERY SYSTEM

2.0.2.8.1 STEAM GENERATION SYSTEM
STEAM GENERATION SYSTEM FOR FUEL and ENGINE HEATING including
Exhaust gas boiler
- Inlet and outlet hoods with inspection doors
- Modulating exhaust gas by-pass damper with actuator
- Manual steam soot blowing equipment

- Shut-off valves
- Blow-down drain
- Safety valve
- Relief valve
- Pressure switches
Level switches
- Level control device
- Insulation and cladding
- Counter flanges, bots, nuts and gaskets
- Mounting supports
- Boiler service platform

Bellows for exhaust gas boiler
Heat recovery container
- Feed water tank
- Feed water pump
- Chemical dosing unit
- Blow-down tank
- Local control panel
- Light fuel oil fired boiler for steam generation
- Oil detector

Steam header
Boiler washing water tank
Boiler washing water pump
Piping, valves and insulation for steam generation system for fuel heating (set)

2.0.2.9 Other miscellaneous System/equipment/materials for mechanical auxiliary system

2.1 Emergency Diesel Generating Set

One (1) set of emergency diesel generating set complete with ancillary equipment shall be of minimum 500 KVA [pf 0.80] having diesel storage capacity for 8 hrs continuous operation for supplying power in case of grid failure to start all engines auxiliaries to facilate engine start after grid available. EDG shall be of automatic starting system including quick start & loading capability. The starting system shall be capable of carrying out at least five (5) consecutive start without auxiliary power supply. A reliable battery charging facility to be provided.

EDG synchronizing with LV facility will be provided to synchronize as per requirement.

2.2 132 Kv Switchgear, Equipment And Transformers

2.2.1 132 Kv Switchgear Equipment

(1) One (1) lot of 132 kV circuit breaker [3 phase trip, Dead/ **live** Tank type] with the following features :

Type	: SF6, Dead Tank/live tank
Rated voltage	: 145 kV (Max)
Rated insulation level	
Lighting impulse withstand voltage	: 650 kV (Peak)

(1.2/50 micro sec).

Power frequency withstand voltage (for 1 mm.)	: 275 kV
Rated frequency	: 50 Hz
Rated nominal current	: 1250 A
Rated Interrupting current	: 40 kA rms [3 sec]
Operating duty (2.5 cycle)	: 0-0.3 sec-CO-3min-CO
Interrupting time	: 50 m sec (max.)
Operating mechanism	: Hydraulic/Motor operated & Spring latch

2) One (1) lot 132 KV Current Transformers. (Sufficient **Core**) with considering main & back up tariff meter.

3) One (1) lot 132 KV Voltage Transformers. (Sufficient **Core)** with considering main & back up tariff meter.

4) One (1) lot 132 KV Lightning Arresters.

5) One (1) lot of 132 KV Isolators.

6) One (1) lot of steel structures for supporting the switchgear, equipment, posts and beams and gantry structures.

7) One (1) lot of suspension/post insulator string sets, tension insulator string sets and station post supporting insulator set with necessary hardware.

8) One (1) lot of shield wire connectors and necessary hardware.

2.2.2 Step-Up Transformers And Associated Equipment:

1) Three (03) nos. of three phase step-up transformers (capacity as specified in Clause 5.2.2) and associated equipment with the following features.

Type	: Oil immersed Single phase, outdoor power transformer
Rating	: To meet the required of the specification as stated in Clause 5

Voltage ratio of single Three (03) phase transformer at full load : 11/132

Connection [HV-LV] : Ynd_1

	HV winding	LV winding
Rated insulation level	:	
Lighting impulse Withstand	: 650 kV (Peak)	75 kV Peak

Voltage (1.2/50 micro sec.)

Power frequency withstand Voltage (for 1 min).	: 275kV	28kV
Impedance voltage	: Shall be within the range of 15% and 18%	
Tap changer	: On load at high tension winding 132±8 x 1.25 %.	
Termination		
High tension side	:Outdoor bushing for Cable Pot Head	
Low tension side	:11 kV Isolated & insulated phase bus duct and XLPE cables.	

2) One (1) lot of associated equipment.

2.3. Auxiliary Transformer and Associated Equipment

1) Two (2) set of auxiliary transformer (one for operation, one for redundant) and associated equipment with the following features:

Type	: Oil immerse, three phase and two windings, outdoor power transformer.	
Rating	: To meet the requirement of the Specification	
Rated high voltage	: 11 kV	
Connection	: Ynd_{110}	
Rated insulation level	: HV Winding	LV Winding
Lighting impulse		
Withstand voltage (1.2/50 micro sec)	: 75 kV (Peak)	60 kV (Peak)
Power frequency Withstand voltage (For 1 mm).	: 28 kV	22 kV
Impedance voltage	: shall be within the range of 5% and 7.5%	
Tap changer	: Off-current on high tension winding ±5%	
Neutral grounded	: Solidify grounded	

2.4 Control And Protection System

The Engine generating plant shall be capable of un-attended operation under local unit control, and shall also be capable of remote control from the central control room within the site area. The automatic start-up and shut down sequences shall be initiated by push button on either the local control panel or the central control panel. Synchronisation shall be automatic with provision for local and remote manual control.

In addition to the unit local control and protection panels/HMI, the following panels shall be provided in the central control room.

a. Engine generating unit remote unit control desks/ HMI [Industrial grade] including microprocessor based control system. Detail of unit control system shall have to be furnished as per designer's recommendation including data logging, storage, printing facility etc.

b. 132/11 KV substation control desk/based on substation Auto Control System.

c. Required No. of control and protection panel for 132 KV circuits breaker (as required)

d. One (1) 11 kV common switchgear control desk board.

e. Required No. of auxiliary Power supply control desk boards.

f. One (1) synchroniser panel (Swing type) with provision of Auto and Manual synch System.

2.5 Other Mechanical System

a. Piping between the on-base equipment and the off base Equipment.

b. Painting, including finished coat and special paints required for corrosion protection and high temperature resistance.

c. Design, operation and maintenance manuals, including drawings in English.

d. All other work necessary for the proper operation and maintenance of the Engine generating power plant.

c. Lubricating oil for flushing and for the initial filling.

f. All lubricant and chemical additives.

g. Liquid Fuel handling facilities including metering & control.

2.6 Other Electrical System

a. One (1) lot 415V power Centre.

b. One (1) lot 41 5 V common power Centre.

c. One (1) lot 415 unit motor control centre for each engine gen. set.

d. One (1) Lot 11 kV XLPE power cables (copper)

e. One (1) Lot Low Voltage power cables (copper).

f. One (1) Lot Control and instrument cables (copper).

g.	One (1) lot	Race way materials
h.	One (1) lot	Grounding system.
i.	One (1) lot	lighting and small power supply
j.	One (1) lot	Communication system including PLC, PABX, paging System
k.	One (1) lot	DC power supply system including 2 (two) banks of 125 V Battery (NiCd, Alkaline) and 2(two) sets of battery chargers (Thyristor type) and other associated facilities.
l.	One (1) lot	UPS for unit control system in addition to Control & Communication system.

2.7 Maintenance Facilities

a.	Two (2) Set	Overhead electric crane for Engine hall [capacity 5 ton each; Capacity will be sufficient enough to lift the heaviest weight of any component of a engine/generator/equipment in the engine room during maintenance]
b.	One (1) Set	Overhead electric crane for Ware house [capacity 3 ton]
c.	One (1) Set	Overhead electric crane for Workshop [capacity 2 ton]
d.	Two (2)	5 ton Fork lifter.
e.	One (1)	1 ton single cab pick-up (**Japan** made).
f.	One (1)	2 ton Double cabs (**Japan** made).
g.	One (1)	Microbus (12 seats, **Japan** made).
h.	One (1)	Jeep (5 doors, **Japan** made).
i.	One (1)lot	Special tools etc.

2.8 Fire Fighting Facilities

a.	One (1)lot	Foam Based Fire-fighting facilities.
b.	One (1) lot	Hydrant system including water main, hydrant Stands, hydrant gun, hoses, motor driven and engine driven fire fighting pumps, jockey pump etc.
c.	One (1)lot	Portable fire fighting equipment.

2.9 Building and Civil Works

Site development, site preparation, soil investigation, cleaning, levelling of site, reclamation; setting out of plant, design and construction of all foundations for the equipment provided by the Contractor. The design shall be as per BNBC [Bangladesh National Building Code].

The design and construction of control room building, engine house, building for Auxiliaries, dormitory, fuel/lube oil unloading shed/room, work shop, ware house, testing lab. guard rooms, fencing, boundary wall, road, water supply system, drainage & sewage system, etc. The design and construction of all major foundations and buildings shall include piling.

- Outdoor lighting, passage ways, access ways for transporting of equipment during overhaul, and re-routing of existing passage way for the site if necessary.

- Surface water drainage system including oil interceptors.

- Removing of debris, surplus excavated materials and rubbish, etc. resulting from the works.

2.10 Training

The training at the Contractor's factory including:

- 15 (fifteen) round trip air fares from Dhaka, Bangladesh to the Manufacturer's factory.
- 15 (fifteen) Man-Months of training on generating unit at Manufacturer's factory.
- Local transportation, meals, lodging, medical costs, insurance and pocket expenses @ US $ **150** per day per person etc.

2.11 Submission of Engineering Data

Drawings and other engineering data for the specified equipment and materials are essential to the design and subsequent construction of the entire generating unit.

The contractor shall be required to submit drawings and engineering data in accordance with the Schedule and requirements specified herein to assure compliance with the overall construction and operating Schedule.

2.12 Manufacturer's Field Training Supervisor

From the date of commencement of initial operation of the major equipment, the Contractor shall dispatch manufacturer's supervisor (s) who shall be technically competent, factory trained, experienced in the operation and maintenance of the equipment to the site.

The supervisor (s) shall be responsible for providing instruction and guidance to B-R Powergen Ltd..'s staffs in the operation and maintenance of the equipment. The supervisor(s) shall not be responsible for any duties required by the test and commissioning program of the equipment during training duty.

The supervisor (s) must be able to fluently understand, speak, read, and write the English language.

2.13 Tests

The Contractor shall be responsible to all testing of equipment and systems supplied under this contract. The Contractor shall submit with his proposal a list of those tests, which in his opinion will satisfactorily check the operating characteristics of the equipment and determine all values necessary for evaluation of guarantees.

In the event of an award of contract, the Contractor shall submit within sixty days of the date of notice of award details of the proposed procedures for each test. All test procedures shall be subject to the B-R Powergen Ltd.'s modification and approval.

For start up and test, B-R Powergen Ltd. will supply operating staff who will operate the equipment as directed by the Contractor under the Contractor's responsibility.

2.14 Commissioning

The Contractor shall be responsible for the commissioning of all equipment in his supply, and shall provide necessary commissioning engineers to carry out all operations from first making alive of auxiliary equipment until the full commissioning has been completed.

The schedule shall cover all necessary inspections, adjustments and tests from no load to full rated capacity.
B-R Powergen Ltd. shall provide its operating and maintenance staff to gain familiarity with the installation but the Contractor shall remain fully responsible for safe operation of all equipment in his supply during the commissioning periods, and until the completion certificate have been issued.

2.15 Supervision During Warranty Period

The Contractor shall provide two (02) competent Engineers **(at least 10 years experience)** from engine manufacture during warranty period for smooth maintenance and operation on the site.

2.16 Inspection [s]/ Overhauling

The Contractor shall be responsible for execution of all inspections/overhauling of the engines during warranty period.

2.17 Transport

The Contractor will supply the following vehicles for the execution of the project within two (02) months after commencement of the project at their own cost:

1. Jeep (5 doors, Japan made)
2. Double cab pick-up (Japan made)
3. Single cab pick-up (Japan made)
4. Microbus (Japan made)

2.18 Spare Parts & consumables

Spares & consumables during Warrantee period

The Contractor shall submit a list of spare parts with OEM Part No. and consumables with specification **(oils, greases, air & oil filters, chemicals etc.)** to be necessary for day to day operation and maintenance of the generating units and other plant equipment inclusive of emergency use that takes place in the course of operation (according to the Manufacture's recommendation and guideline) during the Warranty period (24 months). During the warranty period, the Contractor shall supply all necessary equipment, spare parts, materials/consumables etc**. considering 80% plant factor** at their own cost and whether it is listed or not in their list. Contractor will hand over these spare parts & consumables to the Plant Authority.

2.19 Plant Maintenance Tools

Plant Maintenance Tools include Special Maintenance Tools & Plant Hand Tools. The contractor shall provide all special tools (Not available in market and only available in manufacture of main equipment like engine, alternator, breaker etc) and hand tools, required for maintenance of the unit and hand them over in good condition to the **B-R POWERGEN LTD.** A list of all such tools shall be incorporated with tender. Contractor shall not be permitted to use any equipment/ machinery/ tools, which are to be supplied under the Contract.

2.20 Office equipment

The Contractor shall provide three (03) Nos of Computer (latest model), each with Laser Printer, UPS (30 Minutes at full load, Min.), Stabiliser, Scanner, Photocopier, Racks, Standard Tables & Chairs and other office equipment**.**

2.21 Electrical workshop equipment & tools

-Current injection test set,
-Megger,
-Digital Multimeter,
- Relay testing kit,
-process calibration,
-Pressure **simulator**,
-AVO insulation tester,
-Temperature **simulator** bath,
-Voltage detector with insulating telescope stick,
-Eletric power supply test bench,
-Clamp on meter (0.600A),
-Hand tools etc.

2.22 Machine Shop equipment & Tools

Lathe, Piller drill, Universal miller, Machine hacksaw, Grinding Machine, Small universal machine tools, welding set (arc, tig, mig) Valve seat gridding m/c, Engine cylinder peak meter, seat removing and fixing tools, Bench vies, Cylinder liner honing m/c, Cylinder head bench, measuring tools for maintenance & work shop activities etc.

2.23 Chemical Laboratory equipment & Tools

Chemical Laboratory equipment & Tools shall include among others all necessary equipment & Tools for oil testing, water testing and testing of chemicals & exhaust gas used in the power plant including spectrophoto meter, Fuel/Lube oil testing (Water in oil content, BN, Insoluble, AN, Density, Viscosity, Compatibility), water (PH, Conductivity, TDS, Total Hardness, Nitrite, Total Alkalinity, Silica), Exhaust (SO_X, NO_X, Particulate matter) measuring instrument etc.

Section 3

Power Plant Arrangement

3. **Power Plant Arrangement**

3.1 General
3.2 Guarantee
3.3 Engine Generating Set and Ancillary Equipment

- 3.3.1 Basic Equipment Requirement
- 3.3.2 Engine and Auxiliaries

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  - 3.3.2.2 Turning Mechanism/Gear
  - 3.3.2.3 Accessories drive Gear
  - 3.3.2.4 Wet Washing System.
  - 3.3.2.5 Governor System
  - 3.3.2.6 Lubrication Oil system
  - 3.3.2.7 Fuel system
  - 3.3.2.8 Compressed air system
  - 3.3.2.9 Heat recovery steam generation system
  - 3.3.2.10 Cooling system
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  - 3.3.2.13 Exhaust system
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  - 3.3.2.16 Casing design
  - 3.3.2.17 Insulation and lagging

3.0 Power Plant Arrangement

3.1 General

The arrangement of the plant equipment shall be generally as described below:

The Power Plant (with HFO fired Engine Generating Sets) with a continuous total net generating capacity of 150 MW ±10% MW shall be accommodated in the location proposed.

3.2 Guarantee

The net output and heat rate of the plant shall be guaranteed by the contractor at the following conditions:

a.	Ambient temperature	: 95^0F (35^0C)
b.	Site elevation	: less than 100 ft(msl)
c.	Relative humidity	: 98%
d.	Barometric pressure	: 1.013 bar
e.	Generation voltage	: 11,000 V
f.	Power factor	: 0.8 lagging to 0.95 leading
g.	Frequency	: 50 Hz
h.	Cooling water temperature	: 90^0F (32.2^0C)
g.	Operating fuel	: Heavy fuel Oil (180 cSt)

The contractor shall guarantee the starting reliability of the Units including all ancillary equipment. The guaranteed reliability shall be stated in the Bid form together with the number of consecutive starts to which the Units will be subjected to demonstrate this reliability. (This is for a starting reliability of 95 %, the Units shall be subjected to 20 consecutive starts of which 19 shall be successful) the maximum speed rise after full load rejection is to be guaranteed.

3.3 Engine Generating Set and Ancillary Equipment

3.3.1. Basic Equipment Requirements.

The engine generating unit shall be of well proven design and the offered model shall have satisfactory operating experience outside manufacturer's country for at least 2 (two) years. Tenderer shall have to submit at least one certificate (must be from outside manufacturer's country) from the end users in this respect.

Engine Model :----------

Date of Commissioning :----------

Output of individual unit, kw :----------

This certificate must be notarized or have authentication from the Chamber of Commerce of the Tenderer's country or the Embassy/High commission of the end user's country situated in Dhaka. In absence of that in Dhaka, authentication from bidder's Embassy/High Commission.

The extent of supply shall include, but not be limited to, the equipment described herein. All equipment comprising the engine package shall be pre-assembled in the factory.

3.3.2 Engine And Auxiliaries

The engine unit shall be designed as a multi-cylinder, diesel cycle internal combustion one of the low/medium speed heavy-duty industrial type suitable for Heavy Oil firing for continuous operation at any load between 30% -100% under the site conditions. The engine have to be of two/four stroke, direct injected, trunk piston, turbo-charged and intercooled design.

Vibration Critical Speed

The radial amplitude of vibration of any rotating shaft under steady state conditions at normal operating speed shall not exceed the value specified in API Standard 616 when measured at the shaft local to the bearing. The critical speed shall be beyond $\pm$ 20 % of the operating speed of the engine.

The engine unit shall be designed to burn Liquid fuel (Heavy Fuel Oil/Diesel).

The unit shall be capable of frequent starts and stops without damage to the hot moving components and shall be able to run for base load.

Main components of the engine are stated bellow

Engine block

The engine block to be made of nodular cast iron and is of stiff and durable design to absorb internal forces. The engine block carries the underslung crankshaft. The nodular cast iron main bearing caps are fixed from below by two hydraulically tensioned studs. The caps are fixed sideways by hydraulically tensioned horizontal side studs. Together they provide a rigid crankshaft bearing. The inlet air receiver and the cooling water and lubricating oil channels are integrated into the engine block. The engine is provided with an oil sump, mounted against the engine block and sealed by an o-ring gasket.

Crankshaft

The crankshaft to be forged from one piece of high tensile steel . Counterweights are fitted on the crankshaft webs. The high degree of balancing results in an even and thick oil film for all bearings. The main bearings and the crankpin bearings have a steel backing and a soft running layer with excellent corrosion resistance.

Connecting rod

The connecting rod to be of the drop forged, totally machined type. The connecting rod is of three piece design with a horizontal split at the crankpin bearing and a flanged connection to the rod. The oil supply for the piston cooling, gudgeon pin bush and piston skirt lubrication takes place through a single drilling in the connecting rod.

Cylinder liner

The cylinder liner to be centrifugally cast iron with special alloy elements to create wear resistance and high strength. The liner is of stiff bore cooled collar design and supported symmetrically at the top of the engine block. It is equipped with an anti-polishing ring at the top, preventing bore polishing.

Piston

The piston consists of an oil cooled steel crown bolted on to a nodular cast iron skirt. The piston crown has two compression rings and one oil scraper ring. The piston skirt and cylinder liner are lubricated by a patented pressurized lubricating system utilizing lubricating nozzles in the piston skirt. This system ensures excellent running behaviour, and constant low lubrication oil consumption.

Cylinder head

The cylinder head to be made of nodular cast iron . Ample height and the stiff design allowing only four hydraulically tightened studs to fix the cylinder head on to the cylinder block/liner. Each cylinder head has two inlet and two exhaust valves, all equipped with rotators. The exhaust valves are made of Nimonic and the exhaust valve seat rings are water cooled.

Camshaft and valve mechanism

The cams to be integrated in the drop forged camshaft material. The bearing journals are made of separate pieces that are fitted to the camshaft sections by means of flanged connections. This design allows lateral dismantling of the camshaft sections. The camshaft bearings are located in integrated bores in the engine block casting. The camshaft is driven from the crankshaft through a fully integrated gear train.

3.3.2.1 Starting System

The engines shall have compressed air based starting equipment capable of sustaining the complete starting cycle.

3.3.2.2 Turning Mechanism/ Gear

A turning mechanism shall be provided to minimise thermal distortion of the crank shaft during a shutdown.

3.3.2.3 Accessories Drive Gear

The engine shall also be equipped with gear mechanism for machine driven accessories.

3.3.2.4 Turbocharger Wet Washing System

1. System Descriptions

For cleaning the turbochargers on and off line to remove soot a wet washing system have to be provided. The bidder shall design, manufacture and supply all the components (Viz. water tank, piping, valves, strainer, drains, manifolds, injection nozzles etc.) of the above mentioned wet washing system of suitable grade of material to handle the above wash water without any deterioration. The bidder shall clearly specify the proposed grade of materials of the above components. **The bidder shall provide complete system including quality Water Plant as per manufacturer's recommendation (from the water treatment system).**

3.3.2.5 Governor System

The engine unit shall be provided with a complete governing system which shall be capable of maintaining a required constant speed under conditions of load variations, control the load, combustion gas temperatures and prevent over-speed. The characteristics of the engine generator unit and its governor shall be such that the machine operates satisfactorily in parallel with existing units in the system.

The speed governing system shall be provided with speed changing device capable of local and remote control. Provision shall be made to shutdown the engine under emergency by local and remote control. The speed regulation shall be adjustable (from no load to full load) between plus and minus 5 %. The rated speed at no load condition shall be adjustable within ±0.5 % for easy synchronising. The governing system for the unit shall also be provided with automatic over-speed trip devices adjustable up to 110 % of the rated speed, and a load limiter.

The governing system shall include an adjustable load limit control, minimum fuel regulator, temperature limit control, temperature increment rate control and necessary protection equipment.

The governing system shall be suitable for parallel operation with a large power system and also for completely isolated and independent operation. In addition to the automatic speed governing system, a separate emergency over-speed trip mechanism and over combustion gas temperature trip system shall be furnished on the unit. These systems shall operate to shut the emergency fuel trip valves.

The unit shall not trip with voltage fluctuation of ± 10% and frequencies variation ± 4%.

Over-speed occurring under any conditions shall not have any harmful influence on the engine generating unit or on its auxiliaries. The governor shall have adjustable (± 2%) droop setting.

3.3.2.6 Lubricating Oil System

The lubrication system of the unit shall be equipped with the main oil pump, auxiliary motor driven oil pumps (if required),**Lube oil separator, Lube oil auto flash filter, Lube oil safety filter,** delivery pipes, return pipes, reservoir, strainer, oil cooler, pressure gauges and thermometers, and all necessary oil piping for the system.

Separator will purify engine sump oil (used lube oil) by separating sludge, water and others as per requirement by the engine. Separator will have the capacity to purify whole sump oil by recirculation of the sump oil at least 4-5 times within one day.

Lubrication system will have three (3) types of tank: Fresh lube oil tank, used lube oil tank and maintenance lube oil tank. Fresh lube oil tank and used lube oil tank each having capacity 2 times the capacity of sump of one engine.

Engine lube oil sump top up/drain system will be consists of transfer pump, flow meter (for fresh oil) pipings, valves etc.

Each oil reservoir shall be furnished complete with, level indicator, high and low level alarm switches, strainer, drain valves, overflow pipe, manhole, valves, and piping.

The system shall include oil pressure and temperature alarm, and trip mechanism, each bearing shall be provided with thermocouple cell and a thermometer in pocket of oil drain.

Complete oil coolers each for 100% capacity shall be provided. The oil cooler shall be of either air cooling type or water cooling type. The oil coolers shall be provided with blowers or water pumps, depending upon the type of cooling.

3.3.2.7 Fuel system

HFO (furnace oil) will be used as fuel.

Liquid Fuel oil system

The unit shall be provided with liquid fuel oil system. The operating fuel would be Heavy Fuel Oil (furnace oil) and engine can run with LFO, if necessary. The liquid fuel oil system shall have fuel unloading & handling facility and storage facility for both HFO and LFO, cleaning system, heating system, fuel forwarding system fuel injection system, oil recovery system, waste collection & treatment system etc.

3.3.2.7.1 FUEL STORAGE AND HANDLING

The fuel storage and handling system of the facility can be divided into three parts,

A. Heavy Fuel Oil System (HFO)
B. Light Fuel Oil (HSD) System
C. Fuel Transfer System

Under normal operating condition heavy fuel oil is used for the generator engines for full liquid fuel operation and light fuel oil is used for certain auxiliaries and for the generator engines in emergency and for flushing the HFO system for extended isolation.

A. HEAVY FUEL OIL

The plant have to be provided with four HFO storage tanks with a capacity of 4000 m^3 each and two HFO day tank of 1000 m^3 providing a total HFO storage capacity of 18000 m^3. Each HFO storage tank to be provided with

- A sounding pipe for manually measuring tank level,
- Remote level indication in the monitoring/control system, which shows fuel quantity by mass in the tank in percentage,
- Tank high level alarm,
- Vent with flame arrester,
- Over-flow connection to overflow tank,
- Decanting system with drain pit,
- Steam heating system, and,
- Associated valves and piping for filling, transfer and heating.
- Mass flow meter of micro motion type for measuring fuel inlet of the bunkering tank.

HFO BUNKERING/STORAGE

The plant have to be provided with fully equipped bunkering facility for both riverside and roadway bunker reception. Each bunkering unit is provided with a micro motion flow meter to constantly measure flow of fuel delivered to the storage tank.

B. LIGHT FUEL OIL

The plant have to be provided with only one LFO storage and a day tank each having a capacity of 500 m^3. The LFO storage and day tank is provided with,

- A sounding pipe for manually measuring tank level,
- Remote level indication in the HMI system, which shows fuel quantity by mass in the tank in percentage,
- Tank high level alarm,
- Vent with flame arrester,
- Over-flow connection to overflow tank,
- Decanting system with drain pit, and,
- Associated valves and piping for filling and transfer.
- Mass flow meter of micro motion type for measuring fuel inlet of the bunkering tank.

LFO BUNKERING

The plant have to be provided with a separate fully equipped bunkering facility which is common for HFO as well. Each bunkering unit is provided with a micro motion flow meter to constantly measure flow of fuel delivered to the storage tank. Procedure for LFO bunkering from both riverside and shore side shall be same as HFO bunkering except for valve operation.

C. FUEL TRANSFER SYSTEM

The plant have to be is equipped with a fuel transfer unit to facilitate HFO transfer in between storage tanks. Internal fuel transfer may become necessary to facilitate segregation of fuel from different supply tank.

The transfer unit consists of following components,

Screw type transfer pumps	2 sets
Pump suction strainer	1 each
Transfer unit relief valve	1 on common discharge line
Associated valves and piping	

Transfer pumps takes suction from HFO storage tanks' common outlet header and delivers into bunker filling common line.

3.3.2.7.2 FUEL TREATMENT

Fuel received from supplier may contain water and other solid impurities, which may have detrimental effect on combustion quality and fuel injection system components. So it is imperative that the fuel is properly treated to separate water and sludge before the fuel is fed to the engine.

HFO received from supplier goes through a two-step treatment process and finally stored in the day tank for engine consumption. The first step takes place in the fuel storage tanks, which are equipped with heating and decanting facilities. Fuel

in the storage tank is heated and allowed to settle to facilitate separation by gravity where some of the water and solid impurities accumulate at the tank bottom. Time to time these accumulated water and sludge are to be drained out from the storage tank using the drain valves provided for each fuel tank. Remaining suspended solid and water is separated by centrifuge.

All HFO storage tanks' outlet lines connect into a common header from where the centrifugal separators take suction. Each storage tank outlet line is to be fitted with two valves in series, first one is a hand shut off valve and the second one is a pneumatic control valve, which is to be operated from the quick closing valve panel. HFO day tanks' overflow lines are also connected with the storage tanks' common outlet header, in another words day tank overflow goes back to separator suction. Day tank overflow lines are fitted with hand shut off valves.

3.3.2.7.3 ENGINE FUEL SUPPLY SYSTEM

Centrifuged and pre-heated fuel oil from the day tank is fed with Constant Pressure regulated by variable frequency drive operation to the individual engines by the engine fuel oil supply system have to be manufacturer specific but as a minimum should comprises of following components,

a. Two Fuel Feeder Units
b. Two Fuel Booster Units
c. Engine Wise Fuel Units
d. LFO Feeder Unit

a. FUEL FEEDER UNIT

The engine fuel supply system is equipped with fuel feeder units which take suction from HFO day tanks or LFO day tank as selected by the change over valve and delivers to fuel booster unit. Feeder units are fitted with an inter-connection valve for emergency use. Each feeder unit is equipped with,

- Two feeder pumps
- Individual pump suction filter,
- Individual pump suction and delivery valves,
- Suction valve for HFO and LFO with change over arrangement,
- Common pressure regulating valve, and,
- Discharge line common quick-closing valve.

In each feeder unit one pump remains in use while the other can be kept on standby.

Feeder unit pumps and quick closing valves are controlled from a common control panel for feeder and booster unit located near the booster unit.

Note The feeder unit suction valves for HFO and LFO have to be equipped with a single operating lever for changing over feeder unit suction. Horizontal lever position is for HFO operation and vertical lever position is for LFO operation.

b. FUEL BOOSTER UNIT

Engine fuel supply system is equipped with identical fuel booster units, which take suction from the relevant feeder unit and deliver to engine wise fuel units. In the booster unit fuel oil is filtered and heated to attain suitable viscosity for efficient combustion before delivering to engine inlet header from where engine wise fuel unit take suction. The booster units are also interconnected by isolation valves on the supply and return line for emergency use only.

Each fuel booster unit have to be comprises of following components,

- Automatic back flushing filtration unit
- By-pass duplex filter unit
- Fuel flow meter
- Mixing column
- Two fuel booster pumps
- Two steam heaters
- Viscosity controller unit
- Fuel return line change over arrangement.

Fuel Oil Auto Filter

The system is equipped with a fully automatic back flushing filter unit with a by-pass duplex filter. Under normal operating condition the system should not be operated with the back flushing filter by passed.

Filtration Process

A motor driven change over unit is located at the centre of the filtration unit and surrounded by 4 filter chambers. At any given time 3 filter chambers are in use and 1 remains on stand by. At a preset time interval the filter control unit goes on flushing cycle.

Differential pressure across the filter is continuously monitored by the controller and if at any time the differential pressure reaches the set value the controller initiates a flushing cycle and activates High Filter Differential Pressure Alarm.

Back Flushing

At the beginning of back flushing cycle the controller activates the change over unit. The change over motor rotates the central change over mechanism one fourth of a turn and as a result the stand by filter goes into operation while the 3rd filter chamber goes off line and enters into back flushing cycle

As soon as a filter goes on stand by mode the control unit energizes solenoid valve-A, which allows instrument air to operate the sludge piston and opens the sludge port. Opening of the port allows the air to travel to and open valve-C of air reservoir. Air from reservoir then enters into the outlet side of the stand by filter and drives the fuel oil and accumulated dirt out of the chamber, which flows to the fuel return line to HFO day tank. Fuel from the filter main outlet enters into the stand by chamber through a control hole and gradually fills up the stand by chamber.

HFO Separators
The facility is equipped with two HFO separation units each comprises of two separator units, one Sludge tank and one sludge transfer pump. Separation will purify HFO by separating sludge, water and others as per requirement by engine. One separation unit (Consists of two separators) will purify oil required for whole plant operation and other unit will be kept for standby. Each separator unit comprises of following components,

By-pass Filter
The system is equipped with a set of duplex filter with mesh size of 34 microns connected in parallel with the auto back flush filter. The by-pass filter is provided to facilitate isolation of the back flush filter and to be only used when back flush filter maintenance is necessary while the engines are running. The by-pass filter unit comprises of,

Two filter chambers with filter elements,
One change over cock, and,
One vent line.

Fuel Flow Meter
Each booster unit is provided with a micro motion flow meter to constantly measure flow of fuel delivered to the engines covered by the relevant booster unit. The flow meter is located between the filter unit and the mixing column and fitted with a by-pass valve. The flow meter can register the following information,

Cumulative mass flow	in kg
Flow rate	in kg/hr or litres/hr
Fuel pressure	Fuel temperature

Note The flow meter is capable of registering negative flow rate but the cumulative mass flow is always incremental.

If booster units are operated with the inter connection valves open and if there is any re circulation of fuel through any of the booster units due pressure difference then the flow meter will register incorrect (excess) cumulative mass flow readings.

Mixing Column
Mixing column is located in between the flow meter and booster pumps. Return fuel from engines can also be directed to the mixing column. It is equipped with a float type venting arrangement to bleed of any vapour (water or fuel) and a float operated low-level alarm to ensure positive suction header for the booster pumps.

Fuel Booster Pumps
Each booster unit is provided with two booster pumps with individual isolation valves. The pump takes suction from the mixing column and delivers to the engines through the heater and viscosity controller unit.

Fuel Heaters
Each booster unit is equipped with two tube type fuel oil heater units installed in parallel. Each heater is capable of handling complete fuel heating requirement of one bank at full load. Heating steam supply valve for the heater is a pneumatic control valve controlled by either the viscosity controller or the temperature controller as selected at the booster unit control panel by the selector switch A16S2.

Viscotherm
The booster unit is equipped with a viscotherm unit on the fuel supply line after the heaters. It measures the process fuel viscosity and sends input for the viscosity controller unit. The viscotherm unit is fitted with isolation valves and a by-pass line with a by-pass valve to facilitate maintenance work on the unit while the booster unit is in operation.

Return Line Change Over Arrangement
Returned fuel from the engines can be directed either to the mixing column or back to HFO day tank. Two return lines are fitted with separate isolation valves with a single operating handle and the valves are such configured that while one valve opens the other closes. At horizontal lever position fuel return to mixing column valve remains open and at vertical lever position fuel returns to HFO day tank. In normal operating condition return fuel is directed to mixing column. Sending return fuel back to day tank should be avoided as no flow meter is available to measure the return fuel quantity.

Temperature/Viscosity Control
The fuel booster unit is provided with two separate controller units for temperature control and viscosity control and either one of them can be selected by the selector switch A16S2. When temperature controller is in use it maintains the fuel temperature as per set value while viscosity may vary and when viscosity controller is in use it maintains the viscosity as per the set value by controlling fuel temperature and temperature may vary. In both cases it is the steam supply to the fuel heater, which is controlled.

C. ENGINE WISE FUEL UNIT

Each engine is equipped with a fuel unit to facilitate engine wise HFO / LFO change over option, leak off fuel handling and final fuel filtration before injection.

Each fuel unit comprises of following components,

- Valve unit with solenoid controlled actuator,
- Fuel feeder pump with suction strainer,
- Duplex fuel filter,
- Pressure control valve, and
- Leak off fuel collecting tank with return pump

Fuel unit Feeder Pump
Each fuel unit is equipped with a fuel feeder pump with suction strainer and isolation valve. The pump is provided to facilitate boosting fuel supply pressure and re-circulate fuel through the engine when the engine is stopped and on HFO mode. The engine can operate with or with out the feeder pump running depending on available fuel pressure at the supply header.

Fuel unit Duplex Filter
For the final filtration of fuel before it enters the engine a duplex filter is provided at the engine fuel unit. The filter is fitted with a change over cock, a differential pressure cell, heating steam line and drain and venting arrangement. Normally one filter is kept in use while the other is on stand-by but if required both the filters can be put into service. The DP cell monitors and indicates the pressure differential across the filter unit and activates an alarm at the fuel unit control panel (indicator H5) if it exceeds the set value.

Leak off Tank and Return Pump

Any leakage from individual cylinder's fuel injection pump and fuel injection system double wall pipes are led to the clean fuel leak off tank. Each bank leak off line is equipped with a float type alarm to indicate excessive leakage. The leak off tank is fitted with a return pump with isolation valves, which operates automatically controlled by a float switch. The same activates leak off tank high-level alarm as well. The engine fuel return line passes through the leak off tank to maintain heating for leak off fuel.

Engine Operation in LFO Mode

Engine LFO operation facility is provided as a back up of HFO system and for flushing the fuel system before extended shutdown or to facilitate maintenance work. Engine LFO operation is possible in two different ways,

By feeder and booster units for common LFO operation, and,
By LFO feeder unit for individual engine LFO operation.

Common LFO Operation

This system is to be used when the common fuel supply system needs to be flushed for maintenance work or the plant has to be operated on LFO instead of HFO. Procedure for change over from HFO to LFO operation,

Engine wise LFO Operation

This system is to be used when an individual engine needs to be operated on LFO to facilitate flushing of engine fuel system for maintenance work while the remaining plant operation shall be on HFO supplied by the common fuel system. For engine wise LFO operation a separate LFO feeder unit PCA-905 is provided.

D. LFO FEEDER UNIT

The LFO feeder unit takes suction from the LFO day tank and delivers directly to engine fuel units with Constant Pressure regulated by variable frequency drive operation. It also supplies LFO for following auxiliaries,

- Engine driven emergency fire pump
- Black start generator
- Oil fired steam generator (if required)
- Machine shop for cleaning and testing purposes.

The LFO feeder unit is comprises of as a minimum of the following components,

- Two feeder pumps,
- Individual pump suction filter,
- Individual pump suction and delivery valves,
- Common pressure control valve, and,
- Discharge line common quick closing valve
- Variable frequency drive for pressure regulation.

Note The LFO feeder unit is provided with a low suction pressure alarm to avoid dry running of the pump when suction filter gets clogged.

3.3.2.8 COMPRESSED AIR SYSTEM

Complete compress air systems have to be provided. Compressed air is used for starting the engines and for control and instrument air.

Starting air is produced by the starting air compressor unit. Compressed air from the starting air unit is stored in starting air bottles until it is used for starting the engine. The pressure equipment is to be designed, manufactured and tested according to the European Union directive 97/23/EC "Pressure Equipment Directive" or equivalent standard

The starting air system consists of the following main equipment:

Starting air bottle

The total capacity of the starting air bottles is dimensioned to ensure a total of at least 20 engine starts. Each starting air bottle is equipped with necessary accessories.

Piping and valves compressed air system (set)

This includes pipes, valves, flanges and gaskets for the compressed air system up to the interconnection point.

Starting air compressor unit - (2x100%+1x100%)

Starting air compressor unit is used for refilling the starting air bottle(s). The following components built on a steel frame, which forms a compact skid unit have to be provided.

Electric motor driven air compressor
Capacity, each (for filling the bottoms within 30 minutes)

Pressure 30 bar
Pressure switch for starting and stopping the electrically driven air compressor
Alarm switch for too low starting air pressure to engine
Oil and water separator
Control center for manual and automatic operation
Pressure reduction valve for control and working air
Steel frame
Set of interconnection pipes, flanges, seals and valves

Instrument air compressor unit- (100%+100%)

The control and working air compressor unit produces control, instrument and working air. The compressed air is stored in the built-on air bottle until it is distributed to the different points. The control and working air compressor and related equipment to be built on a common frame to form a compact unit.

Electrically driven air compressor
Compressed air receiver.
Refrigerated air dryer with control panel Dew point
Filter for removal of oil, water and particles
Common control panel
Steel frame
Set of interconnection pipes, flanges, seals and valves

Instrument air bottle

The compressed air is stored in the control air bottle until it is distributed to the different consumers.

3.3.2.9 HEAT RECOVERY STEAM GENERATION SYSTEM

(STEAM GENERATION SYSTEM FOR FUEL HEATING)

The steam generation system generates steam to be used for fuel heating in the power plant. Steam is generated by recovered waste heat from the engine exhaust gas. A standby fuel fired boiler is supplied for backup use. The system have be designed based on an minimum "N/2 (but adequate to meet the plant requirement)+1 principle" (N= No. of units) and one additional fuel fired boiler.

Steam flows from the heat recovery boilers to a steam header for distribution to the steam consumers in the plant. A non-return valve on the steam outlet of the drum prevents backflow when the boiler is not in use. Condensate is collected in the feed water tank and returned to the boilers by the feed water pumps.

A fuel fired boiler may be provided to generate steam when the engines are not running or when the exhaust gas boilers require maintenance.

Exhaust gas boiler

The exhaust gas boiler is to be a horizontal smoke tube type.
The following is to be included:

-Inlet and outlet hoods with inspection doors

-Modulating exhaust gas by-pass damper with actuator

-Manual steam soot blowing equipment

-Shut-off valves

- Blow-down drain

-Safety valve

-Relief valve

-Pressure switches

-Level switches

-Level control device

-Insulation and cladding

-Counter flanges, bots, nuts and gaskets

-Mounting supports

-Boiler service platform

Bellows for exhaust gas boiler

The expansion bellows isolate the exhaust ducting from vibrations and also allow for thermal expansion

Heat recovery container (preferable)

Auxiliary equipment for the steam generation system preferably to be installed into a standard 40 foot container. All installation, piping, insulation, cabling, painting and testing of the equipment inside the container to be done at the factory where the container is assembled, thus saving installation time at site.

The following to be included:

-Feed water tank

The feed water tank is of the "hot well type" working at atmospheric pressure. It receives condensate from the steam consumers and make-up water from the water treatment system. The feed water tank is insulated and located on top of the container.

- Feed water pump (2x100%)

The feed water pump pumps feed water from the feed water tank to the boilers at the appropriate pressure.

-Chemical dosing unit

The chemical dosing unit adds chemicals to the feed water in order to prevent corrosion and scaling in the boiler system.

-Blow-down tank

Blow down water from the boilers is lead via the blow down tank to the drain. The blow down tank can be cooled by tap water when needed. Blow down is performed at regular intervals in order to prevent the accumulation of chemical compounds in the steam system.

-Local control panel

The local control panel contains the components for controlling and operating the steam system as described above

Light fuel oil fired boiler for steam generation (if required)

An independent oil fired boiler is supplied for use when the exhaust gas boilers are not in use, for example during the start-up of the power plant. It is also used for heating the heavy fuel system during outages.

The auxiliary boiler unit includes:

- Evaporator section
- LFO burner
- LFO pump
- Combustion air fan
- Steam pressure gauge
- Pressure switches
- Temperature switches
- Level control device
- Main closing valve for steam
- Non-return valve at steam outlet
- Safety valves
- Local control panel
- Interconnection pipes, flanges and gaskets

Oil detector

The oil detector detects if the condensate return coming to the feed water tank contains oil. If oil is detected condensate will be dumped into the drain system and an alarm will be given to the control system.

Steam header

Steam from all the boilers is collected to the steam header and forwarded onwards to the steam consumers. Shut-off valves are installed on each incoming and outgoing line from the steam header. The steam header also functions to separate possible water droplets in the steam and drain them to the condensate return system

Boiler washing water tank

Dirty washing water from the boilers is collected in the boiler washing water tank

Boiler washing water pump

Boiler washing water pump transfers dirty water from the boiler washing water tank to the water treatment system.

Piping, valves and insulation for steam generation system for fuel heating (set)

3.3.2.10 COOLING SYSTEM

The main task of the cooling system is to provide adequate cooling of critical engine components such as cylinder jackets, cylinder heads and turbochargers as well as to cool the lubrication oil and charge air entering the cylinders after it has been compressed by the turbocharger.

The engine cooling water cools the low temperature charge air cooler, lubricating oil cooler, high temperature charge air cooler and engine jackets in a common single-circuit radiator.

Control system with variable frequency drive will start/stop the radiator fan as per requirement by the engine.

There will be two Maintenance water tank each having capacity more than two times of total cooling water capacity of one engine.

Contractor will designed radiator arrangement for proper accessibility for maintenance considering its motor handling and transportation

3.3.2.11 CHARGE AIR SYSTEM

The charge air filter protects the engine against impurities in the inlet air and the charge air silencer reduces the air intake noise from the engine. Wet type charge air filtration system and separate silencer will be used.

3.3.2.12 Air Inlet System

The air filtration arrangements shall be provided for the air intake of the units to meet the manufacturer's recommendation in this regard.

The bidder shall supply air inlet system complete in all respects including necessary supporting structures, holding frames, fasteners, pressure switches, gauges etc. whichever are necessary. The bidder shall also submit necessary design documents and drawings for this filtration system.

Each air inlet system shall be provided with silencer if required capable of keeping the sound pressure level to the prescribed limit when measured at a distance of 100 meter from the plant operating at full load as per ISO standard.

3.2.2.13 Exhaust System

The exhaust gas of the engine to be discharged at the required height through the exhaust gas silencer and stack pipe . The exhaust gas silencer reduces the exhaust noise from the engine.

Exhaust gas silencer

The exhaust gas silencer reduces the noise emission from the engine exhaust outlet.

Bellows for exhaust gas silencer

The expansion bellows isolate the exhaust ducting from vibrations and also allow for thermal expansion.

Ducting exhaust gas system (set)

This includes ducting for the exhaust gas system between the engine and the exhaust gas stack.

Bellows for exhaust gas ducting

The expansion bellows isolate the exhaust ducting from vibrations and also allow for thermal expansion.

Insulation exhaust gas ducting (set)

This includes insulation material and cladding for the exhaust gas ducts inside the building and in accessible places with a surface temperature over 60°C up to the exhaust gas stack.

Exhaust gas stack pipe

The exhaust gas of the engine is discharged through the exhaust gas stack.

The exhaust gas stack has the following characteristics:

Diameter Material
Height above ground level: No less than 50m

Exhaust gas sampling point will be provided for SOx, NOx and particulate matter measurement as per DoE, Bangladesh requirement.

3.3.2.14 Oily water treatment system

Oily water buffer/interceptor tank consists of four (04) compartments. Plant's all dirty oil, water and sludge will be collected in the first chamber of oily water buffer compartments. By heating and gravity force, sludge, oil and emulsive oily water will be separated in the compartments. Only emulsive oily water will be accumulated in its fourth compartments. Automatic Oily water treatment unit will take its suction from fourth chamber. In the automatic oily water treatment unit (PLC controlled), the chemicals will break the emulsion, and create 3 different layers. (Sludge, disposable water and oil) during settling time. Disposable water will be disposed appropriately and sludge & oil will be send back to the first chamber of buffer tank. Separated sludge and oil from first chamber will be transferred to sludge tank.

Sludge tank and Oily water buffer/interceptor tank each having capacity considering 1% sludge of the quantity of consumed fuel for 80% plant factor for three (03) months not less than 500 m^3.

3.3.2.15 Unit Enclosures

Except as otherwise specified, all equipment shall be enclosed in a minimum number of prefabricated metal enclosures. The enclosures shall be constructed in a neat and workman like manner and shall present an attractive appearance.

Enclosures shall be weather proofed\noise proofed and shall for wind loading of 100 miles / hour.
Enclosures shall be designed to permit easy accessibility to the equipment and to provide necessary protection for maintenance personnel. Sound absorbing insulation shall be provided on the enclosures, Enclosures shall be provided with walkways, steps, strains, and equipment doors of the locking type.

Enclosure insulation, ventilation, and cooling shall be provided to maintain temperatures suitable for personnel and for all systems whether standby or operating. Unit control rooms shall be ventilated and air-conditioned. From control room, all units will be visualized clearly.

The compartment shall be adequately ventilated utilising forced ventilation with louvers and bug screens as required for protection of the houses equipment from outdoor environmental conditions.

Adequate interior lighting shall be provided, and emergency DC lighting shall also be provided, and those shall be energised through an automatic throw over contractor when AC source fails. Enclosure also shall be provided with day light facility to minimize power consumption.

Enclosures shall be provided with 240 volt AC service outlets.

In case of installing engine generating sets within a common enclosure (engine house) above mentioned conditions and environmental limitations will also be relevant

3.3.2.16 Fire Protection Equipment

The entire enclosure including LV, MV switchgear room, all auxiliary compartment storage facilities and transformers shall be automatically protected from fire with complete fire protection system complete with fire suppression system, fire detectors, pipe works, control and safety device. Actuation of the fire protection system shall be indicated at the control compartment and by a visual and an audible alarm to warn any personnel in the compartments.

3.3.2.17 Casing Design

The casings of all the rotary parts on the main unit shall be designed in such a way , so, that are suitable for easy dismantling and inspection. Lugs for lifting the upper portions shall be provided at points which will lift the casings/ heads well balanced. Complete lifting gear together with lifting drawing and instruction shall be furnished.

3.3.2.18 Insulation And Lagging

Thermal insulation shall be provided where necessary. Removable insulation blankets shall be provided in all parts where insulation must he removed for maintenance purposes.

Section 4

Generator and Ancillary Equipment

4. Generator and Ancillary Equipment

4.1 Generator

4.1.1 General Requirement
4.1.2 Generator Rating
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4. Generator and Ancillary Equipment

4.1 Generator

4.1.1 General Requirements

The generator shall be designed and manufactured in accordance with International Electro-technical Commission Publication IEC 34.

The generator shall be cooled by air. The MVAR leading capability shall not be less than 30 % of the MVA rating of the generator at 0.8 leading power factor. The generator in conjunction with its exciters shall be designed to operate stably at all loads up to the maximum continuous rating.

The generator shall be capable of operating continuously under unbalance loading conditions when the negative phase sequence current component is less than 8% of the rated current.

The generator shall be so designed as to minimise the effect of torsional rotor oscillation due to system disturbances and rapid load change. The generator shall withstand continuous over-speed of 1.2 times of the rated speed without damage. The generator shall withstand 120% of rated current for more than 15 seconds.

4.1.2 Generator Rating

a.	Capacity at Site	: To match Diesel Engine peak output at any ambient temperature.
b.	Power factor	: 0.80 (lagging) to 0.95 lead.
c.	Frequency	: 50 Hz
d.	Rated rotating speed	: 100-750 rpm (matching the engine speed)
e.	Rated voltage	: 11 kV

4.1.3 Voltage and Short Circuit Ratio

The generator shall be capable of supplying the rated output at rated speed and at rated power factor with a voltage variation between 90% and 110% of the rated voltage.

The generator shall be designed to guarantee that a nominal short circuit ratio is not less then 0.55 according to IEC 34.1.

The generator shall withstand the electromagnetic and thermal stresses causing from short circuit fault at generator terminal without damage.

4.1.4 Temperature Rise

The temperature rise of the generator under the base and peak rating operations at any ambient condition shall not exceed the values given below:

		at Base	at Peak
a.	Stator winding by resistance temperature detectors method	95^0C	100^0C
b	Field winding by resistance method	100^0C	105^0C
c.	Cores and mechanical parts in contact with or adjacent to insulated winding by thermometer	95^0C	100^0C
d.	Bearing when measured on the surface	40^0C	40 ^{0}C

4.1.5 Insulation

The insulation of the armature and field windings of the generator shall satisfactorily withstand high voltage tests as specified in IEC standard. Insulation of the armature windings, field windings, and collectors shall be class F.

4.1.6 Stator

The cores shall be made up of high permeability, low loss, stampings, tightly clamped together to reduce noise and vibration to a minimum. All burrs of laminations shall be removed after punching. Sufficient ventilation ducts to ensure uniform cooling shall be provided. Clamping of the laminations and securing to the stator frame shall be done by approved methods. Attention shall be given to prevent vibration being transmitted to the generator foundations or associated equipment.

Protective covers and air shields shall be made of steel plates, welded, stiffened with suitable angles and channels, and formed in segments for case of handling. The segments shall be bolted together and to the stator frame.

The windings, terminals, and leads shall be fully insulated throughout and braced, blocked and supported against the single and three-phase short circuits fault at the generator terminals under any operating conditions.

The general construction of the stator and bracing of the winding overhand shall provide adequate cooling surface and to avoid the hot stops. The stator coils shall be either semi or completely pre-formed and shall be made up before insertion to the slots.

4.1.7 Generator Leads

The neutral and output ends of each phase windings shall be brought out to the generator terminal cubicle.

The generator neutral shall be grounded through suitable transformer with secondary resistor.

4.1.8 Bearing

Bearings shall be pressure lubricated by pressured oil from the engine lubricating oil system, and oil drain pipes shall be equipped with pockets for thermometer and suitable sight flow opening for observing bearing oil flow.

4.1.9 Rotor

The packing blocks used especially in the rotor winding shall be of approved material and entirely suitable for the high temperatures and mechanical forces which may cause on rotors.

The rotor slot insulation shall be mainly of epoxy resin or other approved material and particular attention shall be given to the insulating and securing of coil to coil and slip ring connections, if any, and to avoid vibration and the possible failure to either the connector or its insulation.

Adequate precautions shall be taken against local overheating of the rotor surface when neutral short circuits and single phase loading and the Contractor shall submit data showing permissible single phase and unbalanced three phase loading. The rotor shall be capable of withstanding an over-speed test of 1.2 times rated speed for two minutes.

If slip-rings are provided, a grinder for slip-ring maintenance shall be supplied by the Contractor.

4.1.10 Temperature Detectors

More than nine (9) resistance type detectors shall be provided for monitoring of generator stator winding temperatures. The detectors shall be built into the generator, fully protected from the cooling air, suitable distributed around the circumstances, and embedded in the slots in positions normally having the highest temperature in accordance with requirements of IEC standards. All detectors shall be wired out to a terminal box.

4.1.11 Insulation Against Shaft Current

One of the bearings shall be suitably insulated to prevent flow of shaft current.

4.1.12 Accessories

a. Temperature detector (Refer to Clause 4.1.10)
   - normal use :more than 6 (six)

   -Spare :more than three(3)

b. Thermometers and thermocouples at bearing drain of generator and exciter bearings, and at any other location required for operation monitor.

c. Pressure gauge at bearing oil feed, and at any other location required for operation.

d. Alarm contacts

e. Spare heater

The stator shall be equipped with space heater. During the generator stop, the space heater shall be in service automatically.

f. Other

Other instrument, terminal box, hardware buried into the generator foundation and all other necessary accessories for generator.

4.2 Exciter And Automatic Voltage Regulator

4.2.1 Exciter

A complete voltage regulating and excitation system shall be provided. A complete and details description of the proposed system that meets the requirements of these specification shall be submitted with the Tender.

A shaft mounted brushless type with static type control shall be provided.

The excitation system shall match the generator rating and shall maintain the voltage of the unit within a tolerance of plus and minus 0.5% of rated voltage regulation. The exciter shall have capacity to supply not less than 110% of the field current required by the generator at rated output, power factor, frequency and voltage.

The rated voltage of the exciter shall be 110% of the machine excitation voltage at the rated output of the machine.

The ceiling voltage of the exciter shall not be less than 140% of the matching excitation voltage. Insulation of stator and rotor winding of the exciter shall be class F. A field breaker and discharge resistance shall be provided or alternatively special provisions must be taken to either discharge or suppress excitation following generator fault.

The excitation system shall have ample capacity to permit operation throughout its capability up to over-excitation and under-excitation limit as shown in the manufacturer's capability curves.

Over excitation limiter and under excitation limiter shall be provided.

4.2.2 Automatic Voltage Regulator (AVR)

A quick response continuously acting regulator having a negligible dead-band and characteristics enhancing the transient stability of the generator shall be provided.

The regulator shall be responsive to the generator line-to-line voltage and shall restore the exciter output voltage to range of plus / minus 2% of the nominal pre-set level in a response time of less than 50 milliseconds. The accuracy of controlling the AVR shall maintain the generator terminal voltage within plus-

minus 0.5 % of the pre-set value for gradual change of output within the specified load range of the machine. It shall have the capability to adjust the generator voltage between a minimum of 80% of rated voltage (open circuit) and a maximum of 110%of rated voltage (full load).

The regulator shall be equipped with devices which will provide compensating or overriding signals to the regulator in response to the following conditions.

a. Excessive exciter output current in the event of fault in the field circuit.

b. Pole slip due to reverse induced field voltages.

c. Under excited reactive current in excess of generator capability limits

d. Voltage drop due to generator reactance.

e. Dynamic variation of generator output.

Manual control shall be provided to set the generator terminal voltage between 0% and 110% of the rated voltage.

Automatic change-over from Auto to Manual system shall be provided in case of abnormal/faulty PT Voltage.

4.3 11 Kv Generator Switchgear

4.3.1 General

The generator circuit breaker shall be provided, and it shall be accommodated in metal clad switchgear cubicle arranged for local and remote control.

The switchgear and the associated equipment shall be fully metal clad and shall comprise:-

- Switchgear bus bar
- Voltage transformers
- Current transformers
- Surge protective equipment
- Generator circuit breaker (Vacuum draw out type)
- Power fuse switch for station transformers
- Cable termination facilities for 11 KV circuit
- Secondary wiring including cable termination facilities
- Earthing facilities.
- Indication (ON, OFF) facility.

4.3.2 Type And Rating

1) The switchgear shall be of the metal clad type and shall comply with the standards given below and with the relevant requirements stated in this specification.

IEC	298	AC metal-enclosed switchgear
IEC	85	Insulating materials

IEC 51 Electrical indicating instruments

2) The switchgear busbar and associated connections shall have the insulation levels as given below:

System highest voltage : 14 kV

Withstand voltage
Lighting (impulse) : 75 KV (peak)
(11.2/50micro sec.)

Power Frequency (rms.) : 28 KV
(For 1 mm.)

3) The rated service voltage shall be of 11 KV.

4) The current rating of the main bus bars shall not be less than rated current of the related generator and rating of the associated connections shall be determined by the Contractor.

(5) The short time three phase fault level rating for one second of the switchgear shall be of 80 KA (rms) . The Contractor shall check the system fault current level.

4.3.3 Construction And Fittings

(1) The switchgear shall consist of rigid welded steel cubicles and shall house generator circuit breaker, bus bars, current transformers, voltage transformers, neutral grounding transformer, surge absorbing equipment etc, The generator circuit breaker and the voltage transformers shall be withdraw able type. All doors shall be padlock able and readily removable when necessary.

(2) The bus bar and its connections shall be of copper and all joint surfaces shall be silver plated.

(3) All bus bar connections shall be by bolted type. Flexible joints shall be provided wherever for thermal expansion will occur.

(4) Safety shutters actuated by inserting or withdrawing of the circuit breaker shall be provided in the circuit breaker compartment.

(5) Control circuit isolating connector shall also be provided.

(6) Clearly labelled mechanical interlocks shall be provided in each circuit breaker compartment to prevent:

- a close circuit breaker from being withdrawn from or inserted into the isolating contacts;

- A circuit breaker from being moved into any location unless it is fully withdrawn:

- a circuit breaker from being inserted into the fixed position unless the secondary isolating contacts are fitted.

- a circuit breaker from being closed except when fully inserted or fully withdrawn:

- a circuit breaker from being inserted into the fixed position unless the secondary isolation contacts are fitted.

- a circuit breaker from being closed except when fully inserted or fully withdrawn:

- a circuit breaker from being inserted against a locked safety shutter.

7) A common earth bus bar shall be provided in the switchgear. The bus bar shall consist of one copper

8) All secondary wiring shall be terminated on terminal blocks in an enclosure separate from the high voltage compartment.

4.3.4 Circuit Breaker

The circuit breaker shall be of SF_6 gas type only.

The circuit breaker shall comply with the requirements of IEC 56 and the relevant requirements of these Specifications.

- Rated Voltage : 11 kV
- Rated Current : 6 kA
- Interrupting Current : 40 KA (rms) or higher

Only fully type tested circuit breakers complying with IEC 56 will be considered, and a statement as to the availability of certificates of all such type tests including impulse tests on identical or similar circuit breakers shall be submitted with Tender.

4.3.5 Current Transformer

The current transformers in the generator switchgear shall be of the epoxy resin insulated and of the bar or wound primary type. The ratio, rating, polarity and accuracy classes [tariff metering] of current transformers shall conform to IEC185.

4.3.6 Voltage Transformer

The voltage transformers shall be of the horizontally with draw-out type and shall be located on top parts of each unit switchgear. Padlocking facilities shall be provided for both the services and isolated positions. The fixed isolating contacts shall be covered by a positively driven pad lockable shutter when the voltage transformer is withdrawn.

The ratio, rating, polarity and accuracy classes [tariff metering] of voltage transformers shall conform to IEC 186.The current limiting fuses shall be provided on high tension circuit of the voltage transformer.

4.3.7 Surge Absorbing Equipment

The surge arresters and capacitors for surge protection of the generator shall be provided.

4.3.8 Neutral Earthing Equipment

(1) Neutral Earthing Transformer

A single-phase, 50 Hz, dry or oil immerse type, naturally cooled neutral earthing transformer conforming to IEC 76 shall be provided for generating unit.

The voltage ratio of transformer shall be 11,000/ 240 V. The continuous rating in KVA appropriate to an earth fault duration of 30 seconds and a maximum primary earth fault current of 10 A shall be determined by the Contractor.

Insulation level of primary winding shall be of BIL 75 KV.

(2) Earthing Resistor

The resistance of secondary resistor on neutral earthing transformer shall be equal to one third of the zero sequence capacitance per phase of the generator plus the bus bar capacitors if provided. The current rating shall be suitable for a single phase to earth fault on the generator circuit for 30 seconds and a maximum primary earth fault current of 10 A.

The terminals of the resistor shall be corrosion resistance.

4.3.9 Composition of Cubicles

(1) Incoming Circuit Breaker Cubicle for each unit

-	Circuit breaker	: One (1)
-	Current transformer 40 VA, Cl 0.2 & 5P20	: Three (3) units
-	End terminal	: One (1) lot
-	Ammeter with selector switch	: One (1) set
-	Protective relays	: One (1) set
-	Control switch, etc.	: One (1) lot

2) Voltage Transformer Cubicle

-	Voltage transformer	: One (1) three phase unit
-	Under voltage relay	: One (1) unit
-	Voltmeter with selector switch	: One (1) lot

Section 5

Transformers

5. **TRANSFORMERS**

5.1 General

5.1.1 Requirements for Characteristics
5.1.2 Requirements for Construction-

5.2 Generator Step-up Transformer

5.2.1 Type and Ratio
5.2.2 Output and Required Numbers
5.2.3 Impedance Voltage
5.2.4 Winding and Insulation
5.2.5 On Load Tap Changer
5.2.6 Cable Box
5.2.7 Phase & Neutral Circuit Current Transformer

5.3 Unit Auxiliary Transformer

5.3.1 Type and ratio
5.3.2 Output
5.3.3 Impedance Voltage.
5.3.4 Winding and Insulation
5.3.5 Off Load Tap Changer
5.3.6 Cable Box

5.4 Accessories

5. TRANSFORMERS

5.1 GENERAL

The transformers shall be designed and tested in accordance with IEC 76

(1) Generator Step-up Transformer

Three (03) phase, oil immersed, self-cooled / forced air cooled (ONAN / ONAF), outdoor use type for stepping up the voltage from 11 KV to 132 KV with on load tap changer having uniform insulation.

The maximum continuous rating of the transformer (at ONAN) shall meet at any taps a total output of the generator, as defined in Vol. 2 of 2 (Part-A) clause 4.1.2 Generator Rating, which is connected with the transformer shall be 120% (one hundred and twenty per cent) of the corresponding MVA (pf=0.8) of the Guaranteed Net Generator output at Site condition of 35^0 C, 1.013 bar and 98% RH. The vector group of transformer shall be Ynd_{11}.

The self-cooled capacity shall not be less than 75 % of forced air cooled capacity.

(2) Auxiliary Transformer

Three phase, oil immersed type, self air-cooled (ONAN) for stepping up the voltage from 11 kV to 415 V with off circuit tap changer. The capacity of station transformer shall enable to supply start-up power and common station load.

5.1.1 REQUIREMENT FOR CHARACTERISTICS

(1) Efficiency

The transformers shall be of highest efficiency that the Contractor can attain.

(2) Temperature Rise

The temperature rise of the windings shall not exceed 55^0C when measured by he resistance method, after circulating the rated current at rated frequency in the windings under test.

The temperature rise of top insulation oil shall not exceed 55 ^{0}C when measured by a thermometer in an oil filled thermometer pocket on the cover or in the outlet pipe to the cooler, and the method of the test of temperature rise will be decided in accordance with IEC 76-2 .

(3) Dielectric Test Voltage

The transformers shall withstand the following test voltages in accordance with IEC 76-3.

a. 132 KV CIRCUIT

- lightning impulse withstand test voltage (1.2/ 50 micro sec.) : 650 KV (peak)
- Power frequency test voltage : 275 kV for one minute.

b. 11 KV circuit

- lightning impulse withstand test voltage (1.2/ 50 micro sec.) : 75 KV (peak)

- Power frequency test voltage : 28 kV for one minute

c. 415 V circuit

- lighting impulse withstand test voltage (1.2 / 50 micro sec.) : Not applicable

- Power frequency test voltage : 4.0 KV for one minute

4) No Load Excitation Current : The no load excitation current under the rated voltage and frequency shall be as small as possible.

5) Mechanical and Thermal Strength for Short Circuit

The transformers shall be designed and constructed to withstand for three seconds without damage the thermal and dynamic effects of external short circuits under the most severe conditions.

(6) Tolerances

The tolerances on the guarantee values shall be in accordance with IEC 76-1.

(7) Noise

Vibration and noise levels of transformers shall be in accordance with the best commercial practice.

5.1.2 REQUIREMENTS FOR CONSTRUCTION

(1) Tank and Interior Structure

a. The power transformer shall be of such structure to permit installation at the Site to be simple.

Assembling work at the Site such as staking of core and insertion of coil shall not be allowed.

b. The tank shall be of the welded steel plate structure and shall withstand and hold continuously a vacuum of 760 mm Hg.

e. The sealed joint part of the tank shall be designed to prevent oil and gas leakage and shall be water light even after long term use, and careful attention shall be paid to fastening methods of packing of bushing, bursting tube, cooling radiator, connecting pipes and other accessories.

d. Looseness of core, yoke, coil and other parts shall not happen during transportation and long term use.

e. The transformer shall be provided with a bursting tube to discharge the

pressure in case of abnormal rise of the inner pressure. The tube shall be equipped with alarm contact. The tube shall be extended up to tile oil pit which will be constructed around the transformer.

f. No corona shall be discharged inside and outside of the tank under the imposed primary voltage of 132KV x 130%.

g. All generated gas and oil flow under fault conditions shall be concentrated to the Buchholz or similar type relay so as to ensure the relay action.

h. The transformer shall be provided with skid type base.

i. Anti-vibration rubber or the equivalent shall be provided under the base so as to prevent propagation of transformer's vibration to the other Equipment, if installed in the power house.

j. Winding of coils shall be designed so as to make the initial potential distribution caused by impulsive travelling waves as uniform as possible, to avoid potential oscillation and to withstand abnormal voltage due to switching.

k. The ground terminals of the transformer shall be copper faced steel ground pad, and shall be welded on the tank wall near the base. The ground terminal shall be of the bolt fastened type, suitable for 100-200 sq. mm hard or annealed copper stranded conductors.

l. In designing the transformers, the Contractor shall refer to the general arrangement of the transformer and shall consider the location of the lightning arrester.

(2) Bushing and Connection

132 KV line and neutral bushings of the generator step-up transformer shall be oil filled nitrogen sealed draw lead type with an oil level gauge, and 15 kV bushings shall be of the solid type. The glazing colour shall be of brown.

The lighting impulse (1.2/ 50 micro see.) insulation level of bushings shall be as follows:

- 132 KV line bushings : 650 kV_{peak}
- 132 KV line neutral bushing : 650 kV_{peak}
- 11 KV bushings : 75 kV_{peak}

The creepage distance of bushings of outdoor use transformer except neutral bushing shall not be less than 25 mm / KV of rated phase to phase voltage.

(3) Oil Preservation System

Oil immersed transformers shall be provided with an oil preservation system in which the insulating oil shall be isolated from atmospheric air. The oil preservation system shall be of the diaphragm seal or air seal cell type conservator with silica-gel breather. Oil level gauge with low level alarm contact shall be mounted on the conservator.

(4) Cooling system

An adequate number of unit coolers shall be fixed to the tank of oil immersed transformers, and the cooling capacity shall be sufficient to operate the transformer under the rated power. The coolers shall be of such structure that will not be affected by the vibration of transformer. A valve shall be provided with each pipe connecting a unit cooler to the tank. Fixing bolts and terminals shall be such that will never get loosened after being fastened. The power source of the cooling fans shall be 415 V, 3 phase or 240 V, single phase. The fans shall normally be controlled by its own winding temperature relaying device.

(5) Temperature Detector

One (1) temperature detector shall be installed at the point where the highest temperature is anticipated.

(6) Protective Device

The following protection system shall be provided:

- Buchholz relay and Pressure Relieve Device (PRD) similar type for alarm and trip
- High temperature alarm and trip (winding and oil)

A Buchholz relay or oil pressure relay shall be fitted on between the conservator and the tank. A dial type thermometer with hand resetting maximum indicator shall be provided. A Pressure Relief Device (PRD) with operation indicator shall be provided.

The gas relay should be provided with double float (one operated by volume of gas flow and other operated by mass gas flow). It should have following provision:

a. Gas release valve
b. Mechanical test button
c. Provision for testing both the floats by injecting air from outside.
d. Drain cock
e. Transport graduated window
f. The relay should be mounted at such a place that can be visible from the ground without climbing on the transformer.

(7) Wiring

All wiring mounted on the transformer shall be drawn through conduit pipes or adequate protective tubes to the control cabinet which shall be properly located on the transformer.

The wiring shall be connected at the terminal blocks terminating the outgoing control cable. The flexible tube of the vapour tension thermometer shall be covered by a protective tube.

(8) Insulating oil

The insulating oil shall have a sufficient insulation strength, and shall be excellent in heat conductivity, low in viscosity and pour point, and high in flash point. The oil shall not cause any corrosion to insulating materials and structured materials of electrical equipment and shall be chemically stable for long years of use.

Delivery shall be made to Site partly contained in the transformers and partly in steel drums, according to the method of packing employed. An excess of 10% of the quantity of oil required for filling transformers shall also be supplied and its cost shall be included in the price of each transformer.

(9) Skid Base
The transformer shall be provided with a skid base with four (4) steel wheels and necessary jacks for setting and appropriate devices for locking in position of its foundation.

5.2 STEP-UP TRANSFORMERS

5.2.1 TYPE AND RATIO

The transformer shall be of three (03) phase, oil immersed, self-cooled / forced air cooled (ONAN/ONAF) by cooling fans, outdoor use type. Ratio of delta star connection shall be 11 KV to 132 KV on full load condition.

The connection of the three phases shall be arranged in vector symbol Ynd1 according to IEC 74-4 and neutral of star connected high tension winding shall be solidly grounded.

The on load tap changer shall be provided on the high tension winding, and their ratio shall be as follows:

132 kV ($\pm$1.25% x 8)

5.2.2 OUTPUT AND REQUIRED NUMBERS

The maximum continuous rating of the transformer shall met at any taps a total output of the generator which is connected with the transformer in series as shown in the attached single line diagram.

The self-cooled capacity shall not be less than 75 % of forced air cooled capacity.

5.2.3 IMPEDENCE VOLTAGE

Impedance voltage (+ve seq.) shall be within the range of 15% to 18% on the forced air cooled rating on the rated tapping (11/132 kV) and shall be guaranteed by the Contractor.

5.2.4 WINDING AND INSULATION

The full installation shall be applied on both 132 KV (phase & neutral) and 11 KV windings and neutral point of 132 KV windings shall be solidly grounded.

The winding conductors shall be of high conductivity copper.

The insulation shall be designed not merely by normal voltage per turn, but also by variation of line voltage and the operating conditions including impulse surge caused by lightning strokes on the transmission line and switching surges.

5.2.5 ON LOAD TAP CHANGER

The on load tap changer shall be provided on neutral side of 132 KV winding and shall be designed to meet the requirement of IEC 76. OLTC shall be of MR, Germany or ABB, Sweden only. Provisions shall be made for padlocking in any tap position.

5.2.6 CABLE BOX/Isolated & Insulated Phase Bus Duct

The cable box shall be provided on each transformer so as to cover the 11 KV terminals and 11 kV power cables down to ground surface. Proper cable supports and cleats shall also be provided.

Isolated and Insulated Phase Bus Duct shall be provided from Generator terminal to Generator circuit breaker and Generator circuit breaker to LV side of Unit Transformers.

5.2.7 PHASE & NEUTRAL CIRCUIT CURRENT TRANSFORMER

Current transformer shall be provided on the high tension neutral circuit for Restricted Earth Fault & Stand by Earth Fault relays and ratio should match with phases (LV & HV) Differential protection circuit. If necessary Inter-posing current transformers may be used.

1) Use : Protection

2) Ratings
Rated primary current : 400 - 800 A
(depends on rating of transformer)
Rated secondary current : 1 A
Accuracy class : 5 P20
Rated burden : 15 VA

3) Requirements for characteristics and Construction

The current transformer shall be designed to meet the requirements of latest IEC standard.

5.3 AUXILIARY TRANSFORMER

5.3.1 TYPE AND RATIO

The transformers shall be of three (3) phase, oil immersed, self air cooled (ONAN) type. Nominal no load ratio of delta star connection shall be 11 KV. The secondary voltage shall be 0.415 KV.

The connection shall be arrangement in vector symbol Ynd_{11} according to IEC 76-4 and neutral of star connected low tension winding shall be earthed solidly.

The off load tap changer shall be provided on the high tension winding, and their ratio shall be as follows:
11 kV $\pm$ 2.50 % x5/ 0.415 kV Output

5.3.2 OUTPUT

Unit auxiliary transformer shall enable to supply 120% of required power on unit 0.415 KV for the Diesel Engine generating unit and required common power on station service.

5.3.3 IMPEDENCE VOLTAGE

The impedance voltage shall not less than 5 %, but not more than 7.5 % on the rated tapping and shall be guaranteed by the Contractor.

5.3.4 WINDING AND INSULATION

The requirements shall be in accordance with section 5.2.4 for LV side.

5.3.5 OFF LOAD TAP CHANGER

The off load tap changer shall be provided on 11 kV winding and shall be designed to meet the requirements of IEC 76 . The tap changer shall be of three phase resistor equipment with rotary diverter switch, and shall be designed to provide 16 tapping steps, i.e. 17 positions as follows.

Central tap	: 11 kV
Step voltage	: 2.50%
Upper side	: 5 taps (+2.5%)
Lower side	: 5 taps (-2.5%)

All the mechanical operating parts of the gear shall be self lubricated with transformer oil, no special lubrication being necessary. The tap changer compartment oil shall be isolated from main transformer tank oil, and the compartment shall be provided with proper protection facilities and accessories.

5.3.6 CABLE BOX

The cable boxes shall be provided on both high tension and low tension terminals to terminate high and low voltage power cables. Proper cable supports and cable cleats shall also be provided.

Non segregated bus duct between low tension terminals of auxiliary transformer and power centre terminals instead of cables may be acceptable.

Section-6

132 KV Switchgear

6. 132 kV OUTDOOR SWITCHGEAR, EQUIPMENT

6.1 General

6.1.1 Design Requirement

6.2 132 kV Switchgear, Equipment

6.2.1 132 kV Circuit Breakers
6.2.2 132 kV Disconnecting switches
6.2.3 132 kV Voltage Transformer
6.2.4 132 kV Current transformer
6.2.5 132 kV Lightning Arresters

6.3 Steel Structure

6.3.1 Type
6.3.2 Design Criteria
6.3.3 Requirements for Design and Construction
6.3.4 Design Items
6.3.5 Accessories

6.4 Insulators and Wiring Materials

6.4.1 Insulators
6.4.2 Fitting
6.4.3 Standard Conductor for Over Head Line
6.4.4 Miscellaneous Material

6. 132 kV OUTDOOR SWITCHGEAR, EQUIPMENT

6.1 GENERAL

The contractor shall furnish the 132 kV outdoor switchyard equipment which shall comply with relevant IEC as listed below and the 132 kV equipment shall be arranged in the outdoor as shown on the attached drawings or as directed by the B-R Powergen Ltd..

6.1.1 DESIGN EQUIPMENT

(1) System Voltage

The system shall be as follows:

- Nominal system voltage : 132 kV
- Highest system voltage : 145 kV

(2) Insulation level

The insulation level of the switchgear, equipment shall be as follows:

Lighting impulse withstand test : 650 kV (Peak)
Voltage (1.2 / 50 micro sec.)

- Power frequency insulation level (for 1 mm.) : 275 kV

(3) Outdoor Conductor Clearance

- Phase to phase, standard : 3000 mm
- Phase to phase, minimum : 2100 mm
- Phase to ground, Standard : 1900 mm
- Phase to ground, Standard : 1200 mm

(4) Design Conditions

Switchgear equipment shall be designed to avoid local corona formation and discharge likely to cause radio interface, and to endure short circuit current without thermal and mechanical failure for one (1) second. All cubicles and enclosures shall be vermin proof, dust resistance and weatherproof.

6.2 132 kV SWITCHGEAR, EQUIPMENT

6.2.1 132 kV CIRCUIT BREAKERS

(1) Type

Three (3) pole, porcelain type, high speed, outdoor, trip free in any position, motor operated or hydraulic & spring operated SF6 gas puffer, single flow type complete with hydraulic pump, tank, piping, conduit, wiring, and all other necessary accessories.

(2) Use

For paralleling, control and protection.

(3) Ratings

a. Rated voltage : 132 kV
b. Rated insulation level

-Lighting impulse withstand test voltage : 650 kV (peak)
(1.2/50 micro sec.)

-Power frequency withstand voltage
(for 1 mm.) : 275 kV
c. Rated frequency : 50Hz
d. Rated nominal current : 1,250A

e. Rated short circuit breaking current : 40 kA [rms, 3 sec]

f. Rated transient recovery voltage for terminal faults and rated characteristics for short line faults shall be in accordance with IEC
g. Rated short circuit making current : 100 kA
h. Rated duration of short circuit : 1 sec
i. Rated operating time : Less than 40 m sec

j. Rated operating sequence (<2.5 cycles) : O-0.3sec-CO-3min-CO

4) Control System

The rated supply voltages of closing and opening devices shall be 120/125 V DC, and the operation of circuit breaker shall be performed safely under the following conditions:

For tripping operation (-30% to +10%) : 88 V to 137 V DC

For closing operation (-15% to +10%) : 106 V to 137 V DC

The rated hydraulic pressure shall be recommended by the Contractor.

(5) Requirements for Design and Construction

a. The circuit breakers shall have automatic trip free mechanism.

b. Time difference between contacts of three (3) poles shall not be more than 0.006 sec.

c. In case of phase open trouble, all phases of the circuit breaker shall be opened by a protection circuit.

d. The arcing contact shall be of an arc proof metal and the main contact shall be covered with silver electroplated. Five (5) pairs of "a-b " spare contacts shall be equipped with the auxiliary switches.

e. The tripping current of the trip coil shall not be more than 2 A per phase.

f. The porcelain insulator or bushings shall have sufficient strength to withstand stressed due to breaker operation. The glazing colour shall be of brown. The creepage distance shall not be less than 25 mm / kV of phase to phase voltage.

g. Integrating time register for hydraulic pump shall be driven by a self starting synchronous motor through mechanical gears to record operating hours of hydraulic pump and shall be able to perform four operations without AC power.

h. Gas circuit breaker shall be provided with gas density detector responding to gas density and pressure. This gas density detector shall have two (2) different functions according to the gas condition: The first step gives alarm and the second step locks the operating mechanism. Operating mechanism which employs compressed air or hydraulic for driving the circuit breaker shall be provided with pressure detector which have two (2) different functions according to compressed air or hydraulic condition : The first step gives alarm and the 2nd step locks the operating mechanism.

i. The weather and dust proof type control box shall be furnished with the circuit breakers. The control box shall be equipped with all necessary parts to operate the circuit breaker, such as control solenoids, operating switch of remote and local control, auxiliary switch, terminal blocks, protective devices, indicating lamp sockets, and other accessories. An anti condensation electric heater with thermostatic switch shall be provided inside the control box.

j. The circuit breakers shall be provided with an emergency push button switch with cover to prevent inadvertent switching.

k. The circuit breakers shall be provided with an electrical anti pumping relay.

l. The supporting structure shall be free from mechanical vibration and Loosening under long term use.

m. The circuit breakers shall be designed to facilitate inspection, Especially for those parts which need inspection frequently.

n. The circuit breakers shall be filled with sufficient SF_6 gas.

o. SF_6 gas leak detector shall be furnished.

p. The circuit breakers shall be driven by hydraulic and spring latch. Hydraulic supplying system shall be furnished with the circuit breakers, and shall be installed in weather dust proof type housing. The operating mechanism shall be designed to meet the requirements of IEC 56

q. Temperature limitation shall be in accordance with IEC 56.

r. The Contractor shall furnish all control cables, pipes or ducts and fittings between each phase and control box.

s. The indicating lamp signals which display " on (red) " and " off green)" of the main contacts shall be furnished on the each control box of circuit breaker.

(6) Dielectric Test Voltage

a.	Power frequency withstand voltage	:275 kV for one minute
b.	Lighting impulse withstand voltage Full wave (1.2 / 50 micro sec.)	:650 kV_{PEAK}
c.	Test voltage on control circuit	:2.0 kV for one min.

(7) Tools and Accessories

The following tools and accessories shall be supplied for each circuit breakers.

a. Name plate
b. Position indicating lamps (red and green) or flags.
c. Operation counter.
d. Grounding terminals
e. Gas, and hydraulic pressure gauge
f. Safety valves, if any
g. Pressure drop protecting device
h. Manual operation device.
i. Auxiliary switch
j. Control box with locking device
k. Steel supporting structure with anchor bolts and nuts
l. Operating mechanism.
m. Special tools for checking and testing
n. Power outlet, single phase, 132 V, 10 A in control box
0. Conduit pipes
p. Communication facilities between switchgear and control room
q. Other necessary accessories, if any

6.2.2 132 kV DISCONNECTING SWITCHES

(1) Type

For buses

Outdoor, three (3) pole, single throw, group operated, horizontal break, rotating insulator, remote controlled motor operated type.

(2) Ratings

a.	Rated voltage	:132 kV
b.	Rated insulation level lighting impulse withstand test voltage (1.2 /50 micro see.)	:650 kV (peak)
- Power frequency withstand voltage (for 1 mm.)		:275 kV
c.	Rated frequency	:50Hz
d.	Rated nominal current	:1250A

e. Rated duration of short circuit current :1 sec
f. Rated short circuit withstand current :40 kA
g. Rated peak withstand current :63 kA
h. Rated short circuit making current :100 KA

(3) Requirements for Design and Construction

a. The disconnecting switches shall be so designed and Constructed in accordance with IEC 129.

b. The contact part of the blade shall be silver electroplated.

c. The porcelain insulator shall be an outdoor and post type, and shall have creepage distance not less than 25 mm/ kV of phase to phase voltage age. The glazing colour shall be of brown.

d. An electrical or mechanical interlocking device shall be equipped between its related circuit breaker.

e. Revolving parts shall be so designed that operation will be sure and smooth under long term use without necessity of inspection, oiling.

f. Auxiliary switches with three (3) spare parts " a-b " contacts, terminal blocks, indicator lamp sockets, etc. shall be accommodate in a control box shall be of the weather and dust proof type with locking device.

(4) Dielectric Test Voltage

a. Power frequency withstand voltage :275 kV for one minute

b. Lighting impulse withstand voltage
Full wave (1.2/ 50 micro sec.) : 650 kV_{PEAK}

c. Test voltage on control circuit :2.0 kV for one min.

(5) Accessories

a. Nameplate
b. Control box with locking device
c. Grounding terminal
d. Auxiliary switches
e. Steel supporting structure with anchor bolts and nuts
f. Manual operation handle
g. Motor operating mechanism with manual operation inter-lock
h. Conduit pipes
i. Other necessary accessories, if any

6.2.3 132 kV VOLTAGE TRANSFORMER

(1) Type

Outdoor, single phase, oil immersed with level indicator or gauge, N_2 gas sealed Electromagnetic type voltage transformer.

(3) Use

For metering and protection

(4) Ratings

a. Rated voltages

-	Primary	:132/√3 kV	(Two separate cores will be dedicated for main and back-up metering as per advice of BPDB.)
-	Secondary	: 110/√3 V	
-	Tertiary	: 110/ 3 V	

b. Rated insulation level

-	Lighting impulse withstand voltage Full wave (1.2 / 50 micro sec.)	:.650 kV_{peak}
-	Power frequency withstand voltage for one minute	:275 kV

c. Rated frequency :50 Hz

d. Rated burden

-	Secondary	:200 VA
-	Tertiary	:25 VA

e. Accuracy class :**0.20 (metering)**
:3 P (tertiary)

(4) Requirements for Design and Construction

a. The voltage transformers shall be of hermetically sealed and accessories shall be of weatherproof type. The glazing colour shall be of brown.

b. Creepage distance of bushing shall not be less than 25 mm / kV of phase to phase voltage.

c. A protection device shall be provided against short circuit of the secondary circuits of the voltage transformers.

Unless otherwise specified, the characteristic and others shall comply with the requirements of IEC 186.

(5) Dielectric Test Voltages

a. Power frequency withstand voltage :275 kV for one minute on primary windings

b. Lighting impulse withstand voltage
Full wave (1.2 / 50 micro Sec.) :650 kV_{PEAK}

c. Power frequency withstand voltage on secondary windings :2.0 kV for one minute.

(6) Accessories

The following accessories shall be provided for each voltage transformer.

a. Nameplates
b. Grounding terminals
c. Lifting lugs
d. Steel supporting structure with anchor bolts and nuts
e. Junction boxes
f Conduit pipes
g. Other necessary accessories, if any

6.2.4 132 kV CURRENT TRENSFORMERS

(1) Type

Outdoor, single phase, oil immersed with level indicator or gauge, N_2 gas sealed porcelain clad type, quadruplicate cores.

(2) Use

For metering and protection

(3) Ratings

a. Rated current

- Primary :1200-800 A [to be at actual requirement]
- Secondary : 1-1-1-1 A (Two separate cores will be dedicated for main and back-up metering as per advice of BPDB.)

b. Rated insulation level

-Lighting impulse withstand voltage
Full wave (1.2 / 50 micro sec.) : 650 kV_{PEAK}

-Power frequency withstand voltage :275 KV for one min.

c. Rated frequency :50 Hz

d. Rated burden :60 VA for protection and
:30 VA for measuring.

e. Rated continuous thermal current :120%

f. Short time current ratings

-Thermal rating (r.m.s. for one sec.) :40 KA
-Dynamic rating (peak) :2.5 times the thermal

ratings

g. Accuracy classes
-For metering :0.2, n‹5
-For protection :5P20

(4) Requirements for Design and Construction

a. The current transformer shall be of oil immersed hermetically sealed structure type.

b. Internal conductor shall be adequately reinforced taking into account over current intensity.

c. The junction box with terminals shall be provided for the secondary circuit connections.

d. Each current transformer shall be equipped with terminal block of short circuiting type.

e. Creepage distance of bushing shall not less than 25 mm / kV of phase to phase voltage. The glazing colour shall be of brown.

f. Unless otherwise specified, the characteristics and others shall comply with IEC 185 .

(5) Dielectric Test Voltages

a) Power frequency withstand voltage on primary windings :275 kV for one minute

b. Lighting impulse withstand voltage
Full wave (1.2/ 50 micro sec.) :650 kV_{PEAK}

c. Power frequency withstand voltage on secondary windings :2.0 kV for one minute.

(6) Accessories

The following accessories shall be provided for each current transformer.

a. Nameplates
b. Grounding terminals
c. Lifting lugs
d. Steel supporting structure with anchor bolts and nuts
e. Junction boxes
f. Conduit pipes
g. Other necessary accessories, if any

6.2.5 132 kV LIGHTNING ARRESTERS

(1) Type

Outdoor, single phase, self standing, Metal-Oxide type with surge operating counter.

(2) Use

For protection of 132 kV outdoor switchyard equipment and transformer windings.

(3) Electric system to be protected

Three (3) phase, three (3) wire, neutral point solidly grounded system.

(4) Ratings and Performances

a.	Rated voltage	: 126 kV
b.	Rated frequency	: 50 Hz
c.	Nominal discharge current	: 10 KA
d.	Type of duty	: Heavy, Long duration Discharge
e.	Pressure relief class	: C
f.	Lighting impulse insulation level (1.2 / 50 micro sec.)	: 650 KV_{peak}
g.	Maximum residual voltage	: 400 KV
h.	Power frequency spark-over voltage	: 170 KV

(5) Operating duty

The arrester shall successfully interrupt the dynamic current repeatedly conducted by impulse wave.

(6) Requirements for Design and Construction

a. The series gaps shall be so designed that for practical purposes the various characteristics will not alter under the change of weather conditions

b. The various parts of the lightning arrester shall be of complete moisture proof construction so that the characteristics shall not be impaired under long term use. Sealed parts shall be so designed to prevent to ingress of moisture or water under long term use.

c. The operation counter shall be equipped on the lightning arrester in each phase and consist of a sure current recording and measuring device, such as a magnetic link surge crest ammeter, and counter for the number of discharges of the lightning arrester. It shall be located at the position convenient for inspection.

d. Creepage distance of bushing shall not be less than 25 mm/ kV of phase to phase voltage. The glazing colour shall be of brown.

e. Unless otherwise specified, tile characteristics and others shall comply with IEC 99-1

(7) Dielectric Test Voltage

a.	Power frequency withstand voltage	:275 kV for one
b.	Lighting impulse withstand voltage (1.2 / 50 micro sec.)	:650 kV (peak)

(8) Accessories

The following accessories shall be provided for each lightning arrester.

a. Nameplates
b. grounding conductor to grounding terminal
c. Operating counter
d. Grounding terminal
e. Steel supporting structure with anchor bolts and nuts
f. Other necessary accessories, if any

6.3 STEEL STRUCTURE (Busbar & Bay Extension)

6.3.1 TYPE

The steel structure shall be lattice truss construction made of galvanised formed steel and assembled by bolts and nuts.

The component members of steel structure shall have inter-changeability with other identical members. The basis framing of the steel structure shall be identical on all four (4) faces below the bend line.

6.3.2 DESIGN CRITERIA

The steel structure shall be designed in accordance with the following criteria.

(1) Load due to the tension of conductor and wire.

- 132 kV bus and outgoing conductor : 900 kg per conductor
- Overhead grounding wire : 450 kg per wire

(2) Vertical loads

The weight of the conductors, grounding wires, insulator strings and steel structures shall be taken into consideration.

(3) Human Loads

120 kg at the centre of the beam.

(4) Wind loads

Wind loads shall be calculated with wind speed of 100 miles / hr, but the wind loads on unit projected area shall not be less than the followings:

- On conductors and grounding wires :125 Kg/sq.m
- On insulators and other circular section :130 Kg/sq.m
- On lattice structures or beam structure :230 Kg/sq.m

(5) Seismic Coefficient (Horizontal) : 0.28 g

6) Working Conditions

The normal working condition for various loads shall be deemed to work simultaneously. The wind direction shall be classified into transverse, longitudinal and oblique components to the line route and the largest load acting on the line shall be taken as the design stress of the component material.

(7) Combination loads

The Contractor shall calculate the maximum and minimum stresses at any combination of loading conditions. The design of each type of steel structure shall be made by the same manner of analysis. The design stresses of individual components shall be largest value of maximum stresses in the respective loading conditions.

(8) Safety Factors

The safety factors shall not be less than two (2) under the normal working conditions.

(9) Minimum Thickness and Size of Steel Members

Minimum thickness and size of steel members shall be as follows:

a. Formed steel : not less than 45 x 45 x 4 mm
b. Plate : not less than 4 mm thick.

(10) Slenderness Ratio

The slenderness ratio shall not exceed 120 for main members, 200 for bracing and 250 for other members.

6.3.3 REQUIREMENTS FOR DESIGN AND CONSTRUCTION

(1) Workmanship

Workmanship shall be first class throughout. All pieces shall be straight, true to detailed drawings and free from lamination, flaws and other defects. All clippings, back nuts, grindings, bends, holes, etc. shall be true to detailed drawings and free of burrs.

(2) Galvanising

The steel structure shall be completely galvanised (Hot-Deep), except for part which shall be embedded in concrete foundation. All ferrous materials shall be galvanised to meet the requirements of IEC .

(3) Materials of Steel Structure

All materials shall be hot rolled structural steel and or high strength structural steel.

(4) Marking

All products shall be marked with systematic numbers and / or colours for convenience of assembly.

(5) Future Extension of Structure

In designing the steel structure, consideration shall be given in the design criteria to permit easy extension of steel structure in the future and same loading conditions shall be taken into account in accordance with the Specifications.

(6) Bolts and Nuts

All the members shall be connected by bolts and nuts. The diameter of the connection bolts and step bolts shall not be less than 16 mm.

6.3.4 DESIGN ITEMS

The Contractor shall submit to the B-R Powergen Ltd. for approval design sheets and drawings including calculation of Loads, selection of constitution and members, selection of connecting bolts and calculation of reaction load against base concrete.

6.3.5 ACCESSORIES

The following accessories shall be provided, but not be limited.

a.	Anchor bolts and nuts	: One (1) lot
b.	Gauge plate for anchor bolt	: For (4) of each kind
c.	U-hook bolts and nuts	: one (1) lot
d.	Grounding terminals	: one (1) lot
e.	Step-bolts	: one (1) lot
f.	"Roval" paint for repair	: Five (5) Kg
g.	Phase identification plates	: one (1) lot
h.	Other necessary accessories, if any	: one (1) lot

6.4 INSULATORS AND WIRING MATERIALS

6.4.1 INSULATORS

(1) Type and requirements

a. The insulator assembles shall consist of suspension insulator discs, hardware, strain or suspension clamps as required.

b. The suspension insulators shall he of ball and socket type and shall conform to the requirement of IEC 120.

c. The insulator unit shall be standard 254 mm porcelain disc type or fog type 254 mm porcelain disc type, and have a spacing of 146 mm between discs.

d. Total creepage distance of the insulator assemblies shall not be less than 3300 mm.

e. The insulators shall be wet-process porcelain of the highest glade, dense and homogeneous. The glaze shall be smooth, hard, dense and uniform and shall not be effected by weather or sudden change in temperature, salty atmosphere and lighting during certain periods of the year. Colour of porcelain surface shall be brown. All ferrous metals shall be galvanised except for female thread and stainless steel. Each insulator shall bear symbols identifying the manufacturer and indicating the year of manufacturer and tension proof test load.

(2) Characteristics of Suspension Insulators

a. Porcelain disc diameter	: 254 mm
b. Unit spacing	: 146 mm
c. Minimum electromechanical failing load	: 21000 Kg
d. Dimension of ball socket and pin	: Conform to IEC

(3) Characteristic of Insulator Assemblies

a.	Nominal system voltage	: 132kV
b.	Highest system voltage	: 145 kV

c. Creepage distance not less than : 3300 mm
d. Breaking strength of complete set : 1200kg
e. System insulation level
- Basic impulse insulation level (1.2120 micro sec.) : 650 kV_{peak}
- Power frequency withstands voltage (For 1 mm.) : 275 kV

6.4.2 FITTING

The suspension and tension clamps for bus works and outgoing feeders, tension clamps for overhead grounding wires, U-bolts, ball eyes, anchor shackles, etc. for wiring of switchyard shall be furnished by the contractor. Unless otherwise specified, all hardwire fittings shall be made by malleable iron or forged steel hot dip galvanised or aluminium alloy.

All metal shall be free from rust, burrs, sharp edges, lumps and dross and shall be smooth so that interconnecting parts will fit properly and the parts may be assembled and disassembled easily. Hardware shall have ultimate strengths exceeding three (3) times tension load of bus work and overhead ground wire.
The cramps shall not be occurred in excessive heating by magnetising or other causes.

6.4.3 STANDARD CONDUCTORS FOR OVER HEAD LINES

(1) 850 mm^2, hard drawn aluminium conductor

The hard down aluminium stranded conductor of 850 mm^2 shall be used for 132 kV bus bars and for outgoing feeder circuit. The conductors shall comply with the requirements of IEC .

(2) Galvanised Steel Wire

The galvanised steel wire of 55 mm^2 shall be used as overhead grounding wire.

(3) Spools for Conductors

The spools for conductors shall be made of steel and treated against corrosion and rust, and the following marking shall be indicated on an appropriate side of the spool.

- Conductor number
- Kind and cross sectional area of conductor
- Conductor length
- Spool weight
- Name of manufacturer or abbreviation
- Date of production
- Position of beginning of conductor
- Direction of rotation of spool
- Indicator showing the remaining length of conductor

6.4.4 MISCELLANEOUS MATERIALS

All miscellaneous materials such as phase mark plates, angle steel, C-shaped steels, conduit pipes, cable cleats, bolts, nuts, and other materials for completion of the switchyard shall be provided by the Contractor.

Section 7

Low Tension Switchgear

7. LOW TENSION SWITCHGEAR

7.1 6.6 kV SWITCHGEAR

7.1.1 CONSTRUCTION

7.2 415 V SWITCHGEAR AND MOTOR CONTROL CENTRES

7.2.1 SWITCHGEAR (POWER CENTRE)

7.2.2 MOTOR CONTROL CENTER

7. 6.6 kV SWITCHGEAR (if required) AND LOW TENSION SWITCHGEAR

As shown in the Auxiliary One Line Diagram, the auxiliary Power system shall consist of the following equipment, but not be limited to:

- 6.6 kV Switchgear
- 415 V Switchgear and Motor Control Centres

7.1 6.6 kV SWITCHGEAR

7.1.1 CONSTRUCTION

Type and Rating

- Type

Indoor, steel sheet formed cubicle, single bus draw-out type

- Rating

Rated voltage : 6.6 kV

- Rated insulation level

Lighting impulse withstand voltage : 60 KV
Power frequency withstand voltage : 22 KV(1 min)

- Rated frequency :50Hz

- Rated normal current

Incoming and bus tie circuit : 600 A
Feeder circuit : 600 A
Rated short circuit current : 40 kA (rms.)
Rated short circuit making current : 100 kA (peak)

Number of circuit : Determined by the Contractor but two (2) Spare feeders shall be included.

(2) Draw-out System

Circuit breakers shall be drawn out horizontally by hand, and primary and control circuits shall be disconnected from the buses automatically.

(3) Compartment

Circuit breaker chamber and bus chamber shall be isolated by grounded steel plates, and bus conductors shall be installed.

(4) Front Door

Each compartment shall have hinged door mounted with instruments switches, indicating lamps and test terminals.

(5) Rear Panel

Each compartment shall have removable covers.

(6) Leading of Cable

Control cables shall be led from terminal blocks through front bottom of front bottom of cubicle.

(7) Bus bar

3-phase, 3-wire system. Copper bar, totally insulated. Buses shall be suitable for capacity continuous duty.

a. Main bus, more than 1000A
b. Branch bus, more than 600 A

(8) Control Power Bus

2-wires DC 250 volt insulated wire.
Branched circuit shall consist of two circuits of closing and tripping for every circuit breaker.

(9) Neutral Grounding Resistor

Low tension winding of the station transformer shall be grounded through neutral grounding resistor which is accommodate in the compartment of 6.6 kV switchgear. The current rating shall be suitable for a single phase to earth fault on 6.6 kV circuit for 30 seconds and a maximum neutral current shall not be exceeded 10 A.

7.2 415 V SWITCHGEAR AND MOTOR CONTROL CENTRES

As shown in the Auxiliary One Line Diagram, 415 V switchgears and motor control centres shall be supplied to control all electric motor driven auxiliaries and supply power to the other electric load of the generating plant. If control centres or distribution panels not described in this Specification be needed, they shall be supplied with each facility.

The switchgears and motor control centres are classified into the following:

- One (1) sets of 415 V common switchgear.
- Three (3) sets of 415 V unit switchgears.
- Four (4) sets of 415 V motor control Centres.
- One spare C.B must be supplied for each type of C.B.

7.2.1 SWITCHGEAR (POWER CENTER)

(a) Type and Rating

- Type
  Indoor, steel sheet formed cubicle, single bus draw out type.
- Rating
  Rated voltage :415 V
  Rated frequency :50 Hz
  Rated normal current

	Incoming and bus tie circuit	:2,500 A
	Feeder circuit	:600 A
	Rated short circuit current	:40 KA(rms)
-	Number of circuit	:Determined by the contractor, but 2(two) spare feeders shall be provided.

(b) Kind of Unit

Determined by the Contractor, but 2 (two) spare feeders shall be provided on each switchgear. The switchgear shall be of 3 phase, 4 wire, neutral solidly grounded, 415 V power centre type with circuit breakers 40 kA interrupting capacity. The switchgear shall contain the following kind of circuits as general.

Incoming and bus tie circuit
2,500 A, 40 kA (rms) ACB

- Motor feeder circuit

600 A, 40 kA (rms) ACB

- Feeder for motor control center

600 A, 40 kA (rms) ACB

- Voltage transformer unit

All circuit breaker shall be able to draw out horizontally.

C. Compartment

Grounded metal plate shall be provided to separate between the units and circuit breaker section and bus bar section.
Conductor shall be insulated.

(d) BusBars

Bus bars shall be copper bars with insulating cover.

(e) Cable Connection

Power cables and control cables will be led from the terminals through rear bottom of cubicle.

(f) Control Power

The switchgear

7.2.2 Motor Control Centre

a. Type and Rating

- Type

Indoor, steel sheet formed, self standing dual face type motor control centre.

- Rating

Rated voltage	: 415 V
Rated voltage	: 50 Hz

- Rated normal current

Incoming	: 2,500 A
Feeder circuit	: 450, 200 or 100 A

- Rated short circuit current : 40 KA(rms)

- Number of circuit : as required including two(2) spare feeders on each motor control centre.

b. Kind of Unit

The motor control centre shall be of 3 phase, 4 wire, neutral solidly grounded, 415 V motor control centre type and shall contain the following circuits as required.

- Incoming
  2,500 A, 40 kA (rms), moulded circuit breaker.

- Motor feeder circuit

400, 200 or 100 A, 40 kA (rms) moulded circuit breaker, contactor, and reserve units if required.

- Non- motor feeder circuit

400, 200 or 100 A, 40 kA (rms) moulded circuit breaker.

c. Compartment

Grounded metal plate shall be provided to separate between the unit and C B. section and bus bar section conductors shall be insulated.

d. Draw-out system

Control centre unit and incoming circuit breaker shall be drawn out horizontally by hand and main circuits shall be disconnected from bus bar.

e. Motor Feeder Unit

Each unit shall have hinged door on which circuit breaker operating handles, indicating lamps, operating push button and miscellaneous attachment shall be mounted.

f. Non-motor Feeder Unit

Each unit shall have hinged door on which circuit breaker operating handles and miscellaneous attachment shall be mounted.

g. Cable connection

Power cables and control cables will be led from the terminals through front bottom of cubicle.

h. Busbars

Bus bars shall be copper bars with insulating cover.

Section 8

Control And Protection

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8. CONTROL AND PROTECTION EQUIPMENT

8.1 GENERAL REQUIREMENTS

The Contractor shall supply and install all control, protection and instrument panels with measuring instruments, relays, control switches, automatic controllers, annunciator, etc. necessary for proper operation and monitoring of the Dual Fuel Engine generating units, switchyard equipment and their associated facilities. All Control & Protection System must be Micro-Processor based [Numerical] and Protective Relays shall be from ABB/ALSTOM/SIEMENS.

8.1.1 Control and Supervision Concept for Power Plant

The control and supervision system is designed for safe, reliable, efficient and easy operation of the generating sets, and their associated auxiliaries and electrical systems.

The control system allows centralized operation from the generating set control panel, which is placed close to the generating set.

Control modes

The following control modes are available for the generating set control.

By increasing or decreasing the engine fuel supply, the active power can be controlled in:

- MW mode - the generating set power is maintained at a preset value irrespective of system load or frequency. This is the typical operating mode for a base load power plant supplying an infinite grid.
- Speed droop mode - the generating set shares the load with the grid or other generating sets according to a speed droop curve. This is the typical operating mode for smaller grids or in island mode.

By increasing or decreasing the generator voltage, the reactive power can be controlled in:

- Constant Power Factor control - the generating sets power factor is maintained at a preset value and any changes are produced by the grid or other generating sets
- Voltage droop mode - the generating set will share the reactive load with the grid and other generating sets equally in relation to the size of the units.

The control system will automatically switch operating mode based on the "parallel with grid" signal. In Auto mode the setting values for active and reactive power will be based on operator input in the operator interface terminal, while in Manual mode it will be based on the switches in the control panel.

Central common control panel

Central generating set control panel

The central generating set control panel have to contain the following control units and devices:

Power Monitoring Unit (PMU)

The PMU is a digital power monitoring unit where the generating sets electrical measurements can be monitored and supervised.

The PMU includes the following functions:
- Measurement of phase currents, with stored min and max
- Measurement of main and phase voltages, with stored min, max and average
- Measurement of frequency
- Calculation of Active, Reactive and Apparent power
- Calculation of Active and Reactive Energy, imported, exported and total
- Measurement of engine running hour

Generator protection relay.

The digital programmable multi-function protection relay is connected to current and voltage transformers in the generator cubicle and in the generators main terminal box.
The protection relay has the following protection functions:
- Over and under voltage protection
- Over and under frequency protection
- Reverse power protection
- Over current and short circuit protection
- Stator earth fault protection
- Loss of excitation protection
- Negative sequence (unbalance) over current protection

Programmable Logic Controller (PLC) unit for control and supervision of the generating set.
The high grade PLC integrates the control functions as required by the process and operation sequences. The PLC also handles the start/stop sequence, process measurements and alarms
The PLC includes the following units and devices:
- Power supply unit for CPU (110 VDC)
- Central Processing Unit (CPU)
- Communication card
- Analogue measurement Input - Output card
- Digital Input - Output cards

Liquid Crystal Display (LCD) operator interface terminal with generating set measurement, alarm and status information. Display size 127 x 34 mm.

Set of conventional panel mounted meters for:
- Pl Generating set active power (MW)
- P2 Generating set reactive power (MVAr)
- P3 Engine and turbocharger speed (rpm), with selector switch

Manual control interface unit for selection of generating set operating modes. The unit includes the following control devices:
- Generating set control mode selector switch (Auto-Manual)
- Active power control mode selector switch (Speed droop - kW control)
- Reactive power control mode selector switch (Voltage droop - p.f control)
- Engine power control switch (decrease-increase)
- Generator voltage control switch (decrease-increase)
- Synchronising select and start of synchronisation control switch
- Engine start pushbutton with engine running indication light
- Engine stop pushbutton with engine stopped indication light
- Breaker close pushbutton with breaker closed indication light
- Breaker open pushbutton with breaker open indication light
- Engine shutdown indication light with reset pushbutton

- Breaker trip indication light with reset pushbutton
- Indication lamp testing pushbutton

Set of Hardwired engine shutdown and breaker trip circuits. Safety interlocking and important protection of the generating set to be carried out by hardwired connections and the protection relay.

Emergency stop push-button

8.1.2 132 kV SWITCHGEAR CONTROL AND PROTECTION

Substation Automation System (SAS) allows centralized operation from control room.

8.1.2.1 132 kV SWITCHGEAR EQUIPMENT PANEL

The following panels for controlling, indicating and protecting of 132 kV switchgear equipment shall be provided, but not to be limited to, in the central control room:

A. One (1) no of step-up Transformer panel
B. Synchroniser Panel

All front panels of the above shall be equipped with control and metering facilities, and all rear panels shall be equipped with protection relays. The relays to be provided under this Project shall be suitable for proper coordination with the existing relays of the System.

8.1.3 STEP UP TRANSFORMER PANEL

(1) FRONT PANEL

The front panel shall be equipped with the following items of controls and instruments, but not be limited to:

One (1) lot 132 kV circuit breaker control switch.
One (1) lot 132 kV disconnecting switch control switch.(optional)
One (1) lot Ammeter selector switch
One (1) lot Synchronising key switch, removal types.
One (1) lot Ammeter (132 kV side) (0-600 A), Voltmeter & pf meter
Two (2) sets Unidirectional watt hour meter (132 kV side) with provision of reserve stop for export and import of energy and with indicating lamps for voltage failure [Cl 0.2].
One (1) lot Mimic bus
One (1) lot Annunciators (minimum 15 windows)

(2) REAR PANEL

The rear panel shall be equipped with the following items of protection, but not be limited to:

One (1) lot Overall differential relay
One (1) lot Step-up transformer primary over-current relay
One (1) lot Step-up transformer neutral over-current relay

One necessary auxiliary relays, test terminal blocks, lockout relays, etc. shall also be provided.

8.6.3 SYNCHRONIZING PANEL

Swing type synchronising panel shall be equipped with the following items instruments, but not be limited to:

One (1)	Synchroscope	
Two (2)	Voltmeter	(0-120 kV)
Two (2)	Frequency meter	(48-52 Hz)

8.7 DESK BOARD FOR 11 KV COMMON SWITCHGEAR

The desk board for 11 KV, instruments, and other necessary things:

One (1) lot	Control switch for 11 kV circuit breaker for incoming
One (1) lot	Control switch for spare 11 kV circuit breaker
One (1) lot	11 kV bus voltmeter selector switch
One (1) lot	Incoming circuit ammeter selector switch
One (1) lot	11 kV bus voltmeter (0-11 kV)
One (1) lot	Incoming ammeter (0-6000 A)
One (1) lot	Spare breaker watt meter
One (1) lot	Spare breaker Var meter
One (1) lot	Spare breaker watt-hour meter with indicating lamp for voltage failure
One (1) lot	Mimic bus
One (1) lot	Annunciators (minimum 15 windows)
One (1) lot	Test terminal blocks

8.8 DESK BOARD FOR AUXILIARY POWER SUPPLY

- Required no. of 11 kV and 415 V incoming circuit breaker control switch.
- Required no. of 11 kV and 415 V bus tie circuit breaker control switch.
- Required no. of 11 kV and 415 V feeder circuit breaker control switch
- Required no. of 11 kV and 415 V voltmeter selector switch.
- Required no. of 11 kV and 415 V incoming circuit ammeter selector switch.
- Required no. of 11 kV and 415 V bus voltmeter.
- Required no. of 11 kV and 415 V incoming circuit ammeter.
- Required no. of 11 kV and 415 V incoming circuit watt-hour meter with indicating lamps for voltage failure.
- One (1) lot Annunciators (minimum 15 windows).
- One (1) Mimic bus.
- One (1) Test terminal blocks

8.9 DESK BOARD FOR HRSG CONTROL

One (1) set of water/steam pressure monitors
One (1) set of water/steam temperature monitors
One (1) lot of control switches.

8.10 INSTRUMENTATION AND CONTROLS

8.10.1 DESIGN REQUIREMENTS

Control signals and instrumentation signals shall not be affected by stray AC voltage or other interface of any type normally found in a power station. The Contractor shall supply shielded cables and surge arresters where necessary.

Shock absorbing mountings shall be supplied for instrumentation equipment where required.

Each component shall be identified and tagged with a designation number. Instrument scale ranges shall be expressed in SI units metric units.

8.10.2 MEASUREMENTS

Measurements shall be taken for plant operation and control, and for heat balance and equipment's performance & efficiency calculations including supply of software on on-line plant performance monitoring & optimisation to interface with Plant Control, Protection, Monitoring system.

The main modules of on-line plant performance monitoring & optimisation package shall comprise of 1) Data Acquisition; 2) Data Validation & on-line Heat Balance; 3) On Line Performance Module & 4) On Line Optimisation Module.

(1) Pressure Measurement

Pressure shall be measured near the pump discharges, pump suctions where NPSH availability is critical, at either side of equipment where pressure drop id significant, pressure regulated process, remote end of service lines, and near flow and level measurements affected by compressibility or density changes.

Normal operating point shall be approximately 60% of the range, over-range protection of at least 1.3 times the maximum scale reading shall be furnished on all pressure instruments. Accuracy shall be plus / minus 0.5% of calibrated span for bellows or bourdon tube transmitters at the minimum.

(2) Temperature Measurement

Temperature at appropriate locations at discharge, intake, exhaust gas, rotor shaft bearings, stator windings, critical metal points, lube oil, radiators, etc. shall be measured.

In general, temperature element shall be thermocouples, resistance temperature detectors may be used as sensors for control loops. Thermocouples shall be cooper-constan for temperatures upto 200^0C iron constantan up to 750^0C, and

chromel alumel up to 950 ^{0}C. Cold junction compensation shall be achieved in the control room. All extension wires from thermocouples and resistance temperature detectors shall be shielded. Thermocouples shall be accurate to plus / minus 0.75 % maximum measured temperature.

Resistance temperature detectors shall have platinum resistance windings and shall be connected by the three-wire method. Resistance temperature detectors shall have an accuracy of plus / minus 2^{0}C. Local temperature gauge shall be bimetal thermometers and shall have 80 mm round dial at minimum with black and white markings.

Welded wells for temperature element shall be the same material as the associated piping systems. All screwing wells shall be stainless steel.

(3) Level measurement

Level shall be measured in all tanks and vessels. Measurement of level in large or pressurised vessels shall be by differential pressure. Local level indication of small be by gauge glass for clear liquids, and by a top mounted float or bubbler for viscous liquids. Level controllers shall be of the differential pressure, or external cage displacement type.

(4) Flow measurement

Flowmeters shall, with the exception of the area meter, operate on the relationship which exists between differential pressure and fluid velocity. Flowmeters shall have liner outputs. Accuracy for fuel flow meter shall be within 2.0% at rate of flow higher than 80%.

Flow metering of fuel shall be temperature and / or pressure compensated & with integration.

For flow-metering of oil, positive displacement meters or area meters shall be used.

8.10.3 CONTROL EQUIPMENT

(1) Transmitters

Indicating transmitters shall be provided for control loops as required. Transmitters shall be substantially unaffected by changes in temperature and in process static pressure over a range from zero to twice the normal operating pressure. Transmitter shall feature accessible zero. and span adjustment.

(2) Final Control Elements

Control valves and damper actuators shall be pneumatic, where necessary, provided with electric- to-pneumatic converters. The response of final control elements shall have minimum time lag.

a. Control Valves

Control valves rated at 2,00 kN/ sq.m (300 lbs ASA) and below shall be flanged and higher rating shall be welded. Valves shall with stand shock loads imposed by the processor. control valve actuators shall be sized to overcome packing friction and dynamic stem forces. Unbalanced force shall be kept to a minimum level consistent with efficient operation in service.

b. Damper Actuators

Damper actuators shall be fully enclosed and supplied with all accessories including special mounting brackets if required. A solenoid operated, four way pneumatic valve plus open and close limit switches shall be included.

(3) Recorders

The recording instruments shall be of the multi or single point strip chart type or microprocessor based. Circular chart recorders shall not be used. The recorder shall display the previous four hours. Roller type charts shall have a duration of 30 days as minimum.

The whole of the recording mechanism shall be withdrawable from its case from the front for maintenance.

Positioners and E/P Converters

(4) Positioners shall be furnished with final control elements where:

- small change in pneumatic signal are to be amplified
- Split range control is required
- valve pressure drop is greater than 280 kN/sq.m

Positioners shall have a feedback cam to characterize relationship between input signal and final element position.

E / P converters shall be provided to convert electronic control signals to pneumatic output signals. Converter accuracy shall be plus / minus 0.5% of output span.

(5) Solenoid Valves

All solenoids shall have class F insulation or higher class and solenoid enclosure shall be of weatherproof construction.

Solenoid for operation on AC shall give satisfactory operation over the range of 75 % to 120 % AC supply voltage.

Solenoid for operation on DC shall give satisfactory operation over the range of 85 % to 115 % DC supply voltage.

8.11 PANEL CONSTRUCTION

All panels except local control box shall be constructed using steel plate not less than 3.2 mm thick.

(1) Vertical Panel of Front Face

The panel shall be fitted with indicating instruments, annunciator lamps, operating indicators, watt-hour meter and recorders (for generator's output, voltage and frequency) etc. necessary for operation.

(2) Slant Panel

This panel shall be fitted with control switch, indicating lamps and mimic bus, etc., necessary for operation.

(3) Vertical Panel of Rear Face

This panel shall be fitted with protection relays, etc.

(4) Panel Interior Space (132 kV switchgear control and protection panels only)

Sliding type doors shall be furnished on the both sides of panel for access to pace shall be provided in the middle of front and rear faces of the panel to enable a man to pass through it. Chequered plate shall be furnished at the bottom of the panel.

(5) Type of Indicating Meters
110 mm square with about 240^0 C of seal angle, flush mounting type with 1.5 class accuracy, or other approved type by the B-R Powergen Ltd..

(6) Testing Power source

As a result power source for protective relay, meters, etc., one set of 50 A moulded case circuit breakers of 3 phase 415 V and DC 125 V shall be provided.

(7) Test Blocks

Test blocks for P.T. and C.T. circuits, shall be provided on the panel as required. The test block shall be of the back- connected plug or stud type with removal covers. All test blocks shall be provided with suitable circuit identification and shall be arranged to isolate completely the instrument from the instrument transformers and other external circuits so that no other device will be affected, and means shall be provided for testing either from an external source of energy or from the instrument transformers.

The test blocks shall be arranged so that the current transformer secondary circuits cannot be open circuited if any position while the test plugs are in place, being inserted, or being removed. Three test plugs for each type of block furnished shall be furnished.

(8) Control Switch

The handles of control switches for circuit breakers, disconnecting switches and auxiliary equipment shall be of the stick type, the handles of the control switches for adjustment shall be of the oval type, and the handles of the selector switches shall be of the flower type. Every switch shall have engraved identification number on the knob in white.

(9) Internal wiring

a. Wire

The internal wiring shall be made with PVC wire of 2.5 sq. mm copper stranded or larger, and solder- less terminals shall be used for connection.

The secondary circuit of C.T. and P.T. shall be wired with PVC wire 4.0 sq. mm (minimum) copper stranded.

b. Colour Coding

The colour-coding shall be made as follows:

- Secondary circuit of potential transformer	Red
-Secondary circuit of current transformer	Black
- DC control circuit	Blue
- AC control circuit	Yellow
- Main circuit	Yellow
- Earthing circuit	Green

c. Terminal blocks

Terminal blocks to be connected with internal wiring and external wirings shall have the cover (s) and identification numbers.

(10) The secondary circuit of P.T. for metering shall be provided with fuse.

Earth The C.T. and P.T. secondary circuits shall only be grounded inside the panel and appropriate Testing facility shall be provided.

A handset of flush type for paging system shall be installed on the slant part of remote unit panel.

A battery quartz clock and system clock shall be mounted on the upper part of the unit step up transformer control panel.
Switches such as circuit breaker controlling switch, annunciator test switch, emergency stop switch, etc., which may be unwillingly operated by accident due to mechanical or human contact, shall be protected by transparent plastic switch cover.

(15) Name Plate

Switchgear, panels , equipment and power and control circuits shall be provided with an engraved name plate or with other suitable means of identification approved by the B-R Powergen Ltd.. The nameplates shall be made of nickel frosted sheet plastic or of anodised aluminium approximately 2 mm thick engraved with black letters on a white background. Nameplates of all panels, switches, etc. shall be written in English.

Section 9

Cabling and Grounding

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9. CABLING AND GROUNDING

9.1 GENERAL

(1) Scope

The Contractor shall design, supply, install, terminate and commission all the cables for the plant.

(2) Voltage Drop

The maximum permissible voltage drop shall be such that in on case shall the drop exceed 2.5% under normal running condition and 10% under motor starting.

(3) Armouring

All cables except 132 KV power cables, control and instrument cables shall be provided with galvanised steel wire or steel tape armour and PVC cover sheath.

9.2 CABLE TYPES

9.2.1 11 kV XLPE POWER CABLE & BUS.

(1) The cable shall be stranded annealed copper conductor.

The construction of the conductor shall be the compacted circular single core type. The size of the conductor shall be capable to carry the rated capacity of each feeder and at specified site conditions without exceeding its maximum temperature i.e. 90^0 C. The minimum size of 11 KV cable shall not be less than 500 sq. mm. The copper conductor shall comply with latest IEC Standard.

(2) Insulation

The insulation material shall be extruded vertically cross linked polyethylene of low dielectric loss, high dielectric strength, low thermal resistivity and long term stability. It shall be free from contamination by oil, chemical and moisture. The extrusion process shall ensure that the insulation is homogenous and the single core 11 kV XLPE Copper conductor power cable and other necessary items for the completion of the cable system.

The power cable and accessories shall be designed and constructed in accordance with the requirements of latest IEC Standard. High Voltage Cross linked Polyethylene Insulated cable" and the most up-to-date experience for a system of this voltage level and shall incorporate the latest improvements of design and manufacture for the type of cables and accessories required.
Free from voids and impurities. The process shall be dry method. The average thickness of insulation measured at section shall not be less than the value specified in the standard.

(5) Terminations

The end terminating materials shall be supplied for the termination of 11 KV cables.

(6) The cable shall be flame retardant.

The 11 kV Bus shall have the capability to carry the total load to the primary side of the relevant step-up transformer.

9.2.2 400 V Power Cables

The cables shall be rated 400 volts for installation in cable trays, conduits and cable ducts.
All auxiliary power cable with a nominal conductor area of 60 sq. mm and above shall be stranded annealed copper conductor, XLPE insulated with galvanised steel wire or steel tape armour and PVC sheathed. All other auxiliary power cables shall be stranded annealed copper conductor, PVC insulated with galvanised steel wire or steel tap armour and PVC sheathed. All auxiliary power cables shall be designed, fabricated and tested in accordance with the latest IEC Standard.

The cables shall have copper conductor and shall be selected with due consideration to load requirements of each feeder and short circuit current capacity of the cable in order to prevent premature insulation failure. The conductor insulation shall be numbered or colour coded.

For motor circuit, the cables shall have a current carrying capacity of at least equal to 115% of the full load current rating of the motor after application of the appropriate derating factors.

Cable supports shall be provided for the cables and shall be at least one cable support bracket per vertical section for interconnection between adjacent sections. The minimum size of power cable shall be of 10 sq.mm. The cable shall be flame retardant.

9.2.3 CONTROL AND INSTRUMENT CABLES

Control and Instrument Cable shall be provided with galvanised steel wire or steel tape armour and PVC cover sheath.

In general, control and instrument cables shall be rated 600 volt and shall have copper conductor with either PVC overall jacket, unless specified otherwise. All control and instrument cables shall be designed, fabricated, and tested in accordance with the latest IEC Standards.

All cables shall be of oil-resisting, heat-resisting and flame-retardant type (armoured) and shall be stranded copper conductor. The minimum size of control cables shall be as follows:

- **For CT circuit- 5.0 sq. mm**
- **For PT circuit- 2.5 sq. mm**
- **Other circuit - 2.5 sq. mm [min.]**

Wiring for circuits such as the circuits to be connected to electronic circuit, telephone circuit, etc. adversely influenced by stray electric field shall be provided with suitable shielding.

-PVC Insulated and Jacket Cables
PVC insulated control cables shall be used in the area of installation where the ambient temperature is normally lower than 40^0C.

-Cross linked polyethylene Insulated Cables.
Cross linked Polyethylene insulated control cables shall be used in the area

of installation where the ambient temperature is normally between 40^0C and 55^0C.

-Mineral Insulated (MI) Cables.

Mineral insulated control cables shall be used in the area of installation where ambient temperature is normally above 55^0C. Where instrument junction boxes such as for limit switches, pressure switches, transmitters, resistance temperature detectors etc. are at high ambient temperature, they shall be wired with MI cables up to a junction box.

(1) Insulation requirements

All control cables, with the exception of equipment internal wiring and panel wiring, shall be installed in conduits, cable ducts or cable trays.

Cables contained in cable trays, conduit or cable ducts shall be continuos with no splices permitted between loads and supply location. Methods for installation of cables shall be such that there will be no cuts or abrasions in the insulation or sheath or break in the conductor. Conductors used for AC and DC circuits shall not be mixed in the same multi-conductor cable.

In general, conductors and cables shall be supported and terminated so that no strain is imposed on the terminations. Insulated clamped jugs shall be used for all control cable terminals.

9.3 RACEWAY

9.3.1 RACEWAY

Raceway shall be provided for all cables, and these shall be rigid conduit metal through type cable trays.

9.3.2 RACEWAY FITTINGS AND SUPPORTS

Raceway shall include all fittings, junction boxes, flexible attachments, raceway support hardware, etc.

9.4 CABLE ERECTION

Concrete lined cable trenches shall be provided within the power station. All such trenches shall be provided with covers to form a flush finish with the finished floor level. Cables shall be secured by non-corrodible cleats supporting steelwork, or on trays. Wooden cleats shall not be used. Cables shall not be clipped or cleated directly to masonry. All cable supporting steelwork racks cleats trays and fixings in trenches or elsewhere shall be supplied under this contract.

Where the cables are to be installed on racks, these racks shall be of galvanised steel angles or aluminium and designed such that the spacing and type of supporting cleat ensure that no undue pressure is exerted on the sheath or armour of any cable.

Cables tray shall be of the first grade perforated galvanised steel with folded side members and supported on steel work or masonry is required. Segregation of the

various services shall be achieved by use of separate trays for each voltage grade of cable used. The design of the cable tray system shall make due allowance for the future installation of at least 10 percent spare cables and also for the installation of cables supplied by others.

All cables in vertical runs shall be supported to ensure that no strain due to the weight of the cable is taken by any terminating box. Each cable when erected shall have permanently attached to it at each end, non-corrodible metal markers showing the cable identification number, voltage, rating, size and make up.

Single core cables shall be laid up in close trefoil 3-phase groups and erected in separate non-magnetic clamps to the approval of the B-R Powergen Ltd..

Where cables are erected on outdoor steelwork supporters, sun shades of approved design and materials shall be included and erected as necessary to protect the cables.

9.5 GROUNDING

The Contractor shall provide all grounding cable, equipment, and materials required for a complete installation including the direct buried ground mat for the power station,. This shall include, but not be limited to, all facilities for grounding of panel boards, control panels, transformers, switches, lighting poles, lighting standards, and all electrical equipment enclosures. Two point grounding for each equipment, panel board and steel structure shall be provided.

(1) Grounding wire for ground grid

Hard drawn copper stranded wire in accordance with latest IEC Hard Drawn Copper wire for electrical purposes.
Nominal cross sectional area: 200-sq. mm.

(2) Grounding wire of the equipment to be connected with grounding grid.
Annealed copper standard wire in accordance with latest IEC Annealed copper stranded wire for electrical purposes.
Nominal cross sectional area:100 sq. mm.

Ground grid shall be laid so that the completed earthing system shall have a maximum earth resistance value of less than 0.5 ohms, at any point on the system. The contact voltage at any point inside the power station at the incidence of an earth fault shall not exceed 50 volts. The power station grounding shall be embedded to a minimum depth of 800 cm. The grounding rods addition to the above grid shall be provided, if required. The minimum outer diameter of grounding rod shall not be less than 15 mm.

Section 10

DC Power Supply System

10. DC POWER SUPPLY SYSTEM

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10 DC POWER SUPPLY SYSTEM

10.1 BATTERIES

(1) Scope of work

The Contractor shall design, manufacture, delivery to the site and install Two (2) sets of 125 V, Ni-Cd, Alkaline storage batteries, complete with all accessories, as specified, hereunder for the plant.

The Contractor shall provide two (2) sets of 125 V, Ni-Cd, Alkaline storage batteries, complete with stands, inter-cell connections, battery moulded circuit breakers and maintenance equipment. For design purposes the ambient temperature in the battery room shall be taken to range from 10^0C to 45^0C. Each battery shall be associated with battery charger (s) and DC distribution board (s). The rated voltage at the batteries shall be 125 V. The Contractor shall furnish characteristics and performance curves of both for batteries and chargers.

(2) Description of the Equipment

Two (2) 125 V battery set for Diesel Engine generating units with stands and internal connections.

Two (2) sets of accessories comprising:

Two (2) Hydrometers

Two (2) cell voltmeters, plus / minus 3 V, portable type, accuracy Class 1.0 complete with leads and probes.

Two (2) - Alcohol -in - glass thermometers to cover the range 0^0C to 55^0C

One (1) Supply of battery record log books for at least 15 separate recordings for each battery

One (1) Plastic case to contain the above accessories.

Three (3) Connector bolt wrenches.

One (1) set of electrolyte filling tools.

(3) Technical description

a. The batteries shall be of the Ni-Cd, Alkaline. The cell containers shall be of the fully enclosed vented type made of transparent plastic material with clearly visible high and low electrolyte limits indelibly marked on the container. Each cell shall have a large electrolyte reserve capacity above the plates to allow for minimum maintenance, The Contractor shall determine the ampere-hour rating of the batteries based on the battery being capable of supplying the loads connected to the associated DC busbar continuously for 5 (five) hours at 35^0C without the voltage dropping below 90 per cent of the nominal values. But the capacity of the batteries shall not be less than followings.

- 125 V battery : 200 AH

Number of cells of each battery set shall be as follows:

- for 125V battery set : Minimum 108 cells

Cells shall be numbered consecutively and terminal cells marked to indicate polarity.

b. These batteries shall be used for supplying power for DC controls, alarms indication and for emergency lighting and power equipment to be installed within the power station.

c. Each cell shall be sealed type, assembled in heat-resistant, shock absorbing clear plastic containers with covers cemented in place to form a permanent leak proof seal. Vent plug and filler cap shall be provided in the cover.

d. Separators between plates shall permit free flow of electrolyte.

e. The weight of the battery elements shall be supported from ledges moulded in the jar walls or from the cover.

f. Cell posts shall be sealed against electrolyte creepage.

g. Cell terminal posts shall provide with connector clamps, bolts and nuts.

h. Sufficient sediment space shall be provided so that the cells will not have to be cleaned out during normal life.

i. Electrolyte level limits shall be marked on the cell container.

j. The battery shall be shipped uncharged with the electrolyte shipped in separate containers.

k. The battery shall be furnished complete with cell inter-connectors and a two-step steel rack.

l. The battery shall be suitable for operating satisfactorily in an ambient of 45^0C.

10.2 BATTERY CHARGER

(1) Scope of works

The Contractor shall design, manufacture, deliver and install the battery chargers (Thysistor type), complete with all accessories, as specified, hereunder for the plant.
The Contractor shall provide two (2) 125 V chargers, in the auxiliary room of the control building to be used for automatic charging of 125 V. The electrical connections between the batteries, the DC distribution boards and the chargers shall be as shown on the attached single line diagram. Only charger with fully proven design shall be provided. The shall be capable of performing continuously float charge as well as boost charge (with timer).

(2) Description of the Equipment

Two (2) 125 V DC output, 415 V, three phase input, battery chargers with automatic regulator and filters to maintain the performance. One (1) set for one (1) battery set and other set as standby. The continuous current rating of the battery chargers shall be determined by the Contractor so as to meet the capacity of related battery.

But the continuous current rating of the chargers shall not be less than the following:

-125 V battery : 180A

(3) Performance

a. Constant Voltage Characteristic

The chargers shall normally have a constant voltage characteristic and shall be designed to carry the load current while the battery floats and to replenish the battery after intermittent discharge. The set voltage shall be adjustable between 1.20 V / cell and 1.70 V/cell by means of a potentiometer located inside the cubicle.

The DC voltage shall be maintain within plus / minus 1 per cent of the set voltage for all loads from zero to rated output for any variation of between plus / minus 10 percent of the nominal AC input voltage or between 48 and 52 Hz in frequency.

The proper voltage adjusting means such as silicon dropper shall be provided to keep the DC terminal voltage within a permissible range.

If there is a prolonged failure or heavy discharge which causes the battery voltage to fall below the pre-set value, the charger shall operate at the maximum current output not exceeding 250 percent of the rated output to restore the voltage to the pre-set value. Constant voltage charging shall recommence automatically when the battery voltage reaches the pre-set value.

The current limit setting shall be adjustable down to 80 percent rated output.

c. Control

The chargers shall be provided with an automatic / manual control selector switch and the facility by which the output voltage can be adjusted when on manual control. On manual control the charger shall be capable of delivering 50 per cent of its rated output at 1.55 V / cell to enable charging of the battery when isolated from the DC distribution board.

d. Ripple Voltage Limits

With the battery connected and with any non-destructive load between zero and rated the peak value of the ripple voltage (unweighted) measured across the output terminals shall not exceed the followings:

Charge nominal (DC voltage)	: 125 V
Ripple voltage limit	: 2.0 V peak to peak

10.3 DC DISTRIBUTION BOARD

The Contractor shall provide the DC distribution board in the Diesel Engine unit control package and in the auxiliary room of the control building. The Contractor shall determine the continuous current rating of the distribution boards.

Number of the feeders and current rating of feeders shall be determined by the Contractor. Five (5) spare feeders on each distribution board shall be provided.

Section 11

Lighting and Small Power Supply System

11. LIGHTING AND SMALL POWER SUPPLY

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11. LIGHTING AND SMALL POWER SUPPLY SYSTEM

11.1 GENERAL

(1) Scope of Works

The Contractor shall design, manufacture, deliver and install power station lighting and small power supply complete with all the accessories at the site as specified hereinafter.

(2) Details

Detail description and drawings of all lighting fittings, distribution boards, switches, DC equipment, socket outlets, poles, glands, etc., comprising the offer shall be submitted with Tender.

(3) Electricity Supply

Supplies for lighting distribution boards of 415 Volts 3 phase 4 wire 50 Hz shall be taken from the station auxiliary switchboard.

The 125-volt DC supply required for emergency lighting services shall be obtained from the batteries supplied under the Section 10. Under AC failure conditions for the DC, emergency lighting to be installed shall be automatically switched on.

11.2 DISTRIBUTION BOARDS

The distribution boards and all component parts shall be manufactured and tested in accordance with the latest IEC standard. Distribution boards shall have dust proof sheet steel, galvanised, weatherproof cases. The metal casing is to be provided with knockouts or other approved form of cable entries, corresponding to the circuit capacity, together with a suitably screened brass earthing stud.

The distribution boards shall be either double pole and neutral types as required and shall be equipped with means to provide over load protection to each circuit. This protection shall comprise moulded case circuit breaker.

11.3 CABLES

All cabling associated with the lighting and small power socket outlets services shall be stranded annealed copper conductor, PVC insulated galvanised steel wire or steel tape armoured and PVC sheathed as appropriate or mineral insulated copper sheathed cable depending upon the service required.

The Contractor shall select conductor sizes for the respective circuits to mcc the following conditions:

a. Minimum conductor sizes for lighting circuits shall be 2.0 sq. mm and for socket outlets 3.5 sq. mm.

b. The size shall be adequate for the current to be carried.

c. The size shall be adequate to limit the voltage drop in phase and neutral conductor to the farthest lighting or power point under normal full load conditions to within 2.5 %.

11.4 LIGHTING AND SMALL POWER

The following lighting and small power arrangements shall be provided as a minimum by the Contractor.

No	Location	Illumination Level (Lux)	Type of Fitting
a.	Power Generating Area		
	Inside of engine house except control package	100	Fluorescent lamp or incandescent lamp with reflector and guard if necessary explosion proof type shall be used.
	Inside of control package	500	Fluorescent lamp with reflector guard
	Inside of crane rain shelter	20	Fluorescent lamp or mercury vapour lamp with reflector and diffuser
	Surrounding area of engine house including fuel handling area	20	Mercury vapour lamp with floodlight fitting
	Road or path	10	Mercury vapour lamp with highway fitting or floodlight fitting
b	132 KV Switchyard		
	Around Switchgear	20	Mercury vapour lamp with floodlight fitting
	Roadways	10	mercury vapour lamp with highway fitting
c	Control building		
	Control room	500	Fluorescent lamp with reflector and diffuser
	Electrical room and cable room	50	Fluorescent lamp with reflector and guard
	Office	500	-do-
	Toilet, corridor, etc.	50	-do-

f. Plug Sockets

Plug sockets shall be located so that any point inside the engine house, inside a building or outside in the high voltage areas can be reached within the following distances from a plug socket.

(i) Single phase plug socket

Indoor - :10.0 m
Outdoor- :20.0 m

(ii) Three phase plug socket

Outdoor- :45.0 m

At least two plug sockets shall be installed within the vicinity of an indoor control board and no plug socket shall be installed with in a battery room.

11.5 EMERGENCY LIGHTING

The Contractor shall design DC emergency lighting and power supply system for the power station, and illumination level of DC emergency lighting shall be as follows.

The lighting shall consist of 125 V DC operated incandescent luminaries.

Location		Illumination Level (Lux)
Control room and inside of control package	:	15
Inside of other package	:	1
The other area surrounding the plant	:	0.5

Additional emergency lighting arrangement, independent emergency light units operated from built in charger and batteries charged by 230 V AC shall also be provided strategically. Total ten units shall be included in the Tender.

11.6 MISCELLANEOUS MATERIALS

(1) Lighting Poles

Lighting poles shall comprise tubular or octagonal metal or reinforced concrete construction with a base of sufficient section to house an inspection trap, lockable door, cable entry and terminations suitable for the incoming cables and the secondary cables feeding the light sources, all of which shall be supplied with the pole. All poles shall be suitable for burying to a depth of 1.5 m and have an adequate concrete foundation.

Metal poles shall be either hot dip galvanised or covered with a bituminous base protective area with the fitting erected and a safety factor of 2.5 allowed.

(2) Conduits Pipes

The rigid steel conduit pipes shall be galvanised and have a minimum thickness of 2.3 mm and minimum inside diameter of 16 mm.

(3) Outlet Switches, Junction Boxes and Fittings

The boxes to be concealed in the concrete shall be of galvanised sheet steel and shall be fitted with appropriate covers so as to be flush with the finished surface of the concrete structure. The boxes in the exposed work shall be of galvanised steel or alloy fitted with appropriate covers.

(4) Tumbler Switches

The wall switches shall be of the enclose flush or surface mounting tumbler type, single pole, 250 V, 10A and fully installed in the boxes fitted with suitable plates for covering them.

(5) Miscellaneous

All apparatus, accessories and materials which have not been specifically mentioned but which are necessary for the completion of the work shall be provided by the Contractor.

Section 12

Fuel Handling Facilities

12. FUEL HANDLING FACILITIES

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12. FUEL OIL SYSTEM AND HANDLING FACILITIES

12.1 Fuel system

HFO (furnace oil) will be used as fuel.

12.1.1 Liquid Fuel oil system

The unit shall be provided with liquid fuel oil system. The operating fuel would be Heavy Fuel Oil (furnace oil) and engine can run with LFO, if necessary. The liquid fuel oil system shall have fuel unloading & handling facility and storage facility for both HFO and LFO, cleaning system, heating system, fuel forwarding system fuel injection system, oil recovery system, waste collection & treatment system etc.

12.2 FUEL STORAGE AND HANDLING

The fuel storage and handling system of the facility can be divided into three parts,

A. Heavy Fuel Oil System (HFO)
B. Light Fuel Oil (HSD) System
C. Fuel Transfer System

Under normal operating condition heavy fuel oil is used for the generator engines for full liquid fuel operation and light fuel oil is used for certain auxiliaries and for the generator engines in emergency and for flushing the HFO system for extended isolation.

C. HEAVY FUEL OIL

The plant have to be provided with four HFO storage tanks with a capacity of 4000 m^3 each and two HFO day tank of 1000 m^3 providing a total HFO storage capacity of 18000 m^3. Each HFO storage tank to be provided with

- A sounding pipe for manually measuring tank level,
- Remote level indication in the monitoring/control system, which shows fuel quantity by mass in the tank in percentage,
- Tank high level alarm,
- Vent with flame arrester,
- Over-flow connection to overflow tank,
- Decanting system with drain pit,
- Steam heating system, and,
- Associated valves and piping for filling, transfer and heating.

HFO BUNKERING/STORAGE

The plant have to be provided with fully equipped bunkering facility for riverside bunker reception. Each bunkering unit is provided with a micro motion flow meter to constantly measure flow of fuel delivered to the storage tank.

D. LIGHT FUEL OIL

The plant have to be provided with only one LFO storage and one day tank having a capacity of 500 m^3 each. The LFO storage and day tank is provided with,

- A sounding pipe for manually measuring tank level,
- Remote level indication in the HMI system, which shows fuel quantity by mass in the tank in percentage,
- Tank high level alarm,
- Vent with flame arrester,
- Over-flow connection to overflow tank,
- Decanting system with drain pit, and,
- Associated valves and piping for filling and transfer.

LFO BUNKERING

The plant have to be provided with a separate fully equipped bunkering facility which is common for HFO as well. Each bunkering unit is provided with a micro motion flow meter to constantly measure flow of fuel delivered to the storage tank. Procedure for LFO bunkering from both riverside and shore side shall be same as HFO bunkering except for valve operation.

C. FUEL TRANSFER SYSTEM

The plant have to be is equipped with a fuel transfer unit to facilitate HFO transfer in between storage tanks. Internal fuel transfer may become necessary to facilitate segregation of fuel from different supply tank.

The transfer unit consists of following components,

Screw type transfer pumps	2 sets
Pump suction strainer	1 each
Transfer unit relief valve	1 on common discharge line
Associated valves and piping	

Transfer pumps takes suction from HFO storage tanks' common outlet header and delivers into bunker filling common line.

12.3 FUEL TREATMENT

Fuel received from supplier may contain water and other solid impurities, which may have detrimental effect on combustion quality and fuel injection system components. So it is imperative that the fuel is properly treated to separate water and sludge before the fuel is fed to the engine.

HFO received from supplier goes through a two-step treatment process and finally stored in the day tank for engine consumption. The first step takes place in the fuel storage tanks, which are equipped with heating and decanting facilities. Fuel in the storage tank is heated and allowed to settle to facilitate separation by gravity where some of the water and solid impurities accumulate at the tank bottom. Time to time these accumulated water and sludge are to be drained out from the storage tank using the drain valves provided for each fuel tank. Remaining suspended solid and water is separated by centrifuge.

All HFO storage tanks' outlet lines connect into a common header from where the centrifugal separators take suction. Each storage tank outlet line is to be fitted with two valves in series, first one is a hand shut off valve and the second one is

a pneumatic control valve, which is to be operated from the quick closing valve panel. HFO day tanks' overflow lines are also connected with the storage tanks' common outlet header, in another words day tank overflow goes back to separator suction. Day tank overflow lines are fitted with hand shut off valves.

12.4 ENGINE FUEL SUPPLY SYSTEM

Centrifuged and pre-heated fuel oil from the day tank is fed with Constant Pressure regulated by variable frequency drive operation to the individual engines by the engine fuel oil supply system have to be manufacturer specific but as a minimum should comprises of following components,

a. Two Fuel Feeder Units
b. Two Fuel Booster Units
c. Engine Wise Fuel Units
d. LFO Feeder Unit

a. FUEL FEEDER UNIT

The engine fuel supply system is equipped with fuel feeder units which take suction from HFO day tanks or LFO day tank as selected by the change over valve and delivers to fuel booster unit. Feeder units are fitted with an inter-connection valve for emergency use. Each feeder unit is equipped with,

- Two feeder pumps
- Individual pump suction filter,
- Individual pump suction and delivery valves,
- Suction valve for HFO and LFO with change over arrangement,
- Common pressure regulating valve, and,
- Discharge line common quick-closing valve.

In each feeder unit one pump remains in use while the other can be kept on stand by.

Feeder unit pumps and quick closing valves are controlled from a common control panel for feeder and booster unit located near the booster unit.

Note The feeder unit suction valves for HFO and LFO have to be equipped with a single operating lever for changing over feeder unit suction. Horizontal lever position is for HFO operation and vertical lever position is for LFO operation.

b. FUEL BOOSTER UNIT

Engine fuel supply system is equipped with identical fuel booster units, which take suction from the relevant feeder unit and deliver to engine wise fuel units. In the booster unit fuel oil is filtered and heated to attain suitable viscosity for efficient combustion before delivering to engine inlet header from where engine wise fuel unit take suction. The booster units are also interconnected by isolation valves on the supply and return line for emergency use only.

Each fuel booster unit have to be comprises of following components,

- Automatic back flushing filtration unit
- By-pass duplex filter unit
- Fuel flow meter
- Mixing column
- Two fuel booster pumps

- Two steam heaters
- Viscosity controller unit
- Fuel return line change over arrangement.

Fuel Oil Auto Filter
The system is equipped with a fully automatic back flushing filter unit with a by-pass duplex filter. Under normal operating condition the system should not be operated with the back flushing filter by passed.

Filtration Process
A motor driven change over unit is located at the centre of the filtration unit and surrounded by 4 filter chambers. At any given time 3 filter chambers are in use and 1 remains on standby. At a preset time interval the filter control unit goes on flushing cycle.

Differential pressure across the filter is continuously monitored by the controller and if at any time the differential pressure reaches the set value the controller initiates a flushing cycle and activates High Filter Differential Pressure Alarm.

Back Flushing

At the beginning of back flushing cycle the controller activates the change over unit. The change over motor rotates the central change over mechanism one fourth of a turn and as a result the stand by filter goes into operation while the 3rd filter chamber goes off line and enters into back flushing cycle

As soon as a filter goes on stand by mode the control unit energizes solenoid valve-A, which allows instrument air to operate the sludge piston and opens the sludge port. Opening of the port allows the air to travel to and open valve-C of air reservoir. Air from reservoir then enters into the outlet side of the stand by filter and drives the fuel oil and accumulated dirt out of the chamber, which flows to the fuel return line to HFO day tank. Fuel from the filter main outlet enters into the stand by chamber through a control hole and gradually fills up the stand by chamber.

HFO Separators
The facility is equipped with two HFO separation units each comprises of two separator units, one Sludge tank and one sludge transfer pump. Separation will purify HFO by separating sludge, water and others as per requirement by engine. One separation unit (Consists of two separators) will purify oil required for whole plant operation and other unit will be kept for standby. Each separator unit comprises of following components,

By-pass Filter
The system is equipped with a set of duplex filter with mesh size of 34 microns connected in parallel with the auto back flush filter. The by-pass filter is provided to facilitate isolation of the back flush filter and to be only used when back flush filter maintenance is necessary while the engines are running. The by-pass filter unit comprises of,

Two filter chambers with filter elements,
One change over cock, and,
One vent line.

Fuel Flow Meter

Each booster unit is provided with a micro motion flow meter to constantly measure flow of fuel delivered to the engines covered by the relevant booster unit. The flow meter is located between the filter unit and the mixing column and fitted with a by-pass valve. The flow meter can register the following information,

Cumulative mass flow	in kg
Flow rate	in kg/hr or litres/hr
Fuel pressure	Fuel temperature

Note The flow meter is capable of registering negative flow rate but the cumulative mass flow is always incremental.

If booster units are operated with the inter connection valves open and if there is any re circulation of fuel through any of the booster units due pressure difference then the flow meter will register incorrect (excess) cumulative mass flow readings.

Mixing Column

Mixing column is located in between the flow meter and booster pumps. Return fuel from engines can also be directed to the mixing column. It is equipped with a float type venting arrangement to bleed of any vapour (water or fuel) and a float operated low-level alarm to ensure positive suction header for the booster pumps.

Fuel Booster Pumps

Each booster unit is provided with two booster pumps with individual isolation valves. The pump takes suction from the mixing column and delivers to the engines through the heater and viscosity controller unit.

Fuel Heaters

Each booster unit is equipped with two tube type fuel oil heater units installed in parallel. Each heater is capable of handling complete fuel heating requirement of one bank at full load. Heating steam supply valve for the heater is a pneumatic control valve controlled by either the viscosity controller or the temperature controller as selected at the booster unit control panel by the selector switch A16S2.

Viscotherm

The booster unit is equipped with a viscotherm unit on the fuel supply line after the heaters. It measures the process fuel viscosity and sends input for the viscosity controller unit. The viscotherm unit is fitted with isolation valves and a by-pass line with a by-pass valve to facilitate maintenance work on the unit while the booster unit is in operation.

Return Line Change Over Arrangement

Returned fuel from the engines can be directed either to the mixing column or back to HFO day tank. Two return lines are fitted with separate isolation valves with a single operating handle and the valves are such configured that while one valve opens the other closes. At horizontal lever position fuel return to mixing column valve remains open and at vertical lever position fuel returns to HFO day tank. In normal operating condition return fuel is directed to mixing column. Sending return fuel back to day tank should be avoided as no flow meter is available to measure the return fuel quantity.

Temperature/Viscosity Control
The fuel booster unit is provided with two separate controller units for temperature control and viscosity control and either one of them can be selected by the selector switch A16S2. When temperature controller is in use it maintains the fuel temperature as per set value while viscosity may vary and when viscosity controller is in use it maintains the viscosity as per the set value by controlling fuel temperature and temperature may vary. In both cases it is the steam supply to the fuel heater, which is controlled.

C. ENGINE WISE FUEL UNIT

Each engine is equipped with a fuel unit to facilitate engine wise HFO / LFO change over option, leak off fuel handling and final fuel filtration before injection.

Each fuel unit comprises of following components,

- Valve unit with solenoid controlled actuator,
- Fuel feeder pump with suction strainer,
- Duplex fuel filter,
- Pressure control valve, and
- Leak off fuel collecting tank with return pump

Fuel unit Feeder Pump
Each fuel unit is equipped with a fuel feeder pump with suction strainer and isolation valve. The pump is provided to facilitate boosting fuel supply pressure and re-circulate fuel through the engine when the engine is stopped and on HFO mode. The engine can operate with or with out the feeder pump running depending on available fuel pressure at the supply header.

Fuel unit Duplex Filter
For the final filtration of fuel before it enters the engine a duplex filter is provided at the engine fuel unit. The filter is fitted with a change over cock, a differential pressure cell, heating steam line and drain and venting arrangement. Normally one filter is kept in use while the other is on stand-by but if required both the filters can be put into service. The DP cell monitors and indicates the pressure differential across the filter unit and activates an alarm at the fuel unit control panel (indicator H5) if it exceeds the set value.

Leak off Tank and Return Pump
Any leakage from individual cylinder's fuel injection pump and fuel injection system double wall pipes are led to the clean fuel leak off tank. Each bank leak off line is equipped with a float type alarm to indicate excessive leakage. The leak off tank is fitted with a return pump with isolation valves, which operates automatically controlled by a float switch. The same activates leak off tank high-level alarm as well. The engine fuel return line passes through the leak off tank to maintain heating for leak off fuel.

Engine Operation in LFO Mode
Engine LFO operation facility is provided as a back up of HFO system and for flushing the fuel system before extended shutdown or to facilitate maintenance work. Engine LFO operation is possible in two different ways,

By feeder and booster units for common LFO operation, and,
By LFO feeder unit for individual engine LFO operation.

Common LFO Operation

This system is to be used when the common fuel supply system needs to be flushed for maintenance work or the plant has to be operated on LFO instead of HFO. Procedure for change over from HFO to LFO operation,

Engine wise LFO Operation

This system is to be used when an individual engine needs to be operated on LFO to facilitate flushing of engine fuel system for maintenance work while the remaining plant operation shall be on HFO supplied by the common fuel system. For engine wise LFO operation a separate LFO feeder unit PCA-905 is provided.

D. LFO FEEDER UNIT

The LFO feeder unit takes suction from the LFO day tank and delivers directly to engine fuel units with Constant Pressure regulated by variable frequency drive operation. It also supplies LFO for following auxiliaries,

- Engine driven emergency fire pump
- Black start generator
- Oil fired steam generator (if required)
- Machine shop for cleaning and testing purposes.

The LFO feeder unit is comprises of as a minimum of the following components,

- Two feeder pumps,
- Individual pump suction filter,
- Individual pump suction and delivery valves,
- Common pressure control valve, and,
- Discharge line common quick closing valve
- Variable frequency drive for pressure regulation.

Note The LFO feeder unit is provided with a low suction pressure alarm to avoid dry running of the pump when suction filter gets clogged.

Section 13

Fire Protection Facilities

13. FIRE PROTECTION FACILITIES

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13. FIRE PROTECTION FACILITIES

13.1 GENERAL

The Contractor shall design, manufacture, deliver to the Site, install, test and commission the fire fighting and fire detection equipment to protect the Diesel Engine generating unit and all associated equipment. In particular, the following shall be included:

- CO_2 Gas fire protection system for the packaged units (LV, MV etc).
- Water hydrant system including motor & diesel engine driven pumps, jockey pumps etc.
- Portable fire fighting equipment
- Foam based fire suppression equipment for fuel tanks

13.2 DESIGN REQUREMENTS

The general design of the fire protection facilities shall take into account that the basic operating policy for the power station will have the minimum of personnel supervision for the Diesel Engine.

Where automatic systems are provided, alternative manual initiation facilities shall also be provided.

All fire protection installations shall comply with the requirements of the codes of practice of the National Fire Protection Association (NFPA), Boston, Massachusetts, U.S.A., as appropriate for the respective systems, to the approval of the B-R Powergen Ltd.. The codes and practice of the Japanese Fire Protection may also be considered.

13.3 CO_2 /Inert GAS FIRE PROTECTION SYSTEM

An automatic Carbon Dioxide (CO_2)/inert gas fire protection system shall be provided in all enclosures except in the unit local control package. The fire protection system shall comply with the requirements of National Fire Code No. 12A published by the National Fire Protection Association, Boston, Massachusetts, U.S.A. or equivalent.

The equipment shall consist essentially of fire detectors distributed strategically within the enclosures which, on sensing a dangerous condition at any location, will initiate audible and visual alarms, trip all running plant including ventilation equipment, and release CO_2 /inert gas into the affected enclosure. Actuation of the fire protection system shall also. trip Diesel Engine generating unit and immediately shut off the fuel supplies to the unit at a point external to the enclosures. There will be time lag of 30 seconds between the ringing of alarm and discharge of gas, so that the personnel working in the package could leave safely.

Facilities for alternative manual actuation of the fire protection system shall also be provided such that, when the manual mode has been selected the protection sequence will not proceed beyond the alarm stage without manual action by an operator.

System of lock off to (but not exit from) the enclosure affected shall also be provided.

The fire protection system shall be segregated into separate zones so that at least the protection for any one compartment can be selected to the manual mode whilst, at the same time, retaining the automatic mode for the remaining enclosures.

Lock-off boxes shall be provided at all entries to enclosures, with switches whereby an operator may inhibit automatic release of extinguishant. These boxes shall be provided with status indicators signifying 'Auto on' 'Auto-off' and 'Extinguishing Released' and a red lamp shall also be illuminated at the box In the event of' extinguishing release. The status shall be indicated at the control panel of the control building also.

Fire detection shall be by means of ultra violet flame detectors with a backup system utilising rate-of-rise temperature detectors. The use of smoke detectors shall be subject to specific approval by the B-R Powergen Ltd. as regards their type and location.

Audible and visual fire alarms shall be provided in all machinery en-, closures, the local control cabs and in the control room of the control building. Additional audible alarms shall also be provided external to the engine generator enclosures.

Particular areas of high fire risk such as confined spaces where lubricating oil could possibly come into contact with high temperature ,surfaces shall receive special consideration. Such areas shall be treated as separate fire protection zones with detection and gas injection facilities operating independently of the system provided for the machinery enclosure concerned.

The fire protection equipment shall be complete in all respects including pipework, valves, fire detectors, nozzles, control equipment, fully charged $C0_2$ gas cylinders and cylinder racks.

13.4 HYDRANT SYSTEM

Fire hydrant of water type shall be provided in the power station as per USA standard (NFPA).

13.4.1 HYDRANT

Hydrants shall be installed at required places around the Diesel Engine generating unit, electrical building, and 132 kV switchyard. Each hydrant stand shall be fitted with an isolating valve and approved type of instantaneous hose complying 30-m hose with combined jet/water-fog nozzle shall be provided in the cabinet adjacent to each hydrant. Gun type Hydrants shall be installed at some distance of the fuel storage area to protect from oil fire by foam.

13.4.2 PIPING

The fire fighting water mains shall consist of buried piping of at least 120 mm diameter. The underground pipe work shall be provided with an approved protective coating unless the pipe is manufactured from an approved non-corrosive material. To avoid corrosion, cathodic protection will be provided by installing sacrificing material.

13.5 PORTABLE EQUIPMENT

The following portable fire fighting equipment or equivalent shall be provided:

(1) SCBA-self contain breathing apparatus- two sets
(2) Twelve (12) 30 Kg CO_2 with trolley
(3) Eight (08) 20 Kg Dry chemical trolley
(4) Eight (08) 20 Kg Foam trolley
(5) Fifty (50) 10 Kg CO_2 (Carbon Dioxide)
(6) Fifty (50) 10 Kg DCP (Dry Chemical Powder)
(7) Twenty five (25) 10 Kg Foam

The portable equipment offered shall be of a type for which replacement cartridges and dry powder refills shall be readily available locally.

Section 14

Communication Facilities

COMMUNICATION FACILITIES

14. COMMUNICATION FACILITIES

14.1 GENERAL

The Contractor shall design, manufacture, deliver to the Site and install the following communication facilities:

a. Internal telephone system
b. Paging system

14.2 INTERNAL TELEPHONE SYSTEM

14.2.1 PRIVATE AUTOMATIC BRANCH EXCHANGE

The exchange shall be of a PABX type approved by the Ministry of Communications for connection to the public telephone network and in-stalled with in the central control room of the power station.

The initial installed capacity shall be 10 exchange lines and 50 extension lines. The exchange shall be capable of expansion to a capacity of more than 20 exchange lines and 100 extension lines. A single operator's position shall be provided.

All internal telephone connections within the power station boundary shall be the responsibility of the Contractor, but the interconnecting cables between the PABX and the public telephone network shall not be the responsibility of the Contractor except all facilities for the connection of this service within the building.

(1) Functions

The PABX system shall be provided with the following functions:

a. Extension to extension calls shall be made by direct dialling.

Extension to exchange lines and PLC lines for dialling a single access digit shall make outgoing calls.

Operator access from extension by dialling a single digit shall be required.

Trunk barring on outgoing calls shall be provided as required on selected extensions.

Provision for limited barring on outgoing calls from selected extensions shall be provided.

Operator recall from an extension engaged with an incoming or outgoing call shall be effected by operation of a recall button followed by dialling the operator access digit.

Call transfer between extensions on incoming and outgoing public ex-change calls shall be provided.

Operator intrusion into an established call in order to offer an exchange call or urgent message shall be provided. An intrusion tone shall be introduced.

i. Exchange alarms shall be extended to the operator's console or switchboard.

ii. Six (6) extensions shall have a priority facility to intrude into extension to extension calls. An intrusion tones shall be introduced.

(2) Equipment to be provided shall include, but not limited to:

a. A main distribution frame of sufficient size to accommodate the future expansion.
b. Automatic switching equipment.
c. Manual switchboard or console.
d. A necessary inters unit cabling and cables supports.
e. Concealed wiring to each office, workshop, administration building, etc. to accommodate a single instrument at each point.
f. 50 telephone instruments complete which will be connected at telephone points to be advised by the B-R Powergen Ltd..

14.2.2 TELEPHONE FACILITIES

PABX telephones should be located as follows:

a. Control room (2)
b. Control package of Diesel Engine unit
c. Telephone cubicle (1)
d. Auxiliary room (1)
e. Office, Managers room, Workshop, etc (Total 10)
f. Administration building, guard houses and other buildings (Total 25)
g. Spare

Total: 50 Numbers

Land phone must be provided in Administration Building.

14.3 PAGING SYSTEM

14.3.1 GENERAL

The paging system, which shall consist of amplifiers, control equipment, handsets and speakers, shall be provided.

The system shall be provided with one channel.

14.3.2 FUNCTION

(1) Commanding Communication

Commanding and paging shall be made from any handsets through the local speaker sets.

(2) General Communication

When the other party answers the paging, general communication is established by releasing the page button. Simultaneous two way conversations shall be possible on one same channel.

(3) Emergency Alarm

1,000 Hz alarm note shall be sound from all speakers by pushing the button located on the control panel and desk in the central control room

14.3.3 EQUIPMENT

(1) Handset

Flush type	: 5 sets
Indoor wall type	:12 sets
Outdoor wall type	: 7 sets

Handsets installed indoors shall be of noise-proof type.

(2) Speaker Set

15 W outdoor type	:10 sets
5 - 10 W indoor type	:13 sets

All speaker shall be able to adjust their output.

(3) Amplifier Cubicle

All Silicon transistor amplifiers shall be mounted in the amplifier cubicle. The amplifiers shall be suitable for the driving of the above speakers all together and shall be divided into adequate capacity.

One set spare amplifier shall be furnished and it shall be put into operation automatically when the normal use amplifier fails.

(4) Control Panel

a. Relay Panel

Relays shall be provided for the starting and stopping amplifier and to establish the commanding talk from the handsets. The talking shall be indicated with a lamp on all handsets. The relays shall be of semi conductor static type or wire spring relay with sulphuric acid proof type.

b. Change-over Panel

When one set amplifier fails, the failed amplifier's circuit shall be transferred to the spare amplifier's circuit with relays. Manual change-over switch shall also be provided.

c. Amplifier Protection

Protection for the amplifier shall be provided according to the manufacturer's standard.

d. Test device

Ammeter for measuring the emitter current of each transistor and changeover switch and power source voltmeter shall be provided on the front of the panel.

Red lamps for the indication of operation and orange lamps for the warming shall be provided on the front panel.

e. Terminal block

Terminal block shall be provided in order to connect the incoming cables from handsets and speakers.

14.3.4 LOCATIONS OF HANDSETS AND SPEAKER

The location of handsets and speakers will be advised by the B-R Powergen Ltd. after award of the Contract.

14.4 COAXIAL CABLE

Coaxial cables shall be of stranded copper conductor (7/0.4 mm), solid dielectric coaxial type with polyethylene insulated, annealed copper wire braided and with PVC sheathed.

The electric characteristics at 20 deg. C shall be as follows:

Dielectric strength (for 1 minute)	
Between conductor and outer conductor	: 6KV AC
Insulation resistance	: More than 10 M ohms / km
Attenuation	: 3.2dB/km at 3OO kHz
Impedance (nominal)	: 77ohms at 300 kHz

Sufficient length of the coaxial cables and cords with all the necessary cable connectors shall be supplied to each station for making connections between the coupling capacitors and the coupling filters, the coupling filters and the line protective devices, and the line protective devices and the PLC telephone terminals.

14.5 POWER SUPPLY

The communication facilities to be furnished shall be operated by a 240 V, 50 Hz single phase AC (with UPS) and/or DC 50 V. These power supply facilities shall be provided by the Contractor.

DC 50 V system shall be designed and provided based on the following requirements:

(1) Battery

Type of battery : Ni-Cd Alkaline.

Capacity : Capable of loads continuously for five(S) hours without voltage dropping

90% of nominal voltage, but not less than 50 AH (5 hr rate).

Number of cells : 48 cells.

(2) Battery Charger

Type : Thyrister type with automatic voltage regulator, 240V single phase input.

Capacity :120% current of battery 5 hour rate charging current at minimum.

Performance : Performance shall be same as these shown on Section 10.2 (3).

Required Number : 1 set.

14.6 PLC System

The PLC System to be provided [extension from existing system] shall include all necessary equipment (such as PLC exchange, telephone sets, line extension etc.) and have to be matched with the system exists in the grid sub-station. The existing PLC [Power Line Carrier] equipment shall be from ABB and PLC exchange of Siemens.

14.7 Electrical Protection, Communication and Instrumentation System

Separate Marshalling Kiosk shall be provided for Tele-metering terminal for future connection with SCADA. Communication, control, monitoring and voice channels shall be provided between the power station and PGCB`s National Control Centre in consultation with PGCB.

SCADA, communication, telemetry, fibre optical terminal and Tele-protection equipment to be supplied and installed by the contractor shall be compatible with National Load Dispatch Centre (NLDC) equipment and system of PGCB.

The contractor shall provide the following Tele-control facilities required at LDC.

a. Control of the 132kv cut switch and reset of trip.
b. Indication of 132kv switches and trip relays activated.
c. Measurement of 132kv cut MW, MV and Voltage.
d. Alarm facilities in the event of any 132kv cut tripping and protection.

Section 15

Maintenance Facilities

15. MAINTENANCE FACILITIES

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15. MAINTENANCE FACILITIES

15.1 Over head Electric Crane

15.1.1 SCOPE

The Contractor shall provide and install Overhead cranes for the power station requirement (where needed, such as in the engine room, maintenance hut or any other places), complete in all respects including longitudinal gantry structure, gantry rails, conductors, power supply, weather protection shed etc.

15.1.2 EXTENT OF SUPPLY

The equipment to be supplied by the Contractor under this specification shall include, but shall not be limited to, the following:-

a. Capacity of the engine room crane shall be 10 ton & auxiliary 05 ton [hoist capacity 10 ton and auxiliary 05 ton; Main hoist capacity will be sufficient enough to lift the weight of heaviest part during assembly or maintenance].

b. Sufficient sets of steel wire hoisting ropes

c. All integral electric cabling and wiring

d. All limit switches

e. One (1) set of gantry structure, gantry rails, girders, holding down bolts, securing plates, abutments, and weather protection shed.

f. One (1) set of power supply cables and trolley conductors complete with supporting brackets and one (1) set of power supply indication lamp

g. One (l) alarm bell

h. All lifting eyes, rings and bolts to facilitate erection and maintenance

i. All catwalks, ladders, platforms and handrails to provide safe access to items requiring regular maintenance

J. Special tools required for the maintenance of the crane

k. All other equipment required for the safe and efficient operation of the crane

15.1.3 TYPE OF CRANE

The crane shall be of the semi-indoor and low speed overhead electric," travelling type equipped with single trolley, one(l) main and one(l) auxiliary hoist.

15.1.4 RATING

The rating of the crane shall be as follows:

(1) Hoisting capacity
(2) Span : Not less than 11.5 m
(3) Lift : Not less than 10 m
(4) Speed

a. Hoisting speed
Main hoist : 5 m/min
Auxiliary hoist : 10 m/min
b. Trolley travel : 15m/min
c. Bridge travel : 15 m/min

(5) Operating power source and terminal voltage : 3 phase, 4 wire, 415 V AC, 50 Hz
(6) Bridge travelling rail : 37 kg/m
(7) Space limit of the crane : Determined by the requirement of the plant.

15.1.5 REQUIREMENT FOR CHARACTERISTICS

(1) The brake for hoisting shall be capable of stopping and holding 120% of the rated capacity.

(2) Deflection of bridge girder under load on main hook at the centre of the bridge girder shall not more than 1/500 of the span.

(3) The crane shall be capable of raising, lowering, holding and transporting the rated load without damage to, or excessive deflection of any crane parts.

(4) Operation of Hoists
Each hoist shall be controlled individually by the relevant controller equipped in the operator's cab.

15.1.6 REQUIREMENTS FOR MATERIALS

(1) All materials used for the crane shall be new and conform to the latest revision of ISO or approved equivalent standards.

(2) Safety factors shall not be less than the following:

-Shaft and axles : 5.0
-Gears and pinions : 5.0
-Wire rope : 6.0
-Steel structure : 3.0

15.1.7 STRUCTURAL DESIGN

(1) Bridge and End Truck Frames

The bridge structures shall be of welded construction, but with all field connections designed for high-strength bolting. The various parts of the main structure of the crane shall be sub-assembled and the field connections reamed.

The end truck frames shall be either one-piece steel castings or built-up structural steel members.

(2) Trolley Frame

The trolley frame shall be fabricated from steel sections or cast steels and shall be designed to support the hoisting machinery.

(3) Walkway and Ladders

Steel safety tread walkways and ladders shall be provided to allow access to all parts of the crane for inspection, repairs and maintenance. Where required, cross walkways shall be provided, connecting walkways on opposite sides of the crane.

Walkways shall be at least 0.70 m wide and provided with a substantial toe-guard at least 0.10 m high and hand-railing not less than 1 m high over the entire length and ends. Ladders shall be provided where required for access between the walk-ways and operator's cab. The Contractor shall prepare access from the floor to the operator's cab.

(4) Operator's cab

An operator's cab shall be located on each crane and in such a manner as to allow maximum travel of the hooks and maximum visibility for the operator. The cab frame shall be fabricated from steel. All the enclosed walls of the cab shall be of transparent material.

The following controls shall be located inside of cab:

a. Manually operated controllers and master switches
b. Main air circuit breaker
c. Push - button switch for main contactor
d. Individual switches for lighting, warning signal, etc.
e. Volt meter for power source

15.1.8 ELECTRICAL DESIGN

The Contractor shall furnish and install all electrical equipment on the crane including all motors, electrically operated brakes, air circuit breakers, switches, contractors, controllers, resistors, control panels, relays, limit switches, trolley travel conductors, current collectors, transformers, complete lighting system, receptacles, conduit, wiring, cabling, insulators, anchors and other electrical equipment necessary for the safe and proper operation and control of the crane.

The Contractor shall also supply the main runway conductors, insulators, brackets and associated accessories.

The main power supply shall have a short circuit capability of 50 kA.
All electrical equipment shall conform to the appropriate IEC.

All motors, controllers, auxiliary apparatus and conduit shall be substantially grounded to the structural parts of the crane.

(1) Motors :

All electric motors shall be of the wound rotor, drip-proof, protected type and tropicalized. They shall be in accordance with the latest edition of IEC Standard for crane motors.

(2) Controller

The controllers shall be readily accessible for maintenance and inspection purposes. The nominal 415 volts, three phase, 50 Hz power supply from the main collectors shall be controlled by means of a suitable manually operated main air circuit breaker located in the operator's cab.

The main power supply breaker shall be identified by a nameplate instructing the operator to open the breaker when leaving the cab upon completion of work.

a. Bridge and Trolley Travelling

The travel motion of the bridge and trolley shall be controlled by the normal methods of acceleration, reversing and plugging the motor. Multi-pole contactors may be used.

Within limits of each required speed, the drive shall be controlled to provide substantially uniform speed regardless of load. The control shall include all necessary relays, timers, and limit switches required, for smooth and safe operation.

b. Hoisting and Lowering Control

The hoist drive shall be controlled to provide substantially uniform speed on each master switch step regardless of load.

(3) Main Circuit Contactor

A main circuit contactor shall be provided in common for main power supply circuit of main and auxiliary hoists, and for bridge and trolley travel.

The main circuit contactor shall be controlled manually by a pushbutton switch located in the operator's cab and it's control circuit shall have necessary interlocking circuit as follows, but not limited to these.

(4) Master Switch

The master switches for the main hoist, auxiliary hoist, trolley travel, and bridge travel shall be on the cam operated type, with a contact operating mechanism to ensure, positive operation of the contracts in both directions. Contacts shall be double break, spring-operated, readily renewable without disturbing the wiring and with automatically adjusting fingers to reduce wear.

(5) Limit Switch

Automatic reset, totally enclosed, heavy duty, adjustable limit switches shall be provided to limit the travel of the trolley and the bridge. The switches shall disconnect power supply to the motor when either the bridge or the trolley has travelled to within braking distance of its respective stop at either end of the

travel. A warning signal, preferably a buzzer installed in the cab, shall alert the crane operator when the trolley approaches its stops. The signal shall be activated ahead of the trolley's limit switch.

(6) Protective Panel

All power circuits to motors and all secondary circuits such as lighting shall be placed in the panel. The panel shall also include all overload relays, low voltage control, and all other necessary equipment recommended by the Contractor.

(7) Runway Conductors and Trolley Conductor

The Contractor shall furnish the main runway conductors, insulators, support brackets, and all other necessary equipment required for installation. The Contractor shall also furnish and install the trolley conductors, insulators and accessories required for the complete operating system. The insulators shall be brown glazed porcelain insulators. The size of conductor shall not be less than 125 sq. mm solid copper.

(8) Cabling

All cabling, collector gear and power supply conductors required for the operation of the crane shall be supplied by the Contractor. The crane shall be capable of travelling the full length of the engine house area/ equipment bay.

Support brackets, suitably insulated, shall be supplied by the Contractor for power supply conductors. Power cables and isolation switch for the supply to the power supply conductors shall also be supplied by the Contractor.

15.1.9 GANTRY STRUCTURE, RAILS AND GIRDERS

The Contractor shall supply a set of gantry structure complete with
weather protection shed, rails and girders holding down bolts and abutment plates located at the ends of each rail. Gantry rails and girders shall run over the full length of the engine house area/ equipment bay and adequate allowance for thermal expansion shall be provided in the design. The structural steel shall be designed and fabricated conform to the Section 18.5.1.

The weather protection shed shall be provided to cover the working area of the crane. The material of the shed shall be corrugated asbestos cement sheet. The thickness of asbestos cement sheet shall not be less than 5 mm.

15.1.10 SITE TESTS

(1) Control and protective equipment

Static tests of all automatic sequences.

(2) Running tests

The assembled crane shall be load tested including overload test with a load equal to 125% full lifting capacity after erection by the Contractor and all tests shall be in accordance with the relevant IEC Standard.

The Engineer and the B-R Powergen Ltd. shall witness these tests.

The Contractor shall supply all equipment including weights for the above tests. The Contractor shall also be responsible for the disposal of the materials used for the test load.

15.2 Hydraulic Mobile Crane

15.2.1 GENEELAL

The Contractor shall provide the following mobile cranes which will be utilised for erection works and for maintenance works after Taking over of the Plant. Capacity will be 30 ton.

15.2.2 TYPE AND RATING

The crane shall have following features at the minimum.

a.	Maximum lifting capacity	: not less than 30 ton
b.	Basic boom length	: approx. 12 m
c.	Maximum boom length	: not less than 45 m
d.	Wire speed for lifting	: max. Approx. 50 m/min
e.	Wire speed for boom	: max. Approx. 40 m/min
f.	Crane turning speed	: max 5 rpm
g.	Type of carrier	: Diesel engine driven truck type with Rubber tires. Dimension of the crane including basic boom shall be within the road limit in Bangladesh. Crawler type carrier shall not be accepted.
h.	Maximum running speed	: not less than 40 km/hr
I.	Climbing capacity (tan 0)	: not less than 0.30
J.	Minimum rotating radius	: not exceed 12 m
k.	Type of outer rigger	: Hydraulic
l.	Safety apparatus	: Over load limiter, safety interlocks, etc. shall be provided

15.3 TOOLS

15.3.1 GENERAL

The following tools and equipment shall be supplied under this Contract and the Tenderer is required to give a full list with details in the Schedule of Tools and Appliances when submitting his Tender.

Each set of tools and appliances shall be provided with conveniently sized, robust, lockable boxes suitably inscribed with the name of the Plant for which they are to be used.

The tools and appliances with the boxes shall be handed over to the B-R POWERGEN LTD. at the time of issue of the Taking Over Certificate.

15.3.2 SPECIAL TOOLS

Special tools means that type of tool which is fabricated/manufactured by the engine/generation/motor/breaker on its plant manufactures for its maintenance purposes which is not available in common market and which is dedicated for the said plant. The contractor will supply all the special tools required for the plant.

One set of special tools, gauges and equipment required for the normal maintenance of the whole of the Plant shall be provided by the Contractor.

One set of special lifting and handling appliances required for the normal maintenance of the whole Plant and equipment shall be provided by the Contractor.

Special tool list with unit price shall be submitted with Tender.

15.4 HOIST/EOT

The hoist shall be of chain- block type and the capacity shall be selected taking into consideration of weight of object. The hoist shall be provided with the monorail, supporting materials for rail and anchor bolts. The hoists shall be installed in the following area, but not be limited to, for the convenience of maintenance [EDG etc.].

- Auxiliary compartment

15.5 Two number Fork lifter of capacity 5 ton.

Section 16

Tests And Inspections

16. TESTS AND INSPECTIONS

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16 TESTS AND INSPECTIONS

16.1 GENERAL

The Contractor shall perform all tests and inspections necessary to ensure that the material and workmanship conform to the Contract and design drawings. Those tests and inspections shall demonstrate that the equipment will comply with the requirements of this Specification and meet the specified guarantees.

The B-R Powergen Ltd. and the Engineer shall have a right to access the Contractor or sub-Contractor's works to determine or assess compliance with the provisions of this Specification or to witness the Contractor's inspections or tests.

The contractor shall supply to the B-R Powergen Ltd. as soon as practicable which shall contain details of each test performed and shall be prepared as required by the B-R Powergen Ltd., records, results and calculation of all electrical tests shall be provided.

16.2 WORKSHOP TEST

(1) All plant shall be subjected to type, sample and routine tests at the manufacturer's factory in accordance with these clauses and conditions of the Contract.

(2) Type, sample and routine tests shall be to the relevant ISO and IEC Standards or other approved international standards for equipment where the test requirements are not specified in these clauses.

(3) The Contractor may offer type test results for identical equipment in lieu of the type tests specified, in which case the B-R Powergen Ltd. may waive the specified type tests. If type test results for identical equipment are offered in lieu of the specified type tests, the Contractor shall also provide evidence as to the similarity of the equipment tested and the Contract equipment.

(4) The Contractor shall submit evidence to the B-R Powergen Ltd. & Engineer that the instruments used for the testing shall have been calibrated at an approved testing laboratory within a period of up to six months for a portable instrument and twelve months for a fixed instrument.

16.2.1 Engine Generating Sets

The engine generating sets shall be assembled as a complete unit and run under simulated operating conditions at the manufacturer's works. The units shall be tested to ensure smooth running and satisfactory operation of the accessories. Necessary tests shall also be performed for EDG as per relevant standard.

The Contractor shall state in his proposal the performance and reliability tests to be carried out in the works. The Contractor shall give the B-R Powergen Ltd. & Engineer notice of the tests at least six(6) weeks in advance. The tests to be

carried out shall include, but not be limited to, the following:-

a. Dynamic balancing together with over-speed tests
b. Bench testing of all accessories
c. No load operation of the assembled units to test the followings among others:-

- Vibration
- Lubrication system
- Fuel system
- Jacket temperature
- Exhaust temperature
- Governor system
- Temperature control system
- Air system
- Over-speed trip
- Water system
- Individual accessories

16.2.2 GENERATOR

Each generator shall be operated at no-load on the factory test floor with the following observations and respective data so reported and reference to IEC Standard shall be made:-

a. Measurement of resistance of armature and field windings.
b. Mechanical inspection and balance.
c. No-load field current at rated voltages and frequency.
d. Voltage phase balance and phase sequence.
e. Dielectric tests.
f. Insulation resistance of field and armature.
g. Standard no-load and short circuit tests.
h. Characteristic "V' curve test and efficiency tests.
i. Generator fixed losses.
J. Generator variable losses (at loads available with driving motor).
k. Measurement of vibration
l. Temperature rise test

16.2.3 EXCITER

Each exciter shall be operated at no-loads on the factory test floor with the following observations and respective data so reported and reference to IEC Standard should be made:-

a. Saturation run.
b. Mechanical balance.
c. Resistance.
d. Dielectric tests.
e. Insulation resistance of windings.
f. Exciter characteristics tests

16.2.4 STEP-UP TRMSFORMERS

The transformers shall be completely assembled at the factory and shall be subjected to the following tests by the Contractor, in accordance with the latest revisions of IEC 76 "Power transformers" and 551 "Measurement of transformer and reactor sound levels".

a. General inspection
b. Measurements of Winding resistance
c. Voltage ratio measurement and check of polarity
d. Measurement of impedance voltages
C. Measurement of load loss
f. Measurement of no-load loss and current
g. Test of temperature rise
h. Induced over-voltage withstand test
i. Separate-source voltage-withstand test
J. Insulation resistance measurement (megger)
k. Results of shop tests to be submitted.
- Results of type tests of lightning impulse-voltage withstand test
- Test of protective relays
- Characteristic test of bushing type current transformers

16.2.5 132 KV SWITCHGEAR EQUIPMENT

(1) Circuit Breakers

The tests shall be performed in accordance with the latest revisions of IEC 56-4 'High-voltage alternating-current circuit breakers, Part 4: Type tests and routine tests'.

- General inspection
- Insulation resistance measurement
- Dielectric withstand voltage test
- Operation test

In accordance with the requirements of IEC 56, details of the transient recovery voltage to which the circuit breaker will be subjected during short circuit testing shall be submitted to the B-R Powergen Ltd. for approval.

The B-R Powergen Ltd. may require in addition any of the following tests to be carried out, the details of which will be agreed between the B-R Powergen Ltd. and the Contractor:-

- Earth fault interruption tests
- Out of phase switching tests according to IEC 267
- Capacitance switching tests
- Small inductive breaking current switching tests
- Tests under environmental conditions
- Voltage withstand test after breaking capacity tests

(2) Isolators and Earthing Switch

The tests shall be performed in accordance with the latest revisions of IEC 129 "Alternating current disconnectors (isolators) and earthing switches".

- General inspection
- Insulation resistance measurement
- Dielectric withstand voltage test
- Operation test

(3) Current Transformers

The test shall be performed in accordance with the latest revisions of IEC 185 "Current transformers".

- General inspection
- Polarity test
- Insulation resistance measurement
- Dielectric withstand voltage test
- Characteristic test

(4) Voltage Transformers

The test shall be performed in accordance with the latest revisions of IEC 186 "Voltage transformers"

- General inspection
- Polarity test
- Insulation resistance measurement
- Dielectric withstand voltage test
- Characteristic test

(5) Lightning Arresters

The test shall be performed in accordance with the latest revisions of IEC 99-1 "Lightning arresters, Part 1: Non-linear resistor type arresters for AC system".

- General inspection
- Power frequency spark-over voltage test
- Lightning impulse spark-over voltage test
- Measurement of leakage current and insulation resistance

(6) Steel Structures

General inspection
Material quality and quantity check

(7) Bus Support, Insulators and Wiring Materials

The following shop tests shall be performed by sampling inspection method and number of samples for the test shall be decided after award of the Contract.

a. Bus Supports

- General inspection
- Dielectric test of power frequency
- Tension proof test

b. Insulator Assemblies and Grounding Wire Attachment

- General inspection
- Dielectric test of power frequency
- Breakdown test of insulator
- Dimension measurement of hardware
- Tension proof test

c. Stranded Conductors for Overhead Line and Grounding System

- General inspection
- Tensile strength test

d. Other Materials
-General inspection

16.2.6 CONTROL AND PROTECTION SYSTEM

The following tests for the control and protection system shall be performed at the workshop.

- General inspection
- Measurement of insulation resistance
- Dielectric withstands voltage test
- Performance test of relay Error test of meter
- Sequential operation test of Control & Protection System.

16.2.7 OTHER MATERIALS AND EQUIPMENT

All other materials and equipment shall be tested at the Contractor's workshops in accordance with latest IEC, ISO, other approved international Standard and/or the request of the B-R Powergen Ltd..

16.3 TESTS AT SITE

Responsibility for Tests

a. The Contractor shall conduct the tests at the Site in accordance with these clauses and the conditions of the Contract.

b. The Contractor shall provide all equipment and personnel required to carry out the tests, including the provision, installation and removal of all test instruments, the connection and disconnection of plant items and obtaining of all records. The B-R Powergen Ltd. will provide electricity, fuel, lube oil (Engine lubricant oil) and water required for the tests on completion without charge to the Contractor.

c. The Contractor shall prepare and submit to the B-R Powergen Ltd. at least three months prior to the commencement of testing, schedules in approved format for each test together with a programs provided by all Contractors.

The B-R Powergen Ltd. & the Engineer will be responsible for overall co-ordination and safety control of tests.

d. The Contractor shall submit one copy of the results of each of the tests at the Site to the Project Director within one week of the tests being carried out. Four copies of the certificates shall be provided to the B-R Powergen Ltd. within one month of the tests being carried out.

e. The B-R POWERGEN LTD.'s staff will observe and participate in the tests on completion.

f. The Contractor shall submit evidence to the B-R Powergen Ltd. that the instruments used for the tests have been calibrated at an approved testing laboratory within a period of up to six months.

(2) Scope of Tests

The tests to be carried out and passed before taking over of the works by the B-R Powergen Ltd. shall be deemed to comprise two main stages of testing as follows:

a. Preliminary tests which are tests performed prior to rotation or energising at normal voltage or admission of normal water or air pressure to the main or auxiliary plant under test.

b. Tests on completion which are tests to progressively prove the correct operation of complete auxiliary systems and of the main plant items. These tests shall be carried out in accordance with the conditions of the Contract.

(3) Reliability Test Period

a. The tests on completion shall include a reliability test period [Initial Commercial Operation "ICO"] for each generating unit and auxiliaries, which shall commence when the Contractor has notified the B-R Powergen Ltd. that the unit is ready for commercial operation. During this period, the unit and auxiliaries will be required to operate under the working conditions of the station, within their operating limits, either continuously or intermittently as required by the operation of the station, without failure or interruption of any kind for a period of one hundred sixty eight (168) hours. The units will be operated by the station staff and the Contractor shall provide at his own expense a suitable representative during each operating shift to direct the station staff on the operating techniques and the running of the units. The Contractor may make minor adjustments to the units, provided that such adjustments do not in any way interfere with or prevent the commercial use of the units by the B-R Powergen Ltd. or result in reducing the output or efficiency.

b. Should any failure or Interruption occur in the operation of the units due to faulty design, materials or workmanship under the Contract but not otherwise, sufficient to interrupt the commercial operation of the units, the reliability test period of one hundred sixty eight (168) hours shall recommence after the Contractor has remedied the cause of the defect.

16.3.1 TESTS ON COMPLETION

(1) The Contractor shall give to the B-R Powergen Ltd. in writing twenty one (21) day's notice of the date after which he will be ready to make the tests on completion. Unless otherwise agreed, the tests shall take place within ten (10) days after the said date, on such day or days as the B-R Powergen Ltd. shall in writing notify the Contractor.

(2) If the B-R Powergen Ltd. fail to appoint a time after having been asked to do so or to attend at any time or place duly appointed for making the said tests the Contractor shall be entitled to proceed in their absence, and the said tests shall be deemed to have been made in the presence of the B-R Powergen Ltd.'s representative.

(3) If, in the opinion of the B-R Powergen Ltd., the tests are being unduly delayed he may by notice in writing call upon, the Contractor to make such tests within ten (10) days from the receipt of the said notice and the Contractor shall make the said tests on such day within the said ten(10) days as the Contractor may fix and of which he shall give notice to the B-R Powergen Ltd.. If the Contractor fails to make such tests within the time aforesaid the B-R Powergen Ltd. may himself proceed to make the tests. All tests so made by the B-R Powergen Ltd. & the Engineer shall be at the risk an expense of the Contractor unless the Contractor shall establish that the tests were not being unduly delayed in which case tests so made shall be at the risk and expense of the B-R Powergen Ltd..

(4) The B-R Powergen Ltd. except where otherwise specified, shall provide free of charge, such labour, materials, fuel, water, as may be requisite and as may be reasonably demanded to carry out such tests efficiently. However all the calibration devices, standard or sub-standard special test instruments, stores, apparatus etc., required to conduct all the tests would be provided, arranged and installed by the Contractor at his own cost and expenses. The Contractor will pay all expenses including the custom duties etc. on the import or export of all such instruments etc.

(5) If any portion of the works fail to pass the tests, tests of the said portion shall, if required by the B-R Powergen Ltd. or by the Contractor, be repeated within a reasonable time upon the same terms and conditions save that all reasonable expenses to which the B-R Powergen Ltd. may be put by the repetition of the tests shall be deducted from the Contract price.

16.3.2 FIELD INSPECTIONS AND TESTS ON ENGINE GENERATING UNITS

The following field inspections and tests will be carried out in the sequence detailed below, and the successful performance and completion of all the tests taken together shall constitute the B-R POWERGEN LTD.'s acceptance tests:-

(1) Inspection and Checking of Units

After completion of erection and/or installation, and before put into operation, each unit and all its appurtenances (engines, generators, motors, pumps, heaters, fans, piping, valves and all other mechanical and electrical equipment and material) shall be thoroughly cleaned and then inspected under the supervision of the Engineer and in presence of the B-R POWERGEN LTD.'s Engineer for correctness and completeness of installation and acceptability for placing in operation. The time consumed in the inspection and checking of the units shall be considered as a part of the erection and installation period.

(2) Start-up and Trial Operation

Following the satisfactory completion of the inspections and checking of Diesel Engine units, the same will be placed in trial operation during which all necessary adjustments, repairs etc. shall be made as required, then the unit being shut down as required. When the equipment is operating properly its characteristics shall be recorded on the start-up report sheets. Start-up reports for all the

equipment must be completed before the start of the initial commercial operation period.
The time consumed in start-up and trial operation shall be considered as a part of the erection and installation period.

The following test shall be carried out.

- Start-up mechanical running test, adjustment of engine air intake/fuel injection valves control and interlocking, etc. The measured data such as pressure, temperature, vibration, adjustable speed range etc. shall be observed and recorded.
- Checking of cooling system and lube oil system.
- Checking of over-speed tripping devices, protection and interlocking system, start-up and shut-down sequence of auxiliary system.
- Noise, NO_X and vibration level measurement.
- Manual and automatic synchronization.
- Generator Protection relay testing.
- Checking of base load and peak load capability.
- Load rejection and governor tests.
- Testing of start-up times.

(3) Initial Commercial Operation (ICO)

The Contractor shall be responsible for running on initial commercial operation period at the Site, including all auxiliaries and controls for the Plant. The Contractor shall operate the units at various loads as specified by the B-R Powergen Ltd. after synchronising the system.

The initial commercial operation shall start on the specified date and shall last for one hundred sixty eight (168) hours during which time the plant and auxiliaries will operate continuously, uninterrupted without adjustment or repair to the satisfaction of the B-R Powergen Ltd. & Engineer at all loads up to and including the maximum loads.

On the completion of continuous operation for one hundred sixty eight (168) hours on all automatic and supervisory controls, the B-R Powergen Ltd. & Engineer will instruct cycling operation, shutdown and start-up during the next seven (7) days. After satisfactory completion of these observations, plant shall be considered to have been put on initial commercial operation from the date of start of the initial commercial operation.

(4) Performance and Acceptance Tests

Soon after the initial commercial operation tests have been run, performance tests shall be run to determine whether the equipment complies with the guarantee provided that unit is made ready for performance test by the Contractor and certified by B-R Powergen Ltd. & Engineer. The tests shall be conducted in accordance with the latest ISO or ASME Performance Test Codes applicable for Engine Generating Sets (HFO fired) using previously approved correction curves and complying with the following special conditions unless otherwise specified. The chemical analysis and lower heating values of the fuels shall be determined from two laboratories to be chosen respectively, one by the B-R POWERGEN LTD., the other by the Contractor.

The B-R POWERGEN LTD. shall provide without charge such labour, material, fuel and water as may be reasonably required to conduct the performance and acceptance tests. The gross station efficiencies under different load conditions established during an eight (08) hours continuous test shall be calculated in a manner as approved by the B-R Powergen Ltd. Power measurements at HT/Secondary side of the step up transformer and at the incoming circuit of unit motor control centre shall be made with totalising meters.

Generator power output shall be held as constant as possible during the performance test.

The Diesel Engine generator shall run at 25%, 50%, 75% and 100% of base rating and peak load prior to placing the unit into commercial operation and to prove that sudden load rejections from loads up to maximum capability can be accommodated by the engine without the speed rise being sufficient to cause the over-speed trip to initiate.

The output and heat rate tests will be carried out on each unit in the following manner:

i) 1/2 hour at 1/4 load
ii) 1/2 hour at 1/2 load
iii) 1 hour at 3/4 load
iv) 6 hours at full load

Full load at the generator terminal for the purpose of the test will be calculated from the guaranteed output according to the site ambient installation conditions. Correction factors for variations of test conditions from the specified design conditions shall be stated in the Tender.

(5) Test Reports

The Contractor shall submit to the B-R Powergen Ltd. within three (3) months after the signing of the Contract, the detailed procedure for the conductance of the performance and acceptance tests for approval.

The procedure shall include the following for such test or group of tests:-

a. The time duration of each test at each load.
b. The number of test runs at each load.
c. The sequence of the tests to be conducted.
d. A list of instruments that will be used for each test.

The list shall designate which instruments are:

i) Special test instruments
ii) Certified
iii) To be calibrated before and after each test
iv) Check instruments
v) Station supply instruments.

Schematic diagrams showing all test points and cross references to the instrument list shall also be included.

e. All formulas, calculations, conversion factors, curves, correction curves, etc., to be used in the conductance of the tests and the calculations of the test results.

f. Sample test reports or data sheets and all specific result sheet forms that will be used for the test.

g. Written procedure and description of conducting the test.

h. All test data to be recorded by the Contractor and the B-R Powergen Ltd. & Engineer.

Necessary tests shall also be performed for GBC & EDG as per relevant standard.

16.3.3 FIELD INSPECTIONS AND TESTS ON SWITCHGEAR, EQUIPMENT

The following site tests shall be performed by the Contractor.

(1) Protection, Control, Alarm, Measurement and Indication Equipment

a. Wiring

Insulation resistance test using 500 V Megger shall be carried out on all AC and DC protection, control, and alarm and indication circuit.

The insulation of all circuits shall be checked before proceeding with other tests and it is also essential that all AC wiring is correctly connected relay contacts, auxiliary contacts, etc., being closed, as necessary, to verify this. Checks shall be made on cable glands, cable jointing, fuse or circuit breaker and small panel items, such as indicating lamps. Static equipment which may be damaged by the application of test voltage shall have the appropriate terminals short circuited. Inter relay, inter unit and cubicle wiring carried out at the Site shall be checked to the appropriate circuit and/or wiring diagram.

Where, it is found necessary during pre commissioning work to effect site modifications to the secondary wiring, site copies of the appropriate schematic and wiring diagrams shall be suitably marked as agreed with the B-R Powergen Ltd. before the circuit is commissioned.
Loop resistance measurements shall be made on all current transformer circuits. Separate values are required for current transformer circuits.

b. Mechanical Check

All relays shall be examined to ensure that they are in proper working condition and correctly adjusted, correctly labelled, and the relay case, cover, glass and gaskets are in good order and properly fitting.

c. Secondary Injection

Secondary injection shall be carried out on all AC instruments and relays, using voltage and current of sinusoidal waveform and rated power frequency.

(2) Current Transformer Magnetising Tests

The magnetisation characteristic of all current transformers shall be checked at the minimum of two points to identify the current transformers with reference to the manufacturer's estimated design curve, and to determine the suitability of the current transformer for its intended duty. It may be noted that it is not normally necessary to check the characteristic up to the knee-point for this purpose. Special measures may have to be taken to ensure that the core is fully de-magnetised before commencing the test.

a Primary Injection

Primary current injection tests shall be carried out by the Contractor. The primary injection methods employed for a particular installation shall therefore be agreed with the B-R Powergen Ltd..

Tests shall be carried out as follows:-

-Local primary injection to establish the ratio and polarity of current Transformers of similar ratio.

-Overall primary injection to prove correct inter-connections between current transformer groups and associated relays.

-Fault setting tests to establish, where practicable, the value of current necessary to produce operation of the relays. If not practicable, these tests are to be carried out by secondary injection applied at the wiring close to the current transformer.

(3) DC Operations

Tests shall be carried out to prove the correctness of all DC polarities, the operating levels of DC relays and the correct functioning of DC relay schemes, selection and control switching, indicating and alarms.

(4) On Load Tests

In view of the hazards inherent in these tests, they shall be carried out under the direct supervision of the B-R Powergen Ltd. & Engineer.

An operation and stability test shall be carried out for on load commissioning of unit type protection.

Test for restraint shall be carried out to prove the characteristics of protective systems with directional/differential characteristics,

On load checks shall be made after the protection gear has been placed in service to ensure that all connections and test links have been replaced and test leads removed, as well as to confirm the integrity of the current transformer circuits. Where necessary voltage readings shall be taken at the terminals on each relay & meters to ensure that loop connections between the relays & meters are complete. Special attention shall be paid to broken delta voltages and residual current circuits where zero voltage or current respectively may not be proof of the completeness of the circuit.

(5) Step-up Transformers

a. General mechanical checks.
b. Core and winding insulation tests.
c. Ratio and HV magnetizating current tests.
d. Vector group cheek.
e. Motors overload protection tests.
f. Buchholz device tests.
g. Temperature instrument calibration and tests.
h. Operational tests on tap change equipment.
i. Dielectric strength tests of insulation oil.

The above tests shall be recorded on approved test sheets, two signed copies of which shall be forwarded to the B-R Powergen Ltd. immediately after a test or series of tests has been completed.

The B-R Powergen Ltd. & Engineer shall countersign the test sheets if found to be satisfactory and retain one copy. The Contractor shall provide to the B-R Powergen Ltd. six bound copies of all site test sheet as final records.

(6) 132 kV Switchgear

a. General Cheek

A general check of all the main switchgear and ancillary equipment shall be made and shall include a check of the completeness, correctness and condition of earth connections, arcing ring and horn gaps, painted surfaces, cables, wiring, pipework, valves, blanking plates and all other auxiliary and ancillary items. Checks shall be made for oil and gas leaks and that insulators are clean and free from external damage. A check shall be made that loose items which are to be handed over the B-R POWERGEN LTD., e.g. blanking plates$_3$ tools, spares, are in order and are correctly stored or handed over.

b. Circuit Breakers

Following completion of erection of circuit breakers and all high voltage circuits, power frequency withstand voltage test at a level to be agreed shall be applied.

Local air components associated with pneumatic operation, including air compressors, shall be tested and air loss measurements and pressure and alarm settings checked. Tests shall be made also on mechanical and hydraulic operating systems.

Contact resistance tests shall be carried out with not less than 15 amperes passing through the contacts. In the case of multi-interrupter circuit-breakers, resistance tests will be required at each interrupter or pair of interrupters as well as through the series of interrupters on each pole.

Operational tests will include local and remote trip/close. SF6 gas type circuit-breakers testing shall be required on the gas system to prove the gas quantity, its dryness and its dielectric strength. The gas leakage shall also be measured.

c. Isolators and Earthing Switches

Manually operated equipment shall be subject to operational tests to confirm contact pressures, contact resistance, synchronism of operation of all phases and the ease of operation.

Checks shall be made of the local and remote indications and operation of auxiliary contacts.
Motorised equipment shall be tested to prove the motor operation, including local and remote operation. Timing tests shall also carried out.

Earth switches and maintenance earthing devices shall be tested to confirm the opening and closing sequences and checks shall be made on the earth mat, indications and manual locking devices.

d. Voltage Transformers

All voltage transformers shall be checked for polarity phasing and for secondary output.

e. Lightning Arresters

General inspection shall be carried out to verify the condition and satisfactory mounting of the arrester and its earth connections and electrodes.

(7) Interlocking

All interlocking arrangements both electrical and mechanical shall be fully checked and tested.

(8) Earthing System

Tests shall be made on the effectiveness of the bonding and earthing which will include conductivity tests on selected joints, on the main earthing system, and at the connections to equipment and structures. Checks shall also be made on precautions taken to avoid corrosion attack on the earthing system.

(9) Others

All other equipment and/or systems shall be tested in accordance with the instruction by the B-R Powergen Ltd..

16.4 ACCEPTANCE AND INTERIM OPERATION

(1) After the performance tests, if the equipment supplied by the Contractor is found to meet the guarantees and any other specified requirement, and if all other work called for hereunder has been completed, the B-R POWERGEN LTD.'s acceptance will be forthcoming. This acceptance shall, however, not relieve the Contractor of his responsibility for first inspection.

Should the equipment furnished by the Contractor fail to operate as required, or in case of failure to meet any of its guarantees, the B-R POWERGEN LTD. shall

have the right to operate the equipment, using the Contractor's supervisory operating personnel, until such defects have been remedied and guarantees met with. In the event that defects necessitate to the rejection of the equipment or any part thereof, the B-R Powergen Ltd. shall have the right to operate the equipment until such time as new equipment is provided to replace the rejected equipment. Such operation shall not be deemed an acceptance of any equipment.

16.5 FIRST INSPECTION

16.5.1 RESPONSIBILITY DURING GUARANTEE PERIOD

The Contractor shall be responsible for operation during the period commencing with initial start-up and extending through trial operation and all performance tests. The Contractor shall also be responsible for two(2) years operation and maintenance after satisfactory performance test by providing supervisory staff of the required number to be fixed by the B-R Powergen Ltd.. During the trial operation period, the Contractor will furnish the supervisory operating personnel; In addition, any calibration device, special test instruments, etc., required preparing for and conducting the performance tests.

Contractor's supervisory personnel shall conduct instruction sessions in English language for the B-R POWERGEN LTD.'s personnel prior to and during this period and shall otherwise train them so that they will be able to operate and maintain the new equipment satisfactorily after acceptance by the B-R Powergen Ltd.. The training programme of B-R POWERGEN LTD.'s personnel shall be conducted to meet the satisfaction of the B-R Powergen Ltd. & Engineer. The Contractor shall provide the service of competent personnel knowing English language to assist the B-R POWERGEN LTD.'s engineers in training the staff.

16.5.2 FIRST INSPECTION/ OVERHAULING

The first Inspections/Overhauling after the completion of recommended hours of operation shall be undertaken by the Contractor and the charges on this account Including all corrections, repairs and replacements made by him shall be entirely at his own cost.

For the first inspection/Overhauling the Contractor will provide the supervisors with special tools and the B-R Powergen Ltd. will provide labour, normal tools, crane with driver under the responsibility of the Contractor. Fuels, lubricants and wages for the local staff for crane will be paid by the Contractor.

First inspection/ Overhauling will in any case be carried out before expiry of the guarantee period of twenty four(24) months, according to a programme to be mutually agreed between the Contractor and the B-R Powergen Ltd.. The scope of first inspection will include, but will not be limited to, the item listed. The cost of this inspection/overhauling will be included on the cost of spares and services of warrantee period.

Section 17

Civil Works

17 CIVIL WORKS

17 CIVIL WORKS

17.1 GENERAL

The General Conditions, Tender Drawings and Schedules shall be read in conjunction with this Specification. Matters described in one are not necessarily repeated in the others.

17.1.1 GENERAL REQUIREMENTS

The Tenderer's proposal shall cover all requirements of the Tender Documents and any other items not specifically mentioned but which arc deemed to be necessary for the satisfactory design, supply of materials, construction, and supervision of the civil works on the basis of a turnkey contract.

The Contractor shall upon examining the design of the foundations and major structures, develop and prepare the detailed design and the construction drawings of all civil structures for the approval of the B-R Powergen Ltd. which shall meet the equipment and structures specification, to be supplied by the Contractor for the Project.

The B-R Powergen Ltd. shall reserve the right to examine the Contractor's design and to instruct a change or modification by the Contractor.

These modifications shall be carried out by the Contractor without additional cost as a result of any claims made by the Contractor on the B-R Powergen Ltd..

Approval of the design by the B-R Powergen Ltd. shall not relieve the Contractor of liability for the construction works.

The Tenderer shall familiarise himself with the site levels, subsoil and an other data necessary to enable him to estimate the bearing capacity and foundation requirements, for use in the preparation of his tender.

It is the Contractor's entire responsibility to search for filling material for land reclamation work and to make all arrangements necessary for the satisfactory completion of the land reclamation work within the Project. His tender shall include for all local eventualities.

The Tenderer shall quote firm prices which shall remain valid through-out the Contract Period on all items in the Price Schedule unless other-wise stipulated.

17.1.2 TOPOGRAPHIC SURVEYS

The Contractor shall carry out surveys as are necessary for the proper design and execution of the Works. The results of such additional surveys together with the survey drawings shall be submitted to the B-R Powergen Ltd. for approval.

17.1.3 SITE INVESTIGATION

The Contractor may conduct soil investigation if deemed necessary at his own cost before submission of the bid. However, after signing of contract the soil investigation at the cost of the contractor is mandatory for detailed design of the civil work.

17.1.4 SITE LABORATORY

The Contractor shall provide a site laboratory with a concrete floor space of not less than 4m x 6m adequately equipped to carry out quality control tests of material and workmanship in accordance with the procedures and tests as described in the relevant ASTM Standard or other approved Standard. He may as an alternative to the provision of laboratory equipment, make arrangement for all necessary tests to be carried out by personnel with relevant experience from an approved laboratory.

17.1.5 RECORDS AND DRAWINGS

The Contractor shall keep at the Site accurate and upto-date records and drawings of the Works, and shall submit these records to the B-R Powergen Ltd. at the end of every week. Such record shall include the amount of labour, plant and materials employed upon the Site during that week.

17.1.6 SAMPLES, TESTING AND INSPECTION

The B-R Powergen Ltd. may request at any time to test or inspect sample of material and workmanship proposed and the Contractor shall furnish these immediately. When the B-R Powergen Ltd. & Engineer has approved the samples, material, and workmanship not corresponding in quality and character with the samples approved shall be rejected. The costs of all sampling and testing to be conducted either on the Site or in an approved laboratory shall be borne by the Contractor.

17.1.7 STANDARDS AND CODES OF PRACTICE

The Civil Works shall be designed and constructed in accordance with the Specifications, relevant Standards and Codes of Practice of Bangladesh National Building Code. The Contractor shall submit together with his bid a schedule of standards and codes of practice to be followed in the design and construction of the Works. Copies of these codes and standards shall be made available to the B-R Powergen Ltd. & Engineer during the design and construction period. In the case of the Standards and Codes not published in English, the Contractor shall obtain English translations when required and send them to the B-R Powergen Ltd..

The Contractor shall be responsible for the establishment of design parameters to satisfy the requirement of the project.

Basic design conditions shall be as follows: -

a.	For Seismic horizontal ground acceleration: 0.28g	
b.	Design Storm	: Based on frequency-intensity Duration curves prepared for 6h
c.	Wind velocity	: 100 miles/hr
d.	Design load for road	: H-15 (AASHTO)
e.	Standards and codes of practice	: ASTM, ACI, and inter-national codes of practice and other Standards to be approved by the B-R Powergen Ltd.

17.1.8 PREPARATION OF DESIGN AND DRLKWINGS

The Contractor shall prepare all designs and detailed working drawings as deemed necessary for the execution and completion of the Works.

The Contractor shall be responsible for ensuring that the design satisfies the requirements of all local and national authorities. Design calculations shall be in accordance with an approved method and should take into account the most critical combination of dead load, wind load, and seismic load. Design calculations and detailed drawings shall be submitted to the B-R Powergen Ltd. for approval. The Contractor may commence construction on the Site only after drawings are approved by the B-R Powergen Ltd. & Engineer.

17.2 SCOPE OF CIVIL WORKS

The civil works shall include collection of site data, detailed design, production of working drawings, provision of labour, supply of construction plant and materials, construction and rectification of defects during the Warranty Period of the Works.

The Scope of Work shall include, but not be necessarily limited to, the following:

a) Site Works: Site clearance, excavation and filling of the Site to formation level (Site development up to same level of existing .....) including running surplus excavated materials to disposal area, sheet piling work, site roads and surfacing, water supply, sewage treatment cable ducting, pipe ducting, drainage, landscaping, fencing, boundary wall and gates.

b) Foundation: For all plants and structures supplied under this Contract. Suitable foundations shall be provided for the engine generating unit(s), 132 kV switchgears, transformers, elevated water tank, overhead travelling crane, buildings, Oil storage Tanks, Fuel oil Handling System, emergency diesel generetor (EDG), and all other equipment, buildings and structures.

c) Temporary works as necessary to construct the permanent works. Provision of site office for the Engineer and the Project Director including all services, furnishings, and attendance for the period required by the Engineer but not exceeding one month after the final taking-over date.

17.3. EARTHWORKS

17.3.1 GENERAL

The Contractor shall prepare the drawing necessary for his construction purpose based on drawings and the specification, and submit them to the B-R Powergen Ltd. for approval. The Contractor shall be responsible for and shall complete all the earthworks as shown on the approved drawings or as directed by the B-R Powergen Ltd..

17.3.2 EXCAVATION

Before commencing any excavation on the Site, the Contractor shall notify the B-R Powergen Ltd. at least 48 hours before starting any additional surveys. He shall carry out, where directed by the B-R Powergen Ltd. extra surveys required resolving any doubts which may arise as to correctness of any surveys or record. Thereafter the decision of the B-R Powergen Ltd. & Engineer regarding what shall be recorded as the correct survey shall be final.

Excavations shall be carried out to the width, lengths and depths shown on the approved drawings. The Contractor may excavate by any method he considers suitable, subject to the approval of the B-R Powergen Ltd..

Selected granular materials from the excavation as approved by the B-R Powergen Ltd. shall be used in the embankment construction and filling.
Unsuitable materials shall be removed from the Site to disposal areas.

Cut and fill slopes shall be designed for to be thorough stability. Unless otherwise indicated On the Drawing the exposed surfaces of all cuttings and embankments shall be soiled and turfed to the satisfaction of the B-R Powergen Ltd..

The Contractor shall take particular care during the excavation of the foundation to avoid deterioration of the ground due to exposure to the weather. The final 120 mm of excavation above formation level shall be carried out by hand immediately before the next stage of construction is to start. A similar method shall be adopted in the ease of the sides of excavation against which the structure is to bear.

The Contractor shall provide all strutting and shoring necessary for the safe execution of the Works and shall provide the necessary pumps, de-watering facilities, and temporary drains to ensure that all excavation shall be carried out in the dry.

The rates for excavation and filling shall be deemed to have included for the full cost of excavation and filling of the materials including site clearing, stripping of top soil, all pumping and temporary works necessary to keep the excavation and filling free from water, temporary shoring and timbering, trimming to line and level, stock-piling, handling, compaction, cutting, slope protection, removing surplus excavated material to spoil tips, together with all other costs incurred in com--plying with the contract requirements.

17.3.3 FILLING

The area to be filled shall be cleared of vegetation and the top soil shall be stripped and stockpiled. All soft yielding material shall be removed and replaced with granular selected material. Where fill has to be deposited against the hill slope, the Contractor shall take all necessary precautions to ensure that a good bond is achieved between the fill and the original ground.

No fill shall be deposited in the area to be filled until the B-R Powergen Ltd. & Engineer has inspected and given approval. Filling to the formation level shall be brought up form the bottom in uniform compacted layers. Excavated material obtained from the Site may be used for embankment construction and filling.

Filling, levelling and compaction on the Site shall be carried out in layers not exceeding 300 mm thickness. The Contractor shall carry out all necessary quality control works including in-situ soil density tests, moisture content and other laboratory testing to ensure that all materials used in the embankment or filling elsewhere are compacted in accordance with the specified requirements.

The maximum dry density (MDD) for the purpose of this specification shall be determined by the following procedures or equivalent.

a. Selected materials used in the embankment other than below buildings shall be compacted to a density not less than 95% MDD.

b. Sub-grade for road below formation level to a depth 650mm shall be compacted to a density not less than 95% MDD or as approved by the B-R Powergen Ltd..

c. Location of buildings and equipment foundations shall be compacted to a density not less than 95% MDD or as approved by the B-R Powergen Ltd..

The following standards tests (any one) shall be conducted for determination of MDD.

(1) Standard Proctor Method
(2) Modified AASHTO Test

17.3.4 BACKFILLING

This section shall apply to the performance of all work in connection with the required backfill for the permanent works.

(1) Material

Material for backfill shall be obtained from excavated soil or other sources approved by the B-R Powergen Ltd.

(2) Workmanship

Backfill to all foundations trenches, pits, etc., shall not be placed until the work has been inspected and approved Backfill around sewers, water mains and other utility lines shall be carefully placed so that the piping will not be displaced or damaged. Fill in contact with pipes shall be entirely free of rocks. Backfill around service pipe shall be of sandy material. The backfill shall be compacted at optimum moisture content in layers not exceeding 15cm to 92% of the maximum dry density. Compaction shall be carried out by vibratory plate compactor.

17.3.5 MEASUREMENT AND PAYMENT

(1) Land reclamation works

Measurement by volume, for the payment of filling for the land reclamation works shall be made on the basis of the original ground surf ace and the site formation levels shown on the approved drawings. The quantity of filling given in the Schedule was estimated for Tendering purposes. If the final quantity of the filling work varies beyond 10 (ten) percent, the Contractor shall notify the B-R Powergen Ltd. for approval regarding the re-measurement and subsequent a variation the contract amount will be adjusted. Payment for the filling of the land reclamation works shall be made based on the unit price fixed by the Tenderer.

(2) Foundations and Ducts etc.

All expenses required for excavation and back filing of foundations, ducts, trenches, roads and all other structures shall be included in the lump sum price bid for the respective work item in the Schedule. The lump sum price bid shall not be modified or subject to adjustment for any design variation due to a change of geological or other conditions.

17.4 FOUNDATION

17.4.1 GENERAL

The Contractor shall take full responsibility for the suitability of the type of foundations he proposes to use and shall guarantee the performance of the foundations.

All foundation shall be designed in accordance with the requirement as laid down in CP2004: 1972 Foundation" or other approved Standards and Codes of Practice/BNBC.

17.4.2 PILING

Pile foundations shall be designed and applied to buildings, equipment, and structure where required based on available information obtained from the subsoil investigation to be carried out at the Project Site by the Contractor.

In the event that piled foundations are proposed, the Contractor shall submit a detailed design for piled foundations to the B-R Powergen Ltd. for approval. The Contractor can apply any type of pile design to satisfy the soil condition. The bid price for piling shall be lump sum and shall remain firm irrespective of the type of design.

(1) General

The Contractor shall supply, install and test at least one of the types of pile specified herein, or in accordance with the approved design and the drawing showing the piling arrangement. Each pile shall be suit existing the sub-strata at the Site. The B-R Powergen Ltd. reserves the right to order additional test piles at no extra cost if the type of pile or the sub-strata differs from the one originally driven and tested.

The Contractor shall take full responsibility for the suitability of the type of piles he proposes to use and shall guarantee that each pile will carry a test load equal to twice the working load in accordance with this specification.

The standard of workmanship shall be as laid down in CP.2004; 1972 "Foundations" or other approved standard/BNBC.

(2) Pre-cast Piles

The Contractor's arrangements for the provision of piles shall be to the approval of the B-R Powergen Ltd.. The Contractor shall submit full details of the manufacture including details of formwork, placing of concrete, vibrators, curing, handling, storage, and transport.

All concrete, reinforcement and other materials used for the manufacturing of piles shall comply with the requirements of the relevant sections of the Specification. Concrete may need to be made from sulphate resisting cement where necessary.

The reinforcement for a pile shall be fabricated to form a rigid cage. The main longitudinal reinforcement shall be in one continuous length except where otherwise approved and shall be finished level and cut square at the head of the pile, and shall bear against pile shoe. The minimum cover to the main reinforcement shall be 65mm. The spacer blocks shall be made of concrete of the same grade as that used in piles. Cast-in threaded inserts or metal tubes of an approved type shall be used to form holes in the piles where required.

Pile shoes shall be firmly fixed during concreting to prevent any displacement. The whole of the concrete in any pile shall be poured continuously. After a pile has been cast, the date of casting and reference number shall be clearly inscribed near the pile head.

The maximum variations permitted on the specified cross section dimensions shall be -3mm to +6mm. The maximum departure from alignment on the face of the pile shall not exceed +6mm over a 3-metre length and 12 mm over the total length of the pile.

Piles shall not be lifted without permission of the B-R Powergen Ltd. and such permission will not normally be given until the concrete in the pile has attained a strength of 175kg/cm^2 During lifting, adequate precautions shall be taken not to cause undue stress to the piles. Piles shall be stored on adequate supports correctly located and spaced to avoid undue bending in the piles. Due consideration shall be given to future handling, curing and withdrawal of older piles without disturbing newer piles.

All piles shall be kept continuously wet for a minimum 7 days from the date of casting, or as directed by the B-R Powergen Ltd..

No pile shall be driven until the concrete has reached the strength specified on the drawings or as otherwise described.

(3) Driving Piles

The Contractor shall submit with his tender full details of the performance, size and type of his driving plant together with information on the type of hammer and the number of rigs he proposes to employ on the works.

The driving rig shall be approved by the B-R Powergen Ltd..

Piles shall be adequately guided whilst being driven and the guides shall be held rigidly in position down to the lowest level reached by the hammer.

The maximum departure of any pile head at cut-off level from the position indicated on the drawings shall not exceed 75mm. The Maximum departure from the vertical or the correct angle of rake shall not exceed 1 in 50.

The Contractor shall provide the B-R Powergen Ltd. with three copies of the driving record for each pile, these records shall reach the B-R POWERGEN LTD.'s Representative not later than the day following the driving of the relevant pile and shall contain details of the following

(a) Location

(b) Pile details such as reference number, date of casting, length, and dimensions.

(c) Date and time of driving

(d) Type, weight and drop-of hammer or equivalent information if other type of equipment is used.

(e) Information on number and thickness of packing used during the driving of the pile and their condition after removal from the pile head.

(f) Number of blows per 300mm over the last 3 meters of penetration.

(g) Number of blows per 50 mm over the last 300 mm of penetration.

(h) Toe level of pile.

(i) Other relevant information as may be required by the B-R Powergen Ltd..

If any pile is in any way considered unsatisfactory by the B-R Powergen Ltd., he reserves the right to order the Contractor to remove the pile and/or to install replacement piles at positions selected by the B-R Powergen Ltd., all at the cost of the Contractor.

(4) In-Situ Piles

Before commencing the piling, the Contractor shall submit details of the type and number of rigs to be used for in-situ piles.

Jetting shall be permitted only with the approval of the B-R Powergen Ltd..

The spoil from the pile holes and material remaining from the cutting of piles shall be removed by the Contractor to a tip to be provided by him.

Before pouring concrete into the core, the reinforcement for each pile shall be made up to form a rigid cage and lowered into the core. Arrangements are to be made to ensure that the minimum cover to the main reinforcement is 50 mm. The main longitudinal reinforcement shall be in one continuous length except where otherwise approved and the main bars shall extend at least 1 metre above cut-off level.

The concrete for the pile cores shall comply with the concrete specification. Concrete may need to be made from sulphate resisting cement where necessary. Concreting of the core shall not commence until the B-R Powergen Ltd. has inspected.

The concrete shall be transported and placed in such a way that it is homogeneous with a high density, and care shall be taken to avoid segregation. The method of placing and compacting the concrete shall be to the complete satisfaction of the B-R Powergen Ltd.. Care shall be taken that harmful materials do not fall into the pile hole during concreting.

Curing of pile-heads expose to the atmosphere below cut-off level shall comply with the concrete Specification where practicable.

The concrete shall be finished 40 mm above cut-off level. Concrete shall not normally be placed in or through water. In particular circumstances only, the B-R Powergen Ltd. may allow the Contractor at his own expense to place concrete (using suitable mix) through water by means of a termite pipe. If the Contractor's piling system does not normally exclude water during concreting, he should allow in his tender for the use -of compressed air or other method to keep the pile hole free' from water whilst the concrete is being placed.

(5) Steel Piles

The Contractor shall take all necessary precautions to prevent damage to steel piles and fittings when handling, pitching and driving piles. Adequate bearers shall be provided under stacks of piles at positions to prevent distortion of the piles. Any piles which are permanently deformed will be rejected.

Details and jointing lengths- of piles will only be permitted with the B-R Powergen Ltd.'s approval. The type of joint and weld details shall be in accordance with the pile manufactures recommendations.

Where the completed pile will be subjected to long term corrosion adequate measures shall be taken to protect the surface of the exposed pile by casing in concrete or such other means satisfactory to the B-R Powergen Ltd..

(6) Miscellaneous Piling Systems and Subsoil Improvement Method

The Contractor can propose any system of piling or subsoil improvement method not covered by the foregoing specification and shall submit his proposal thereon to the B-R Powergen Ltd. for approval in sufficient time to allow the suitability of the system in the ground conditions prevailing on this Site to be investigated fully.

(7) Testing

The Contractor shall install at least two piles solely for testing purposes and shall submit a detailed driving record and other data as directed by the B-R Powergen Ltd. for the purpose of proving the proposed pile design. If this pile test does not satisfy the specified settlement, further piles shall be installed and tested.

The Contractor shall provide all the equipment required for carrying out load tests on piles together with the apparatus for measuring shall be to the satisfaction of the B-R Powergen Ltd..

Measurement of pile movement during testing shall be by a means capable of reading to 0.1 mm. This shall be related to a benchmark situated at a sufficient distance from the pile to ensure a permanent datum.

The loading system shall incorporate a proving ring, load cell or other apparatus capable of measuring the load to an accuracy with 2%.

(8) Test Pile Load

The test pile load shall be twice the specified working load and shall be applied in steps not exceeding 10 tons. Displacement readings shall be taken every 5 minutes after application of the load increment until two consecutive readings show that the displacement has ceased. When the test load reaches the specified working load, the displacement readings shall continue until it is established that no further displacement has occurred over a 15 minute period.

The working load shall be then maintained for a further 24 hours, displacement readings taken every 2 hours.

When no further displacement is apparent on completion of the 24 hour period or when approved by the B-R Powergen Ltd., the load shall be removed in one stage and the recovery readings taken every 15 minutes until recovery has ceased.

The pile shall then be reloaded in one stage to the specified working load, readings being taken every 15 minutes until displacement has again ceased.

The load shall be then increased in equal increments up to twice the specified working load, the same procedure being followed as stipulated for the beginning of the test. The maximum load shall be maintained for 24 hours or as directed by the B-R Powergen Ltd. after all displacement has, ceased, and readings shall be taken every 2 hours during this period.

On completion of this period or when approved by the B-R Powergen Ltd., all loads shall be removed and the displacement on recovery noted.

(9) Settlement Under Test Loads

The settlement of the pile head under test load shall not exceed -the following figures under the loads stated :

Under 120% working load, settlement of 8mm.

Under 200% working load, settlement of 25mm.

After removal of test load immediate residual settlement of 3m m for 120% working load and 15mm for 200% working load.

On completion of each pile test the Contractor shall supply the B-R Powergen Ltd. with two copies of a complete report which shall include graphs of load-settlement, load-time-settlement and recovery of the pile as the load is removed.

(10) Rejection of Piles

If any pile is in any Fay unsatisfactory to the B-R Powergen Ltd. he reserves the right to order the Contractor to install replacement piles at the locations selected by the B-R Powergen Ltd. at no extra cost.

17.4.3 FOUNDATION of Engine Generators, Engine house, Fuel Oil Tanks Transformers, Switchgears etc.

Appropriate foundations shall be provided for the Diesel Engine generating units. The Diesel Engine generating units shall be supported by the reinforced block foundation.

The Tenderer shall together with his Bid provide adequate information and data required for the design of the Diesel Engine generating units foundation.

The design drawings and calculation sheets shall be submitted to the B-R Powergen Ltd. for approval prior to commence the construction.

(1) Design load and Combination

The following loads and external forces shall be considered for structural analysis of the Diesel Engine generating unit foundations.

a. Concrete weight
b. Machine weight
C. Dynamic load (vertical direction)
d. Dynamic load (horizontal direction)
e. Short circuit force of generator
f. Seismic horizontal ground acceleration : 0.05g

In following load cases, the worst case shall be selected for the design of the Diesel Engine generating unit foundation.

Long term
a+b+c or a+b+d

- short term
a-b+e or a+b+c+f or a+b+d+f

17.4.4 FOUNDATION FOR BUILDING AND OTHER EQUIPMENT

Suitable foundations shall be provided for the elevated water tank, switchyard equipment, radiators, overhead travelling crane, buildings, transformers equipment, and miscellaneous structures.

17.4.5 HARDCORE

The Contractor shall place where required hardcore under the foundations of the equipment. The material shall be crushed rock or natural rubble stone not larger than 15 cm in size containing suitable quantities of fines to a grading and quality approved by the B-R Powergen Ltd..

17.4.6 REPLACEMENT OF UNSUITABLE MATERIAL

In a case where the in-situ soils are found unsuitable for proper construction of the foundations, such materials shall be excavated and replaced with sand or other suitable granular material to be approved by the B-R Powergen Ltd.. The Contractor shall submit materials samples, laboratory test results and the proposed method of compaction and construction to the B-R Powergen Ltd. for approval prior to commence the construction.

17.5 Deleted

17.6 CONCRETE WORKS

17.6.1 GENERAL

Standards of design, materials, and workmanship shall be in conformity with this Specification, ACI Standard or other internationally accepted Standards approved by the B-R Powergen Ltd..

For the purpose of the Contract, this Specification shall be applicable to all concrete works to be included in the civil engineering and building works.

17.6.2 COMPOSITION

The Contractor shall make trial mixes using samples of aggregates and cements typical of those to be used at least four weeks before commencing any concreting in the Works. The strength requirements for each grade of concrete proposed in the design shall be determined by the Contractor by means of trial mixes to satisfy the conditions specified in Table 17.1.

Table 17.1

Class	A	B	C
Maximum size of aggregate (mm)	20 – 40	20	20
Water-cement ratio	Less than 0.55	Less than 0.55	Less than 0.55
Maximum slump (In cm)	7 - 10	7	7
Compressive strength at 28th day (kgf/sq. cm)	240	210	160

Approximate Percentage of air content	2 ± 1	2 ± 1	2 ± 1
Fineness Modulus of fine aggregate	2.3 - 2.4	2.3-2.4	1.8
Applicable to	Foundation, Column, slab, beam, wall pile, road, pavement	Trenches, drain-channel, corner stone, ducts	Levelling

17.6.3 TESTS

In order to control the quality of concrete to be placed, samples of concrete for testing shall be taken and cubes made as and when directed by the B-R Powergen Ltd.. Tests shall be done in accordance with this Specification or equivalent Standards approved by the B-R Powergen Ltd..

a. Slump test
b. Compression test
C. Air test

For each grade of concrete, six test cylinders conforming to ACI or equivalent shall be prepared for each 30 cubic meters of concrete in each day's work. Three cylinders shall be tested on the 7th day and the remaining three on the 28th day. The slump and compression tests shall be carried out and the results shall submitted to the B-R Powergen Ltd. in written form.

The cost of preparing, storing and transporting test specimens to the place of testing and testing shall be borne by the Contractor.

17.6.4 CEMENT

All cement shall be of normal Portland cement complying with BSTI or other approved standard. When required by the B-R Powergen Ltd., the Contractor shall obtain for him the manufacturer's test certificate prior to any delivery. All cement shall be stored dry in a well-ventilated and weatherproof building. The cement shall be furnished either in bulk or in bags from the cement factory approved by the B-R Powergen Ltd..

17.6.5 ADMIXTURE

The Contractor may use water-reducing and set-retarding agents, but the use of admixture must have the prior approval of the B-R Powergen Ltd..

17.6.6 WATER

The water used for making concrete, mortar and grout shall be clean, fresh and free from injurious amounts of oil, organic-matter or any other deleterious substance.

17.6.7 AGGREGATE

The fine and coarse aggregates shall be durable, non-reactive hard materials complying with internationally accepted standards approved by the B-R Powergen Ltd.. All aggregates shall be washed prior to use in order to remove clay, silt, dust and adherent materials.

The aggregates shall be stored on drained concrete paved areas in such a manner that intermingling of different sizes and types of aggregates is prevented. The stock piles of the aggregates shall be protected from rubbish or wind blown dust.

Coarse and fine aggregates shall be well graded within the standard limits specified as follows.

17.6.8 STANDARD GRADING

a. Coarse aggregate

PERCENTAGE BY WEIGHT

Sieve size	50.8	38.1	31.7	25.4	19.1	15.9	9.52	4.72	2.38
Size of Coarse Aggregate (40-5 mm)	100	95-100	-	-	37-70	-	10-30	0-5	-
(20-5 mm)	-	-	100	95-100	-	30-70	-	0-10	0-5

b. Fine aggregate

Sieve size (mm)	Percentage passing by weight
9.52	100
4.76	90 - 100
2.38	80 100
1.19	50 90
0.595	25 65
0.297	10 35
0.149	2 20

Limits of injurious material content Maximum (percent by weight)

	Silt/Clay	Volume lost by washing test	Less than specific gravity
Coarse aggregate	0.25	1.5	1.0
Fine aggregate	1.0	7.0	1.0

17.6.9 CONCRETE MIXING

All concrete except where specifically approved by the B-R Powergen Ltd. shall be mixed in weigh batch mixing machines. The machine shall have a Water storage tank with a gauge so that a predetermined quantity of water can be injected direct into the mixer drum. If concrete is to be mixed by hand, it shall be approved by the B-R Powergen Ltd.. The Contractor shall take all precautions to protect the concrete from the effects of injurious materials.

17.6.10 PLACING

The concrete shall be placed in the positions and sequences indicated on the approved drawings immediately after mixing under the supervision of the B-R Powergen Ltd. or his representative.

Prior to placing the concrete all deleterious substance such as organic matter, standing water, flowing water, wood fragments shall be removed from the surf ace against which the concrete is to be placed. When concrete is to be placed against a construction joint or adjacent to a set surface the whole surface shall be thoroughly roughened. It shall be cleared of all loose and foreign matter and washed with water immediately before fresh concrete is placed.

The concrete shall be fully compacted throughout the layer and it shall be thoroughly worked against the formwork and round the reinforcement without displacing them Unless otherwise directed by the B-R Powergen Ltd., approved power driven vibrators of the immersion type shall be used. Vibrators shall penetrate to the full depth of the concrete layer and shall re-vibrate that layer to ensure that the successive layers are well knitted together. The placing of concrete shall not be permitted under the following conditions unless specifically approved by the B-R Powergen Ltd..

a. If it rains
b. If it is poorly illuminated during night work
C. If ordered to stop by the B-R Powergen Ltd. or his representative.

17.6.11 TRANSPORTATION

Ready mixed concrete shall be transported speedily to the point of placing by a means that shall be approved by the B-R Powergen Ltd. and which shall give little chance for segregation of materials. Generally, the transportation of ready mixed concrete shall be limited to within one hour. Concrete delivered in excess of the time limit shall be rejected. When concrete is observed to have segregated or started solidifying at the transportation of placing, it shall be rejected and replaced.

17.6.12 CURING

Concrete shall be protected during the first stage of hardening from the harmful effects of sunshine, drying winds, hot weather and rain or running water. The concrete shall generally be wet-cured for at least 7 days. The curing method for concrete shall be submitted to the B-R Powergen Ltd. for approval.

17.6.13 FORMWORK AND TIMBERING

Formwork and timbering shall be so designed and constructed that the required finishes in concrete works are achieved. Formworks shall be constructed accurately to the required shape, position and level and shall have sufficient strength to withstand the compaction pressure. The materials to be used for formwork, shall be approved by the B-R Powergen Ltd..

Forms shall be removed without damage to the concrete. The use of form oil or other release agents shall be approved by the B-R Powergen Ltd..

The removal time of formwork and timbering shall be as follows

Walls, beams, column	: 3 days
Beam soffits (props left under)	: 3 days
Slab soffits (props left under)	: 4 days

17.6.14 WATERSTOPS AND EXPANSION JOINTS

The Contractor shall place waterstops, water proofing membranes and expansion joints at locations as are necessary for the proper construction of the concrete structure. The materials to be used shall be submitted in advance to the B-R Powergen Ltd. for approval.

17.6.15 FINISH AND REPAIR OF CONCRETE

(1) General

The classes of finishes and the requirement for finishing concrete surfaces shall be as specified in this clause or as shown on the approved drawings. Surface irregularities in finishes shall be distinguished from construction tolerances, which are allowable deviations from established lines, grades and dimensions, as described herein.

Surface irregularities are designated "abrupt" and "gradual" for purposes of classifying finishes. Offsets resulting from displaced, misplaced, or mismatched forms or by loose knots in forms, or other similar forms of defects shall be considered "abrupt" irregularities and will be checked by direct measurement. All other surface irregularities shall be considered "gradual" irregularities and will be measured as a departure from the testing edge of three meter template.

Finishing of concrete surfaces shall be performed only by skilled workmen.

Concrete surfaces shall be free from imperfections such as honeycombs and cracks. The Contractor shall at his own expense repair honeycombs, cracks, and irregularities promptly as directed by the B-R Powergen Ltd..

(2) Concrete Construction Tolerances

Variations in alignment, grade and dimensions of the structures from the established alignment, grade and dimensions shown on the approved drawings shall be within the tolerances specified in the following tables. Concrete work that exceeds the tolerance limits specified herein may be required by the B-R Powergen Ltd. to be remedied or removed and replaced by the Contractor.

Construction Tolerances for Concrete

a.	-Variation from vertical:		
	In the lines & surfaces of columns, walls and towers	In 3 m	5 mm
		In 6 m	10 mm
		In 12m or more	20 mm
	For exposed columns, joint grooves and other Conspicuous lines	In 6 m max,	10 mm
		In 12 m or more	15 mm
b.	Variation from the level or from the grades indicated On the approved drawings:	In 3 m	5 mm
		In any bay or 6 m max.	15 mm
	- In floors, inverts,	In 12m or more	20 mm
c.	Variation of the linear structure lines from estabt-lished position in plan and related position of walls	In any bay or 6 m max.	20 mm
		In 12m or more	30mm
d.	Variation in locations of sleeves and sizes and locations of floor openings and wall openings		10 mm
e.	Variation in cross-section @1 dimensions or columns, beams and in the thickness of slabs and walls	minus	10 mm
		Plus	15 mm
f.	Variation in steps:		
	In a flight of stairs	Rise	3 mm
	In consecutive steps	Tread	5 mm
		Rise	2 mm
		Tread	3 mm
g.	Variation in other structure Construction Tolerance for Placing Reinforcing Steel		30 mm

a.	Variation of protective covering	50 mm cover or less	10mm
		more than 50 mm cover	15mm
	Variation from indicated spacing (any one bar)		25mm

(3) Repair of concrete

he Contractor shall repair at his own expense the imperfections of concrete surfaces and the irregularities which do not meet the allowance specified in the preceding item. Repairing works shall be performed and completed within 24 hours after the removal of forms, in accordance with the direction of the B-R Powergen Ltd..

17.6.16 REINFORCEMENT BAR

The reinforcement bars for the Diesel Engine generating units foundation blocks shall be deformed steel bars. Dimension, shapes, tensile strength, yield point and other mechanical properties of the reinforcement bars shall comply with relevant approved standards. All reinforcement must be free from oil, grease, paint, dirt, loose scale or rust at the time of concreting.

The physical properties of the reinforcement bar shall have the following values

Yield point : more than 2400 kg/cm^2

Ultimate tensile strength : more than 4000 kg/cm^2

Reinforcement bars shall be stacked of f the ground on sufficient sup-ports to prevent distortion of the bars. Prior to fabricating and placing the reinforcement, the Contractor shall prepare a bar bending schedule, and drawings for submission to the B-R Powergen Ltd. for approval. Reinforcement shall generally be bent cold by an approved means to the dimensions shown on the approved bar bending schedule and shall be rigidly fixed in the positions shown on the approved reinforcement drawings using annealed soft black iron binding wire to prevent movement during concreting. The B-R Powergen Ltd. shall have the right to select at any time samples of reinforcement bar for testing for compliance with the Specifications. The spacer blocks, prior to using, shall be submitted to the B-R Powergen Ltd. for approval.

17.6.17 PAYMENT

All costs associated with concrete work and reinforcing bar for equipment foundations, duets, roads, buildings, drainage system and all other structures shall be deemed to include in the lump sum price bid for the respective work item in the Schedule. The lump sum price bid shall not be modified or subject to any adjustment for design variations due to changes of geological and other conditions.

17.7 ROADS AND SURFACINGS

The Contractor shall furnish all designs and construct the roads, yards, paths, surfacing as necessary for the proper functioning of the power station.

The roads and yards as indicated in the Drawings or directed by the B-R Powergen Ltd. shall be generally designed with raised kerb, in compliance with the approved Standard and to satisfy the following basic design requirement

Maximum grade : 7%
Pavement width : as directed by B-R Powergen Ltd..
Turning radius : more than 10 mm.

17.7.1 CONCRETE PAVEMENT

The roads and yards shall be paved with reinforced cement concrete and shall be designed in accordance with the procedures as outlined in the AASHTO Standard or any other acceptable international standard or Design of Pavement Structures or other internationally accepted methods approved by the B-R Powergen Ltd.. Basic design conditions are as follows

Design load	:Minimum 15 ton axle weight
Minimum thickness of concrete pavement	:20cm

17.7.1.1 Sub-grade Preparation and Test

The aggregate sub-base for the concrete pavement shall be prepared by bringing the sub-grade to a firm and unyielding surface by rolling the entire area with an approved roller weighing not less than ten (10) tons. The sub-grade shall be sprinkled with water, if necessary, to attain satisfactory compaction. All soft, yielding material which will not compact readily when rolled shall be removed as directed. All holes or depressions shall be filled with suitable material and the whole surface compacted uniformly. In cut, sections, the ground below the surface of the sub-grade, shall not be plowed or disturbed, except as otherwise directed by the B-R Powergen Ltd.. When necessary, additional approved material shall be added to bring the sub-grade to the desired elevations and cross section, and the whole shall be rolled until compacted thoroughly.

The Contractor shall perform a bearing test by a method to be instructed by the B-R Powergen Ltd. on the surface of the sub-grade and he shall examine the thickness of sub-base.

The B-R Powergen Ltd. may instruct a modification to the design of pavement, if required based on test results without any claim on the B-R Powergen Ltd..

17.7.1.2 Aggregate Sub-base Materials for Concrete Pavement

Aggregate sub-base material for concrete pavement (roadways, parking areas, etc.) and roadway shoulder shall consist of hard, durable fragments of crushed gravel and stone or other similar materials, including additional selected filler for blending under the direction of the B-R Powergen Ltd.. The maximum dimension of any particle shall not be greater than two-thirds of the required thickness in which it is to be placed. Oversized material, if present, shall be removed at the quarry by screens, grizzlies, or by hand. When necessary to obtain proper uniformity, additional filler shall be blended by mixing on the roadway. The faction of the aggregate sub-base material, including any additional filler passing the No.200 sieve shall not be more than of that passing the No.40 sieve. The fraction of the material passing No.40 sieve shall have a liquid limit not greater than 25 and a plasticity index of not more than 6.

The following gradation requirements shall apply to the sub-base for concrete pavement and the thickness of sub-base shall be not less than 20 cm after it is compacted or as otherwise agreed with the B-R Powergen Ltd..

Sieve designation (Square Mesh Sieves)	Percentage by Weight Passing	
38.1 mm (1 1/2")	95	100
19.1 mm (3/4")	60	90
2.5mm (No.8)	20	50
0.074 mm(No.200)	2	10

17.7.1.3 Construction of Aggregate Sub-base for Concrete Pavement

The aggregate sub-base material shall be placed on the prepared and approved sub-grade. The deposition and spreading of the material shall bc as directed by the B-R Powergen Ltd.. It shall start at the point farthest from the point of loading, and shall progress continuously without breaks. The materials shall be deposited and spread in a uniform layer and without segregation of size, to such a loose depth of not more than 15 cm each layer, making allowance for any filler to be blended on the road, that when compacted, the layer shall have the required thickness. Spreading shall be from spreader boxes or from moving vehicles, or by placing in a windrow followed by spreading to required depth and width by means of a blade grader. After the sub-base material has been spread, it shall be bladed to a smooth surface conforming to the cross section.

The Contractor shall schedule his operations so as to assure completion of spreading within 48 hours after processing. Immediately following the final spreading and smoothing, all materials placed shall be compacted to the full width by rolling with a power roller weighing not less than 10 tons. The rolling shall start longitudinally at the sides and shall progress toward the centre, overlapping on successive trips by at lest one-half of the width of the roller unit. In confined areas the direction of rolling shall be as ordered by the B-R Powergen Ltd.. Alternate trips of the roller shall be slightly different in length. The rollers, unless directed otherwise, shall operate at a speed between 3 to 5 kilometres per hour. Rolling shall be accompanied by watering if necessary and as directed by the B-R Powergen Ltd..

17.7.1.4 Concrete Pavement

(1) Materials

(i) Cement and reinforcing steel will be furnished by the Contractor. The concrete to be used for concrete pavement shall be not less than 240kg/sq.cm in the strength at 28 days. The concrete pavement shall be 20cm in thickness or as designed.

(ii) Fine and coarse aggregates, and water shall conform to the applicable Section of the Specification.

(iii) Preformed Expansion Joint Filler B-R Powergen Ltd. - The preformed expansion joint filler for the concrete pavement shall be l9mm (3/4") in thickness, non-extruding type, shall conform to the requirements of ASTM Dl 752-67, "Specifications for Preformed Expansion Joint Fillers for Concrete Paving and Structural Construction, Non-extruding and Resilient Non-bituminous Types", Type II.

(iv) Dowel bars All dowel bars except at the expansion joints, shall be deformed steel bars and shall conform to ASTM A6 15 Grade 60.

(v) Joint Sealer Concrete joint bituminous sealer for all joints shall conform to ASTM Dl 850-67, "Specifications for Concrete Joint Sealer, Cold-Application Type".

(vi) Slab reinforcement The slab reinforcement shall be made of steel bars of

10 mm conforming to ASTM A615 Grade 60. The longitudinal and transverse spacing shall be 15cm respectively or as design each intersection shall be firmly bound by binding wires or fixed by an adequate method approved by the B-R Powergen Ltd.. It shall be embedded in the concrete at 6cm below the surface.

(2) Construction Method

(i) Formwork

The concrete pavement shall be constructed one lane at a time. The side forms for the concrete pavement shall be made of shaped steel sections which shall have sufficient strength when staked down to resist the pressure of the concrete mixer and finishing machine, or finishing tools, without springing. They shall be straight and of a depth equal to the thickness of the pavement at the edge and free from warps or bends at all times. Flexible or curved forms of proper radius shall be used for curves 30 metres radius or less. The form base shall not be less than twenty (20) centimetres wide for forms twenty (20) centimetres or more in height. Flange braces shall extend outward on the base not less than two-thirds (2/3) of the height of the form. The use of wooden side forms may be permitted.

Timber formwork shall be oiled or greased at all times to prevent warping or cracking.

When placing the forms, they must be seated firmly and in contact with the sub-base surface for their entire length, exactly on the desired line and grade.

Before the mixing of concrete, forms shall have already been set for a sufficient length well in advance of the forward end point where the concrete is to be placed, but in no case less than the length between expansion joints, except for closures which may require a shorter length. Sufficient forms shall be provided so that it will not be necessary to move those in place within twenty four (24) or more hours after the concrete has been poured. All forms shall be cleaned and oiled each time they are used. In the pouring of sections, construction joints shall be located at expansion joints. Should it be necessary to make construction joints beyond the expansion joint, such construction joints shall be made at the location of contraction joints.

(ii) Joints

(a) Longitudinal Joint: The longitudinal joint running at the centre line of the pavement shall be formed in accordance with the section and dimension shown on the approved drawings. Before concreting the next lane, the longitudinal joint shall be painted with two (2) coats of liquid asphalt applied at a temperature of 65^0 to 135^0 Fahrenheit. The asphalt should be completely dry before commencing pour to the next lane.

(b) Transverse Joints: The transverse joints consist of the expansion joints and contraction joints. The expansion joint shall in principle be formed at every 40m and the contraction joint shall be formed at an interval of every 8m between the expansion joints. In the expansion joints, 19 mm (3/4") preformed expansion moulding strip shall be placed and bituminous Dealer shall be poured after removing the strip and before opening the road to traffic.

(c) Dowels :In all longitudinal joints, 75cm long tie dowel bars of 3/4" d diameters shall be used for concrete pavements. In all contraction joints, 75cm long slip dowel bars of 3/4" diameter shall be embedded in the concrete. All dowel bars shall be placed at an interval of 75 cm. The remaining half of the dowel bars for the transverse joints shall be painted, greased, and wrapped with wax paper before concreting the next slab. The slip dowel bars in the expansion joints shall provide a cap having adequate size and type at the end of the bars.

(iii) Mixing

Hand mixing of concrete will not be permitted. Machine mixers, if used, shall have a standard mixer of an approved type with a capacity of at least 0.76cu.m. (1 cubic yard). Truck mixers, if used, shall be of the revolving drum type, water-tight, and so constructed that the concrete can be mixed to ensure uniform distribution of material throughout the mass. The procedures of concrete mixing shall be in accordance with the Specification for Concrete Work Section.

(iv) Placing

Concrete shall be placed only on aggregate sub-base that has been prepared as previously prescribed and approved by the B-R Powergen Ltd.. The concrete shall be deposited in such a manner as to require as little handling as possible, and shall immediately be distributed or spread by shovelling or by other approved methods, to such depth, and grade, that when compacted, the finished grade of the pavement will be attained correctly. Vibrators of approved type and capacity for the purpose intended shall be used to sufficiently compact the concrete.

(v) Finishing

After the concrete has been deposited, distributed and vibrated, the concrete shall be struck off and screeded by mechanical means approved by the B-R Powergen Ltd.. The finishing machine shall be of the screeding and trowelling type designed and operated both to strike off and to compact. Hand finishing may be employed in limited areas where finishing machines can not be operated. Finishing of concrete shall be done, as directed to the satisfaction of the B-R Powergen Ltd.. All finished surfaces shall be tested with a 3-meter straight edge and it shall not vary more than 1cm in 3m from the designed surface. Any variation of the surface from the desired crown or cross-section shall be properly corrected.

(vi) Removal of Formwork and Repair

All forms for concrete shall remain in place undisturbed for not less than twenty-four (24) hours after the concrete is placed, after which the forms may be removed. In the removal of formwork, care should be taken so as not to break the edges of the pavement. In case portions of the concrete are spalled, they shall be immediately repaired, at the expense of the Contractor, with fresh mortar mixed in the proportion of one (1) part cement to two (2) parts clean sand. Major honeycombed area will be considered as defective work and shall be removed and replaced at the expense of the Contractor. Any area or section removed shall not be less than 3 meters in length nor less than the full width of the lane involved.

The Contractor shall repair at his own expense all imperfections, or irregularities of the concrete pavement in accordance with the direction of the B-R Powergen Ltd..

(vii) Curing

As soon as the concrete has sufficiently set, and to prevent the marring of the surface, the pavement shall be covered with burlap or canvas, which shall be kept wet with clean water for a period of not less than twenty-four (24) hours.

After removing the burlap, the pavement shall be covered immediately with either a layer of earth or sand four (4) centimetres in thickness and shall be kept wet for a period of not less than fourteen (14) days. Ponding of the surface of the pavement may also be adopted for curing the concrete, in which case, the pavement shall be kept under water during the same length of time.

(viii) Opening to Traffic

From the start of curing, the pavement shall be closed entirely to traffic until twenty-eight (28) days have elapsed after the concrete was poured.

(ix) Cleaning and Sealing Joints

After completion of the required curing and before opening the pavement to traffic, all Joints shall be thoroughly cleaned of all concrete or aggregate fragments, earth or other foreign material. Longitudinal, expansion and contraction Joints shall be poured with bituminous sealant to the depth of 40mm from the top concrete surface. Only after the joint sealant has thoroughly hardened shall the pavement be opened to traffic.

(x) Protection of Adjacent Construction

Any adjacent construction such as concrete pavement, curb and gutter, stone masonry and handrails shall be protected by shields, covers or other means. If concrete is applied to adjacent construction either by accident or because of inadequate protection, the Contractor shall remove such material as directed and at his expense.

(xi) Maintenance

The Contractor shall be responsible for the maintenance of the surface for a period of twenty eight (28) days or until such time as the B-R Powergen Ltd. may direct, after which the work shall be accepted in writing by the B-R Powergen Ltd..
No extra compensation will be made to Contractor for any maintenance work required as specified. All costs attendant thereto shall be included in the lump sum price bid for Road and Parking Area in the Schedule.

17.7.2 Gravel Surfacing

The Contractor shall supply and place a layer of gravel not less than 10cm in areas other than the paved and lawned areas in the power station as shown on the Drawing or as directed by the B-R Powergen Ltd.. Materials for graveling shall be 3 to 7cm in size conforming to the grading requirement of the Specification.

17.7.3 Landscaping And Turfing

Areas around the power house building, administration building shall he turfed as shown on the Drawings or as directed by the B-R Powergen Ltd..

Turf shall be freshly cut approved carpet grass free from thorns and weeds. The area to be turfed shall be provided with a layer of 20cm top soil suitable for the growth of the lawn. The Contractor shall maintain and replace all dead turf at his own expense until the end of maintenance period.

The Contractor shall submit a detailed proposal on landscaping for the Site. Trees, flowers and other plants adaptable to the climate and soil conditions of the Site shall be planted in the open spaces provided adjacent to the control and administration building area and along the perimeter of the boundaries to form a green belt around the power station. A proposal which shall include a landscape drawing with a schedule showing types of trees, planting positions and other details shall be submitted to the B-R Powergen Ltd. for approval.

17.8 Drainage System

17.8.1 Design Conditions

The design of the storm water drainage system comprising the interceptor, roadside and perimeter drains for buildings, powerhouse, and switchyard shall be submitted to the B-R Powergen Ltd. for approval.

The Contractor shall carry out detailed designs of the storm water drains using the rational method or other approved procedures. The work shall be carried out in accordance with the rules and regulations of the local and other authorities.

Design conditions for drainage system shall be as follows :

Rainfall intensity	100 mm/hr
Run-off coefficient	0.6
Manning's roughness coefficient for concrete lined channel	0.013

All drains or channels shall be concrete lined. Concrete sumps, silt traps, screens and drain covers shall be incorporated in the design where it is appropriate.

17.8.2 Drain Laying

All trenches and drains are to be set out accurately to line and fall as specified. Trenching for pipes shall be excavated with sufficient width to allow adequate working space for pipe jointing. Backfilling of trenches to a height 300 mm above the top of the pipes using selected materials shall be hand packed and well rammed against the side of the pipes.

The laying of each length of drain is to be commenced at the lower end and socketed pipes shall be laid with their sockets at the higher end Each pipe is to be accurately levelled and securely held in position be fore the joint is made.

All surface water channels shall be made from concrete grade B as described in Section 17.6.

The Contractor shall keep sumps, drains, trenches and ditches free from water at all times until, in the opinion of the B-R Powergen Ltd., the concrete works has hardened.

Man-holes, inspection chambers and catch-pits shall be constructed.

17.9 Sewage Works

17.9.1 General

As there is no existing government central sewage treatment system operating in the vicinity of the Site, individual septic tanks shall be provided in the Site.

17.9.2 Sewer, Manholes And Septic Tanks

Pipes proposed for use in the sewer shall be approved by the B-R Powergen Ltd., cast iron pipes and fittings complying in all respects with B.S.78 and/or B.S.437 shall be used. Manholes or inspection chambers with covers shall be provided at every change in direction or gradient to satisfy the requirement of the Local Authority.

The sewer shall be laid accurately to the design levels and gradient. Each length of sewer shall be carefully water tested to the satisfaction of the B-R Powergen Ltd. before the concrete haunching is placed and before the trench is back filled. Septic tanks shall be constructed in accordance with the details shown on the approved drawings.

17.10 Water Reticulation System

17.10.1 Internal Water Reticulation System

The water supply system shall be designed to serve a dual purpose of providing potable water for domestic consumption, fire-fighting and plant.

17.10.2 Water Requirement

The system shall be designed to meet the project requirement as follows:

1. Plumbing

The facilities for general plumbing comprises two (2) deep wells not less than 120 m in depth with pump and G.I pipes of appropriate sizes connecting the supply to the internal plumbing facilities provided for electrical building connection with existing water supply system at a suitable point. The supply system shall be extended with sufficient number of taps to provide water for lawns.

17.10.3 Design Parameters And Standard

The water reticulation system shall be designed and installed in compliance with the requirement of the local and other authorities. The parameters and criteria to be adopted for design are:

a. Design population : 100 persons

b. Storage requirement for plumbing system :3 times the average daily demand

c. Minimum fire flow : 2.5 m3/min

d. Minimum diameter of fire-fighting main (steel):120 mm

e. Pressure in pipe : 7 bar

f. Maximum spacing of fire hydrant : 60 mm

17.10.4 Materials And Workmanship

All pipes, fittings, jointing materials and valves which are necessary for the complete installation of the system shall be supplied and installed in compliance with the approved standards and workmanship.

The Contractor shall supply all pipe, special fittings, valves, joints, jointing materials and other necessary materials for the complete installation of the system as shown on the approved drawings.

The installed system shall be tested to the satisfaction of the B-R Powergen Ltd..

17.10.5 Deep-well And Deep--well Pump

17.10.5.1 General

(1) Scope of Work

In accordance with the Specification and as shown on the bid drawings or as directed by the B-R Powergen Ltd., the scope of this work shall cover the supply, fabrication, construction, installation, erection and all the necessary materials, labour, tools and equipment for the complete and satisfactory operation of the domestic water supply system from deep-well [2X100% capacity] to storage tank. Water quality for Plant/ Fire Extinguisher shall be as per Plant/Equipment manufacturer's requirement. Water for drinking purpose shall be as per WHO's standard. Contractor shall design the reservoir/ storage tank as per requirement of the Tender.

All materials, equipment and accessories shall be new and unused, free from defects and imperfections and best suited for the purpose intended. Materials used in the manufacture and installation of all equipment to be furnished shall be of the required quality used in commercial products of reputable manufacturers. All equipment or substitute materials and equipment to be used shall conform to the latest specifications and provisions of approved Standards of the Engineering Institutes or other equivalent standards approved by the B-R Powergen Ltd..

One deep-well pump shall be installed for each well.

(2) Instruction Book

The Contractor shall submit ten (10) copies of instruction books on the operation and maintenance of equipment furnished and installed by him under this clause two (2) months before he starts on the installation work.

(3) Painting

All metal, wooden and textile surfaces of materials furnished and installed by the Contractor under this Section shall be painted in accordance with Section 18.6, except as listed below. Performance of painting work shall be as specified in the Section 18.6 of the Specifications.

a) Portions to be embedded in concrete or in the soil
b) Plated surfaces other than zinc plating
c) Concealed zinc plated portions
d) Surfaces treated with special decorative finishes
e) Surfaces where so indicated by the B-R Powergen Ltd.

Colour of paint shall be as directed by the B-R Powergen Ltd..

(4) Concrete, Plastering and Earth Work

Concrete, reinforcing, plastering and earth work to be executed under this clause shall be performed according to the applicable provisions of the relevant clauses of the Specifications.

17.10.5.2 Drilling, Developing And Testing The Deep-well

(1) General

The Contractor shall provide plant, labour, material, equipment and perform all operations in connection with the drilling, developing, placing of casings and well screens, and pumping tests for the deep-well which shall be drilled to a depth as indicated below.

(2) Drilling

Drilling of the deep-well shall be carried out by an appropriate method most suited to the conditions of the deep-well site to be drilled. When necessary, temporary casings shall be used in sections of the hole through over burden or unstable material to prevent the caving-in of the well. The location of the well drilling site shall be as shown on the bid drawings or as directed by the B-R Powergen Ltd..

(3) Well Log

A written record of the drilling information which is called a Well Log shall be kept by the drillers and shall be available for examination by the B-R Powergen Ltd. at any time during the work and a complete typewritten copy of the well log shall be submitted to the B-R Powergen Ltd. within ten (10) days after completion of the work. The well log shall show amongst other things the type of materials

encountered, colour of the return water, depth at which circulation as lost, manner of drilling, length of casings installed, and other pertinent drilling data.

(4) Well Completion and Development

The Contractor shall undertake all operations pertaining to the completion and development of the well which shall consist of the installation of casings, installing well screen within a sand and gravel formation, developing the water-bearing formation, grout filling of the upper section of the well casing (from collar to at least 6m deep), surging and back-washing.
The well casings to be installed shall be carbon steel, ASTM A-53, seamless, Grade B or equivalent. Openings of the well screens shall be so designated to prevent clogging and shall be free from jagged edges and irregularities so as to avoid clogging and corrosion.

(5) Pumping Test for Yield and Draw-down

Pumping tests shall be performed to determine the deep-well capacity and other hydraulic characteristics of the water-bearing strata.

The Contractor shall furnish and operate a pump for this purpose that is capable of continuous operation at a sustained delivery of 380 lit/mm or more in a duration of at least five (5) hours of pumping test operation. Measurements of the volume of water pumped per minute, the depth of static water level before pumping started, the depth of the pumping level at one or more constant rates of pumpage, the rate of recovery of the water level after pumping test stopped and the length of pumping time of each pumping rate shall be made by the Contractor in the presence of the B-R Powergen Ltd. & Engineer. The Contractor shall construct any other structures necessary to conduct water away from the deep-well.

For a comprehensive test of the well, the pump shall be operated continuously at about 1/3 of its capacity until pumping level is attained. After making the necessary measurements, the pump rate is adjusted to about 2/3 of the pump capacity and measurements are repeated when the pumping level becomes constant. By increasing the rate of pumpage to produce maximum draw-down; or increasing it to the full capacity of the pump and making measurements a third time when the pumping level becomes stable.

All the necessary equipment the measuring devices for testing the deep-well shall be calibrated and provided by the Contractor at his own expense.

After developing and testing operations are completed to the satisfaction of the B-R Powergen Ltd., the Contractor shall measure the depth of the well and record the total open depth of the casing. Sterilisation of the well is done by pouring a solution of 450 grams of high test Calcium Hypochlorite (HTH) in 45 litters of water.

Upon completion of the drilling, the Contractor shall submit to the B-R Powergen Ltd. the complete well-draw-down test results for check and determination of the actual head and setting of the deep well pump.

(6) Data to be Submitted with Bids

A complete list and description of equipment, plant and tools for executing the work in accordance with these Specifications and their location at the time of opening of bids in order that they may be inspected by the B-R Powergen Ltd..

17.10.5.3 Deep-well Pump

(1) General

The Contractor shall furnish, deliver, install and test a motor-driven pumps (2X100 % capacity) complete with accessories and housing at the top of the well in accordance with these Specification.

(2) Type and Description

The deep-well pump shall be a submersible type with a cast iron body, bronze impeller, high-grade steel discharge column and stainless steel shaft. The discharge pipe column and drive shaft of ample size shall be supplied with interchangeable sections of not greater than 3.0 m in length.

This pump shall be operated in conjunction with the float switch to be installed in both the elevated water tank and fire fighting storage tank.

All water passages of the pump shall be smooth and long term corrosion-resistance of dependable operation.

(3) Rated Capacity

The deep-well pump shall be rated to a discharge capacity of approximately, 600 lit/m against a total dynamic head of the system as determined. The total head of each pump may vary and it is required that the pump be capable of satisfactory operation within fluctuations of head.

The pump shall be guaranteed to circulate not less than the specified quantity of water when pumping and without producing excessive vibration and noise. The efficiency of the unit shall be as high as good engineering practice will permit.

(4) Electrical Works

a) Pump Motor

The motor shall be submersible type, full voltage starting and with torque-locked rotor current and slip characteristics conforming to standard equivalent to those of the IEC Standard.

It shall be of the continuous duty type for operation on 415 volt, 3-phase, 50-flz. Motors shall be capable of operating continuously at rated output plus or minus

5% of the rated frequency and at any voltage within plus or minus 10% of the rated value.

b) Control Equipment

The control equipment shall be of the float-switch actuated control type installed in the water storage tanks and shall be of suitable switch for draw-down in the deep-well. One of the two deep-well pumps shall start operation alternately when the water level in the water storage tank goes down to the designated level.

When the water level of the deep-well goes down to the designated level, the deep-well pump shall be stopped immediately, and the other deep-well pump shall be started automatically. Breakdown of deep-well pumps shall be connected to an alarmed on the control board in the control room.

c) Control Board

The control board shall be installed in the fire pump-house.

A boxed knife switch shall be provided in the fire pump-house for each pump.

d) Signal Indicators

i) All indicator lights shall be of AC type with coloured glass or plastic lens and shall be so constructed that the lamp can be readily fitted and removed and the lens changed from the front of the boards.

ii) Ammeters shall be capable of accepting the starting current characteristics of the corresponding motor and shall be suitably calibrated to indicate the full load running current at three quarter full scale deflection.

e) Conduit Piping and Wiring

Conduit piping and wiring for the work shall comply with the applicable provisions of the Specification.

(5) Installation

The Contractor shall construct a concrete base foundation for accurate mounting of the pumping unit and shall provide foundation bolts for anchoring the pump, which shall be carefully levelled and grouted in place.

The pumping unit and control equipment shall be housed for all weather protection.

(6) Accessories

The following accessories shall be equipped for each pump:

Sluice valve	: 1 Pc
Check valve	: 1 Pc
Air release valve	: 1 Pc
Pressure gauge with cock	: 1 Pc

Water pipe	: Required Length
Well cover	: 1 Pc
Submersible cable	: Required Length
Flanges	: 1 Set
Foundation bolts	: 1 Set
Other necessary accessories	

(7) Data to be submitted with Bids

Complete specifications of the supply including the physical dimensions and materials used for the principal parts of the supply.

Pump discharge capacities, efficiencies, horsepower input and performance characteristic curves at various heads on pump settings.

Guaranteed brochures, catalogues and other related technical data concerning the operation of the supply.

(8) Piping

Materials and Performance of piping for the work shall be in accordance with the applicable provisions of the Specification.

17.11 Ducts

The concrete ducts to install cables and pipes shall be provided. The ducts shall be covered with concrete or steel checkered plate, both having enough strength, and shall be provided with the, necessary number of racks for cable and pipes. The thickness of the concrete ducts shall be not less than 18cm, width and depth of ducts shall be more than 40 cm respectively and an appropriate drainage system shall be designed within the duct.

The Contractor shall submit design drawing to the B-R Powergen Ltd. for approval.

17.12 FENCING AND GATES, FLAG POLES AND SITE BOUNDARY WALL

17.12.1 Fencing

Chain link fencing shall be installed as directed by the B-R Powergen Ltd.. The chain link fencing shall be 2.4 m high with 3 strands of barbed wire at the top, generally complying with B.S. 1722 or other approved Standards.

Posts and struts shall be fabricated from 100 mm x 100 mm x 6.5 mm thick angles and set in concrete. The struts shall be fitted to all end and corner posts at changes in direction or acute variations in levels and at intervals not exceeding 9 meters in straight lengths of fence. All posts shall be hot dip galvanised.
Prior to the supply and installation, the Contractor shall submit samples of fencing materials, structures and colour to be adopted to the B-R Powergen Ltd. for approval.

17.12.2 Gates

Sliding metal gates of 2.4 meter high and pedestrian swing gates of 2.0 meter height shall be constructed at suitable locations as directed by the B-R Powergen Ltd..

Decorative brick walls to be incorporated in the work next to the pedestrian gate at the power station shall have the following dimensions:

Height :	2.4 metres
Length :	5.0 metres
Thickness:	0.25 metre

The Contractor shall submit design drawings showing details of the gates for approval of the B-R Powergen Ltd..

17.12.3 Flag Poles

Three (3) flag poles shall be erected at locations as directed by the B-R Powergen Ltd..

The poles shall be of tapered steel pipe, about 15 m in height with a diameter of 20 cm at the bottom. The pole shall be firmly held to a concrete foundation.
It shall be equipped with a brass pulley near the top and nylon rope for hoisting the flag.

The pole shall be painted in accordance with the specification for painting to the satisfaction of the B-R Powergen Ltd..

17.12.4 Site Boundary Wall

The site boundary wall shall be installed around the power station as directed by the B-R Powergen Ltd.. The site boundary wall shall be of brick wall with RCC frame in accordance with KPI Standard and 2.40 m high and 0.25 m thickness.

Section 18

Building Works

18 Building WORKS

18. Building Works

18.1 General

The General Conditions, Tender Drawings, relevant Specifications On materials and workmanship described elsewhere in this Documents, Schedules shall be read in conjunction with this Specification.

18.1.1 Contractor's Responsibilities

This is a turnkey contract which includes all building works and services. The Tender shall cover all requirements of the Tender Documents and any other items not specifically mentioned but which are deemed to be necessary for the complete execution of the Works to the entire satisfaction of the B-R Powergen Ltd.. No additional cost will be considered for any item which the Contractor has over looked but are essential for the full completion of the Project in every respect.

The Tender shall include the building works proposal complete with out-line drawings indicating any variation or improvement which he deems technically or financially justified for the works mentioned in the Tender Document, schedule of materials and finishes on which the tender has been based. The Building shall generally conform to the sizes shown below & as per approval of the B-R Powergen Ltd..

The Contractor shall be responsible for all performance in the detailed design, supply of material, labour, plants and equipment, construction and relevant works incidental to the completion of the Building Works.

The Contractor shall perform the Works thoroughly in accordance with the agreed construction schedule and direction to be made by the B-R Powergen Ltd. during the Contract Period.

18.1.2 Building Sub-Contractor

The Contractor may employ a building subcontractor for building works. If the Contractor intends to subcontract the building works design and/or construction, his tender shall include full details of comparable works carried out elsewhere by the subcontractor, together with details of the financial stability and general efficiency of the proposed subcontractor.

18.1.3 Construction Schedule

A preliminary building construction schedule showing the completion time for the building works shall be submitted by the Tenderer based on the overall project implementation schedule. The Contractor shall prepare and submit to the B-R Powergen Ltd. for approval a detailed construction schedule for the building works developed from the preliminary building construction schedule before commencement of the Work on the Site. The approved construction schedule shall not be altered without the written consent of the B-R Powergen Ltd..

18.1.4 Records

The Contractor shall keep accurate and up-to-date records and drawings of the Works at the Site and shall provide the B-R Powergen Ltd. with copies of these records. The Contractor shall submit to the B-R Powergen Ltd. weekly reports of labour, plant and materials employed on the Site.

18.1.5 Samples Testing And Inspection

The Contractor shall perform testing and inspection of materials and shall submit sample materials, test certificates and workmanship details to the B-R Powergen Ltd. for approval. The costs of all samples and testing shall be borne by the Contractor.

18.1.6 Temporary Services

The Contractor shall be responsible for arranging the provision of electricity, water, drainage, etc. necessary for the proper execution of the Works. All costs for these services shall be borne by the Contractor.

18.2 Scope Of The Works

The building works shall include collection of the Site information, detailed design, production of working drawings, provision of labour, plant and materials, tests/inspection, construction and remedy of defects during the Warranty Period. The Building shall generally conform to the sizes as mentioned below.

a) Control building, Engine house, Fire Fighting pump house, Emergency Diesel Generator house, Guard house, water supply house, fencing, boundary wall, road etc. shall be constructed by the Contractor within the Site area.

b) Dimensions and number of rooms of the Buildings mentioned shall be to the standard practice based on the size and number of Equipment and acceptable to B-R Powergen Ltd..
However, dimension of 1) control building [two storied, 10 (ten) air-conditioned rooms including control room, battery room, auxiliary room] shall not be less than 13 Metres $\times$ 24 Metres;

18.3 Design Of The Works

18.3.1 Designs And Drawings

The Contractor shall design in accordance with this Specification and prepare complete working drawings as necessary for the construction of the Works. All drawings shall be submitted for the approval of the B-R Powergen Ltd..

18.3.2 Standards And Codes Of Practice And Other Design Conditions

Design and construction of building works shall conform to recognise authoritative intentional or national standards and codes of practice [BNBC]. The adopted standards or codes shall be consistent throughout any section of the works unless otherwise specified. The Contractor shall have full responsibility to investigate the

existence of any decrees and local bylaws governing the proposed works and to fully comply with such requirements which are effective when the date of tender submission.

As described elsewhere in the documents the Contractor shall indicate in his tender standards and codes to be conformed in design and construction of the Works. Copies of these codes and standards shall be made available to the B-R Powergen Ltd. during the design and construction period.

a. Basic design conditions for buildings are outlined as follows:-

Design wind speed	: 100 miles/hr.
Seismic horizontal ground acceleration	: 0.05g
- Ditto - (vertical)	: Nil

b. Live load of each floor shall be more than as follows : -

Auxiliary room	: 500 kg/sq.m
Cable spreading room	: ditto

18.3.3.1 Submission Of Designs And Drawings

The Contractor shall be required to produce full design calculations for the foundations, building structures, and detailed working drawings and reinforcement bar bending schedule etc. Design calculations shall be prepared in accordance with an approved method of computation based on the most unfavourable combination of dead load, live load or crane load and wind load. The Contractor shall be responsible for the detailed design, strength and safety of the structures, and ensuring that the design satisfies the requirements of all authorised local and international bodies.

Design calculations and detailed drawings shall be submitted to the B-R Powergen Ltd. for approval in accordance with the requirement set out in Section 18.3.1 of the Tender Documents. Construction on the Site shall only commence after drawings are finally approved.

Notwithstanding the B-R Powergen Ltd.'s approval, the Contractor shall be held responsible for the accuracy of his submitted information, designs and drawings.

18. 4Building And Services

18.4.1 Control Room Building

Construction Control Room Building

(1) Main construction materials

Frame	: Reinforced concrete

Roof	: Reinforced concrete roof with lime concrete water proofing.
Exterior wall	: Reinforced concrete and/or brick.
Partition wall	: Brick
Floor	: Concrete with plastic tile, ordinary tile, trowelled mortar finish, etc
Foundation	: The Contractor shall examine subsoil condition for design of foundation. Proper foundation shall be designed by the Contractor in accordance with the Specifications

(2) Windows:

Aluminium sash shall be provided. Window area shall be generally more than 1/10 of the room floor area unless otherwise indicated. All windows except toilet, store, and cable spread mg room windows shall be fitted with sun blinds of approved made.

(3) Machines and utilities:

Air conditioning system, ventilation system, water supply system, power supply system, drainage system, sanitary system and lighting system shall be provided.

(4) Finishes and room sizes:

The Contractor may submit the layout to suit any particular requirement subject to the approval of the B-R Powergen Ltd..

(5) Other Requirement:

a. Control room	: Noise level shall be kept to a value less than 45 db(A).
b. Toilets	: Toilets shall be provided with sanitary fittings as follows:

	Water closet	Urinal	Washbasin with hot and cold water and mirror
Ground floor	2	2	1
First floor	1	1	1

c. Ventilation and air conditioning

All rooms shall be provided proper ventilation system. The control room, relay room, electronics spares store, shall be provided air conditioning system.

18.4.3 AIR CONDITIONING SYSTEM

The detail design of air conditioning system for control building shall be based on the following criteria :

Outside temperature	: 36 ^{0}C
Inside temperature	: 20 ^{0}C
Relative humidity	: 60%
Type of system	: Package air conditioning units

Design calculations and drawings shall be submitted to the B-R Powergen Ltd. for approval prior to commencement of the work.

Details of the equipment proposed shall be submitted with the Tender.

18.4.4 Ventilation System

All rooms in the control building, guard house etc. shall be designed and furnished proper ventilation system in principle.

Unless otherwise specified, natural ventilation will be acceptable for the minor buildings. All toilets, battery room and shall have exhaust fans of approved made.

All fans shall be statically and dynamically balanced to avoid vibration and shall have blades to secure quiet efficient operation.

18.4.5 Plumbing And Sanitary Installation

The whole of the plumbing works in the buildings shall be provided in accordance with the relevant bylaws and to the complete satisfaction of the B-R Powergen Ltd.. Pipes shall be connected to each point where water is required, with a minimum head of 2 metres at all outlets.

All cast iron pipe works and fittings as are necessary for the complete installation of the sanitary system shall be supplied and installed in accordance with the requirement of the local authorities and other standards approved by the B-R Powergen Ltd..

18.4.6 Lighting

The whole of the power supply and lighting system for the buildings shall be designed and installed in accordance with the Section 11.

18.5 Materials And Workmanship

18.5.1 Structural Steel

(1) General

Structural steel, bolts and nuts shall comply with the requirement of an approved standard and this Specification in all respects and those shall be fabricated from hot rolled sections unless other wise specified or agreed in writing by the B-R Powergen Ltd..

(2) Materials

The materials to be used shall be free from harmful defects and rust. Samples of materials shall be tested, and copies of the test reports giving physical and chemical properties shall be submitted to the B-R Powergen Ltd. for approval. The Contractor shall carry out all necessary tests, at his own expenses, to prove that the materials offered for the intended purpose are in compliance with the approved Standard.

In lieu of these tests, mill sheets issued by the authorised manufacturers will be acceptable. The characteristic strength of the structural steel shall have the following values regardless of the standard and code used: -

a. Yield Point : not less than 2400 kg/sq.cm
b. Tensile Strength : not less than 4100 kg/sq.cm
c. Elongation : not less than 20%

(3) Bolt and Shear Connector

High strength bolts, anchor b6lts, ordinary bolts and shear connectors to be supplied for the erection of structures shall conform to the Standard approved by the B-R Powergen Ltd. and shall be of an approved manufacturer. Specially devised high strength bolts, if used, shall tightened in accordance with the manufacturer's instructions. Any bolt that has been fully, tightened and then un-tightened shall not he used in the permanent Works.

(4) Fabrication

Fabrication and erection drawings shall be submitted to the B-R Powergen Ltd. for approval prior to commencement of any fabrication and erection work. Steelwork shall be fabricated to the required details in a manner approved by the B-R Powergen Ltd.. The Contractor shall provide adequate facilities for the B-R Powergen Ltd. to inspect materials and fabrication works in the shop and at the Site when required.

(5) Welding

Welding of structural steel shall be performed to the required type and size by an electric arc process by qualified welders under approved conditions. The plant, equipment and the adopted testing and inspection method shall conform generally with the relevant approved standard and other details in this Specification and shall all be to the satisfaction of the B-R Powergen Ltd..

Welding shall not be performed when the ambient temperature is less than 0 deg C; when surf aces are wet or exposed to rain, or strong wind; or when welders are exposed to inclement weather conditions.

Surfaces to be welded shall be free from loose or thick scale, slag, rust, moisture, grease and other foreign material that will prevent proper welding or produce objectionable fumes. Welding shall be principally carried out in workshops. Where necessary the B-R Powergen Ltd. may approve site welding, subject to the satisfactory provision of effective protection and safeguards for welding works by the Contractor.

(6) Welding Procedure

Details of the proposed welding procedure, manufacturer, classification on, code type and size of electrodes to be used shall be submitted to the B-R Powergen Ltd. for approval. When necessary, welding tests shall include specimen weld details representative of the actual construction which shall be welded in a manner simulating to most unfavourable conditions liable to occur in the particular application. All costs of the tests shall be borne by the Contractor. All welds shall be finished full and made with correct number of runs. Slag and other inclusions shall be cleaned from all welds.
Notwithstanding the approval of welding schedule and procedure by the B-R Powergen Ltd., the Contractor shall bear full responsibility for correct welding and for minimising the distortion in the finished structure.

a. Preparation of Base Metal

Surface and edges to be welded shall be smooth, uniform, and free from fins, tears, cracks, and other discontinuities, which will adversely affect the quality or strength of the weld. In the preparation of the fusion faces, shearing shall be limited to metal thickness not greater than 8 mm. All fusion faces shall be pre-pared by machining shall be limited to metal shall be prepared by machining or flame cutting, or where approved, by special oxygen cutting apparatus. Fusion faces, angle of level, root radius, and the like shall be properly prepared to give the approved weld forms. The parts to be jointed by fillet welds shall be brought in-to contact as close as practicable. The gap between parts shall normally not exceed 4.8 mm (3/16 in.). A butting parts to be joined by butt welds shall be carefully aligned and the correct gap and alignment maintained during the welding operation.

b. Butt Welded Joint

Ends of the welds shall have full throat thickness by means of runoff tab. Additional metal remaining after the removal of the tab shall be removed by machining, or by other approved means. Ends and surfaces of the welds shall be smoothly finished. All main butt welds shall have complete penetration and, except on tubes or partial penetration Joint, shall be welded from both sides. The back of the first run shall be suitably gouged out.

c. Intermittent Welds

Intermittent welds shall not be permitted without the approval of the B-R Powergen Ltd..

(7) Paint

Prior to delivery after shop inspection, the whole of the steelwork shall be prepared for painting by an approved blast cleaning method.

All rust, grease, mill scale and harmful matter shall be removed. The surface shall be blast cleaned to:-

a. Swedish Standard Sa 2 1/2 SIS OS 5900 1967

b. British Standard 4232 Second Quality

U.S.A. Standard commercial blast finishSSPC-SP-6-63

The first coat of primer of recommended by the manufacturer as suitable for use under the prevailing condition at the application site shall be applied immediately after blast cleaning (or within two hours).

No paint shall be applied to the surfaces to be embedded in concrete, to contact surfaces for joints using high strength friction bolts and to surfaces within 50 mm either side of joints to be welded.

Painting shall be carried out in a clean, dry building where air temperature shall not be allowed to drop below 5 deg.C. No paint shall be applied on the steelwork with condensation. Painting shall not be carried out when the relative humidity is over 90%, or if in the open, during rain, fog or mist. The welded areas and the edges of site joints shall be cleaned down, primed and painted' all in accordance with the standards specified, after erection.

Each coat of the paint will be applied in different colour. When paintwork is damages it shall be cleaned and re-painted following the procedures as approved by the B-R Powergen Ltd.. The manufacturer's instructions regarding inter-coat intervals shall be strictly observed.

(8) Transportation and Storage of Steelwork

The whole of the steelwork shall be handled in such a manner that the shape and surfaces of the section shall not be damaged during lifting and transportation. The Contractor shall take all necessary measures, to ensure that steelwork members shall be handled, stored and erected without their being subject to stresses in excess of those for which they were designed. Chains and hooks will not be used in contact with the steel work and lifting slings shall be of nylon rope. Steel work shall be stored in clean, dry conditions off the ground. Separate pieces of steelwork shall have spacer blocks between them.

(9) Erection

The Contractor shall ensure the correctness of alignment, plumbing and stability of the various frames and members. He shall also take all necessary measures, by adequate resistance to wind and stability against collapse, during construction.

No permanent bolting and site welding shall be carried out until proper alignment has been obtained.

18.5.2 Concrete

The specifications for concrete works under Section 17 are applicable to building works.

18.5.3 Grouting Of Structural Steelwork

(1) Materials for Grouting

The aggregate for grouting shall consist of hard siliceous sand, and grained chips, gravel or crushed stone, or other approved inert materials with similar characteristics. The materials shall be clean, free from lumps, soft or flaky particles, shale, crusher dust, silt, alkali, loam, organic matter or other deleterious substances. The aggregate shall be of uniform grading and shall be of such a size that 100% will pass through a 10 mm mesh and not more than 10% will pass through a 120 micron mesh. A pre-mixed non-shrink resin grout may he used. The manufacturer's instructions on mixing and the placing of the grout shall be observed.

(2) Admixtures

An admixture which acts as a non-shrinking agent shall be added to the grout only with the B-R Powergen Ltd.'s approval. All proprietary admixtures shall be added and mixed strictly in accordance with the manufacturer's instructions.

(3) Surface Treatment

Concrete surface which is to be grouted shall be thoroughly cleaned and all laitance removed from the surface by means of a hammer and chisel. A power hammer shall not be used.

(4) Mixing

The Contractor shall submit to the B-R Powergen Ltd. for approval details of the mix and the methods he intends to use, prior to the commencement of the grouting.

(5) Placing

For cement based grouts the concrete surface to be grouted shall be thoroughly saturated with water at least two times before the commencement of grouting.

18.5.4 Roofing And Brickwork

(1) Roofing

Roofing material for administration building shall be of corrugated galvanised iron sheet. The Contractor shall submit samples and technical details of the roofing material for approval of the B-R Powergen Ltd..

An insulation layer of glass fibre or rock wool board of minimum 25 mm thick shall

be incorporated in the roofing system. The thermal conductance of the composite roof cladding shall be less than 1.10 kcal/sq.m hr-deg C at 25^0C.

All accessories and the method of fixing shall be strictly in accord-dance with the manufacturer's instructions and to the satisfaction of the B-R Powergen Ltd..

(2) Waterproofing

Waterproofing for reinforced concrete flat roofs shall be of lime concrete. The minimum thickness of lime concrete shall be 10 cm.

(3) Eaves Gutters and Down Pipes

Eaves gutters shall be of PVC or galvanised steel sheet coated with bitumastic painting to be approved by the B-R Powergen Ltd.. Where large section is required, steel sheet is preferable for strength. Down pipes shall be of PVC pipe, galvanised steel pipe or cast iron pipe to be approved by the B-R Powergen Ltd..

(4) Brick Walls -

Bricks to be used for walls shall be Bangladesh made. Unless otherwise specified or as shown in drawing, the thickness of brick-wall shall be more than 15 cm.

Mortar for use with brickwork shall be mixed in the proportions of 1:3 cement, sand or 1:2:5 cement, lime and sand by volume. Mortar may be mixed by hand or machine. Hand mixing shall be carried out on a clean, watertight platform. Cement shall be of a quality as described in the Section 17 for concrete. Sand shall be well-graded (2.5 mm down) hard and free from deleterious substances. Lime for mortar shall be pure calcium carbonate properly burned, then hydrated, and finely ground. All joints shall be completely filled with mortar. The thickness of the horizontal mortar Joints shall not exceed 40 mm to every four joints. The mortar shall be used within 2 hours of mixing with water and any mortar not used then shall be discarded.

All brick-walls are to be reinforced with approved reinforcing material at every fourth course.

The damp proof course shall be provided at joint and intersections laid on a bed of cement sand (1:1), bedded in and coated on the upper surface with liquid bitumen.

External fair faced wall shall be weather struck; faces or wall which are to be plastered or rendered shall have their joints raked out to form key.

(5) Calking

The Contractor shall calk the joints to ensure water tightness of the building structures. Prior to calking materials and working method shall be approved by the B-R Powergen Ltd.

18.5.5 Carpentry And Joinery

(1) Timber

All timber shall be of best quality, perfectly dry and well seasoned, sawn die square, free from sap, shakes, wanly edges, large loose or dead knots and all other defects and shall be to the approval of the B-R Powergen Ltd..

(2) Preservative

Timber to be used in shower rooms or in contact with the ground floor, shall be treated with an approved preservative against rot or termite attack. The backs or frames to be fixed to walls and all other bedding surfaces shall be painted with two coats of preservative before fixing. All fixing blocks, pallets, and other hidden timber shall be so treated prior to fixing.

(3) Joinery Fittings

All timber for Joinery fitting shall be of selected type properly seasoned and dry to a agreed moisture content not exceeding 18%. The B-R Powergen Ltd. shall have the right to check all timbering used and to reject any timber found to have a moisture content exceeding 18%.

Joinery fittings and built-in cabinet are to be constructed exactly as shown on the approved drawings.

All work must be carried out by experienced cabinetmakers in a sound and workmanlike manner with properly fabricated joints, dovetailed, mitred or mortised and with concealed pins and screws. All joints shall be glued before pinning or screwing.

(4) Faults

Any defect in the wood works such as shrinks splits, fractures, etc shall be removed and replaced to the satisfaction of the B-R Powergen Ltd..

18.5.6 Doors And Windows

Prior to furnishing and installing, the Contractor shall submit the shop drawings indicating shape, dimensions, material including hard wares and locking method of doors and windows for all buildings for the approval of the B-R Powergen Ltd..

The standard requirements of doors and windows are as follows :

a. Steel doors

Frame and Stile Plates	: more than 2.3 mm thick
Stile and Panel	: more than l.6mmthick
Thickness	: 80 mm
Size	: double door 2.0 x 2.0 m single door 1.0 x 2.0 m or other sizes as shown on the

approved drawing

b. Wooden doors

Plywood for panel : more than 5 mm thick

Thickness : 40 mm

Size : 0.9x2.0 m or other sized as shown on the approved drawing

Hollow flush door shall be painted 2 coats of rust resistant paint and finish coat. Hollow flush door shall be of the waterproof type.

c. Aluminium window : 70mm

Thickness : Alumite

Finishing : double window 0.9 x 1.8 m e

Size single window 0.9 x 0.9 m or other sizes as per approved drawing

Glass (tinted) : 6mm

d Aluminium swing doors

Frame and stile plate : More than 2.3 mm thick

Thickness : More than 45 mm

Size : As directed by the B-R Powergen Ltd..

All other type of doors, windows, which are not specifically mentioned, shall be provided to the satisfaction of the B-R Powergen Ltd..

18.5.7 Glazing Works

(1) Materials

Sheet glass shall be of good quality, free flow unevenness and strain of bubbles. All the glass used on the ground floor shall be tinted glass (salon-radiation absorbing glass), and all the glass used on the first floor shall be clear glass. Where so required figured glass shall be used. Minimum thickness of tinted glass and clear glass shall be 6 mm. Glazing beads, sealant, putty, clips and setting block shall be of good quality and those recommended by the glass manufacturer. All the glass used in the following rooms shall be tinted wire glass.

Auxiliary room and cable spreading room Warehouse and workshops Stores

(2) All glass shall be installed tightly in accordance with the instructions of the glass manufacturer.

Upon completion of the works, glass shall be wiped clean and shall be inspected by the B-R Powergen Ltd..

18.5.8 Metal Works

(1) General

The metal works will include handrails, drain pipes, steel ladders, step ladders, cable duct hatch cover plate, removable hatch cover plate, rain water leader, air duct, louver and others. Prior to fabrication work drawings and quality of materials shall be submitted to the B-R Powergen Ltd. for approval.

(2) Materials

The materials to be used in the Works shall be free from defects and conform to JIS Standard or relevant Standards approved by the B-R Powergen Ltd..

(3) Workmanship

All plates and sections shall be true to form, free from twist and straightened before any fabrication work is started on them. The works of cutting, fabrication, welding, installation and painting shall be done in accordance with this Specification and relevant Standard. If difference quality metals are in contact with each other, these contact surfaces shall be separated by means of bituminous paint, felt strip, rubber sheet and other material to be approved by the B-R Powergen Ltd..

18.5.9 Floor-laying

(1) PVC Flooring

PVC flooring shall be heat resisting vinyl tiles obtained from an approved manufacturer. The tiles shall be not less than 2.4 mm thick and laid by an specialist to a jointing layout approved by the B-R Powergen Ltd.. A matching PVC cove-type skirting is to be used in conjunction with the floor tiles. The tiles and skirting shall be laid on a flat, clean concrete floor, in strict accordance with the manufacturers instructions, using the recommended adhesive.

(2) Unglazed Vitreous Ceramic Tiles

The tiles shall be plain and of manufacture and colour approved by the B-R Powergen Ltd.. The tiles shall be laid by experienced craftsman, on a concrete slab accurately formed with a true, smooth surf ace. Joints shall be accurately aligned in both directions and matching covered skirtings. Expansion Joints shall be the same width as tile Joints, approximately 5 mm, and filled with approved filling material. The surface of the base shall be cleaned of all dirt, grease, grit, etc. and the tiles shall be dry and clean.

(3) In-situ Terrazzo

In-situ terrazzo paving is to consist of2 1/2 parts 6.5 mm 9.5 mm approved marble chippings, clean and free from dust, mixed with one part of "concrete" or "snowcrete" or approved equivalent according to the background required. The terrazzo shall be laid by a specialist.

The terrazzo is to be trowelled to a dense even surface, rubbed down and polished to approval. Where surface are required to be left rough finish the finishing coat shall be brushed with wire brush while still green to expose the aggregates.

Brass dividing strips 25 mm x 3.2 mm shall be provided at junctions of different floor finishes, finishing flush with flooring non-slip nosing tiles of approved manufacture and colour shall be provided in finishing works for steps and stair.

(4) Damp-Proof Membrane

An approved bitumen/PVC water-proof membrane shall be placed on the blinding concrete under concrete slabs, to exclude rising moisture.

18.5.10 Wall And Ceiling Finishes

(1) Materials

Cement, sand, hydrated lime, gypsum plaster, expanded metal lathing, flat headed galvanised nails, galvanised staples and wire shall all comply with approved standards. Materials shall be carefully store in a dry weatherproof store until required for use.

(2) Preparation of Backgrounds

Backgrounds for plaster work shall be carefully brushed out and removed dust and other deleterious matter likely to impair the bond of the under coat with the structure. When the background surface is dry and undue suction occurs, this shall be sprinkled with water to, prevent drying the applied plaster.

(3) Plasterwork

Undercoat shall consist of Portland Cement, hydrated lime and sand gauged in the proportions 1:1:6. The undercoat shall be keyed to take the finishing coat and allowed to dry out completely before the latter is applied.

Finishing coats shall be applied in accordance with the recommendations of the manufacturer of the particular brand to be used. The total thickness of the two coats shall not be less than 15 mm thick.

(4) External Rendering

External rendering shall be applied in two coats, with an approved waterproof agent added to the mixes. The walls shall be wetted before the application of the first coat, which shall be finished flat and vertical by straight edge, and scored to form a key. The second coat shall not be applied until the first coat has dried out completely. Immediately before application of the second coat, the surface of the first coat shall be wetted, and the second coat shall be applied by machine, to give a "Tyrolean" finish of uniform thickness and texture.

An approved plasticizer may be used in both coats. All external rendering shall be protected from rain and direct sunlight for period of 7 days.

(5) Glazed Ceramic Tiling

Glazed ceramic wall tiles shall be of nominal size 100 mm x 100 mm x 5 mm, colour to be selected. Fittings shall be obtained from a supplier approved by the B-R Powergen Ltd.. The ceramic tile fixing and grouting materials shall be obtained from the same source.

The Contractor shall ensure that the rendering is accurately formed and has a true plumb surface which is free from all high spots and depressions.

The rendered backing for tiling shall be cleaned and will be wetted (just enough to prevent it from absorbing water from the fixing bed) immediately prior to tiling. All tiles shall be dipped in water to ensure that they are completely clean prior to fixing. All tiles shall be immersed in water in clean containers for at least half an hour before use. Tiles shall then be stacked lightly together on a clean surfaces to drain with the end tiles, turned glaze outwards. They shall be fixed as soon as all surfaces water has evaporated they must not be allowed to dry out more than this.

Approximately two days after the fixing of the tiles, all joints shall be pointed with neat white grouting cement; the finish shall be flushed and free from all voids and irregularities.

All wall faces shall be finished plumb and flush throughout free from unevenness and irregularities of plain; all angles shall be straight and true. The finished work shall be left clean and free from all materials, which will scratch or in any way impair the finished work. Final polishing shall be done with a dry cloth. The Contractor shall be responsible for the adequate protection of the tiling from all damage until the handling over. Any damage which does occur shall be made good by the Contractor at his own expense. The whole of the work shall be left in a state satisfactory to the B-R Powergen Ltd..

(6) Suspended Ceiling

Materials, samples and drawings showing details of construction of all types of ceiling required shall be submitted to the B-R Powergen Ltd. for approval.

Appropriate size of aluminium tees shall be grided to the module of standard panels to accommodate acoustic boards, or approved equivalent, the odd size panels at perimeter shall then be arranged to equal dimension.

Fixing of hanger to beams, floor slab and soffits must be capable of carrying the load of ceiling boards and ventilation grill should be supported from the strengthened aluminium tee grids.

(7) Gypsum Board Partitions

Gypsum panels shall be 1000 mm wide by 12 mm thick obtained from an approved manufacturer.

The stud partition shall be extended from floor to ceiling with variation in heights

to suit. Stud shall be formed of approximately 0.03 gauge cold rolled steel with prepunched holes in the web 120 mm on centre to allow horizontal passage of utility lines. Studs shall be spaced 1000 mm on centre with horizontal spacer channels and framing materials.

Glass panel framing shall be anodised aluminium with glazing recess. Glazing shall be 6 mm clear sheet glass fitted with neoprene or vinyl gaskets.

The Contractor shall submit samples of metal and drawings showing details of constructions for approval of the B-R Powergen Ltd..

18.6 Painting

18.6.1 Materials

All paint distempers and other materials shall be of an approved brand or brands and shall comply with JIS Standard or other, equivalent standard to be approved by the B-R Powergen Ltd.. Paint for use on concrete or brickwork shall be of a type specially prepared for this purpose. Each coat shall be of a distinct colour from the preceding one and all colours shall be approved by the B-R Powergen Ltd.. Mixed paint and synthetic resin emulsion paint shall be applied based on the following method

(unit: kg/sq.m)

	Mixed paint		Synthetic resin emulsion
	Metal	Wood	Concrete Brick
First paint (Rust inhibitive paint)	0.14	0.09	0.13
Second paint	0.08	0.11	0.13
Finishing paint	0.04	0.09	0.13

Note: Rust inhibitive paint shall be either red lead or zinc rich lead type.

For painting of structural steelwork, see Section of 18.5.1(7).

18.6.2 Surface Preparation

Prior to painting, the dust, grease, injurious adherent substance, rust shall be removed from the surface to be painted. The planed grain, interlocked grain, fluff in wood shall be ridded with sandpaper and all cracks, manholes open; duct and other imperfection shall be made good with hard stoppings consisting of paste white lead and gold size stiffened with whiting. Cracks and holes on the concrete surface shall be flattended with cement paste, mortar, or cement filler.

18.6.3 Workmanship

All painting and decoration shall be carried out by skilled workmen according to the best current practice in accordance with manufacturer's instructions.

All materials shall be applied by brush unless otherwise specified or approved.

18.6.4 Priming

All joinery, metal works to be painted shall be primed using appropriate and approved primer before delivery assembly or fixing. No primer is required on surfaces to be distempered or emulsion painted unless otherwise specified.

18.6.5 Number Of Coats

Unless otherwise specified, the required finishes shall consist of the following treatments, in addition to preparation, priming etc:-

a. Distempering	Two coats
b. Emulsion painting	Two coats
c. Oil painting	Three coats on woodwork
	Two coats on elsewhere

18.6.6 Storage

The Contractor shall furnish an exclusive place for storing the combustible paints. The place for storage shall be fully ventilated. Adequate measures shall be taken against the ingress of dust and direct rays of the sun.

Section 19

Spare Parts

SPARE PARTS

Page

19.1 General

Spares during Warrantee period

19. SPARE PARTS

19.1 GENERAL

The Contractor shall provide Mandatory/safety spare parts list for the life time (20 years) of the Plant and guarantee that the spare parts shall be available during the life time (20 years) of the plant.

Spares & consumables during Warrantee period

The Contractor shall submit a list of spare parts with OEM Part No. and consumables **(lube. oils, greases, air & oil filters, chemicals etc.)** to be necessary for day to day operation and maintenance of the generating units and other plant equipment inclusive of emergency use that takes place in the course of operation (according to the Manufacture's recommendation and guideline) during the Warranty period (24 months). During the warranty period of 24 months, the Contractor shall supply all necessary equipment, spare parts, materials/consumables etc. at his own cost and whether it is listed or not in their list.

Sreepur 150 MW±10 Power Plant (HFO fired engine Generating Set)

Mandatory Spare Parts of the Generating Sets (Engine & Generator) for Two (02) years after warranty period.

SL No.	Description	Quantity	Price

Section 20

Appendixes [Data/ drawings]

Appendixes

Page

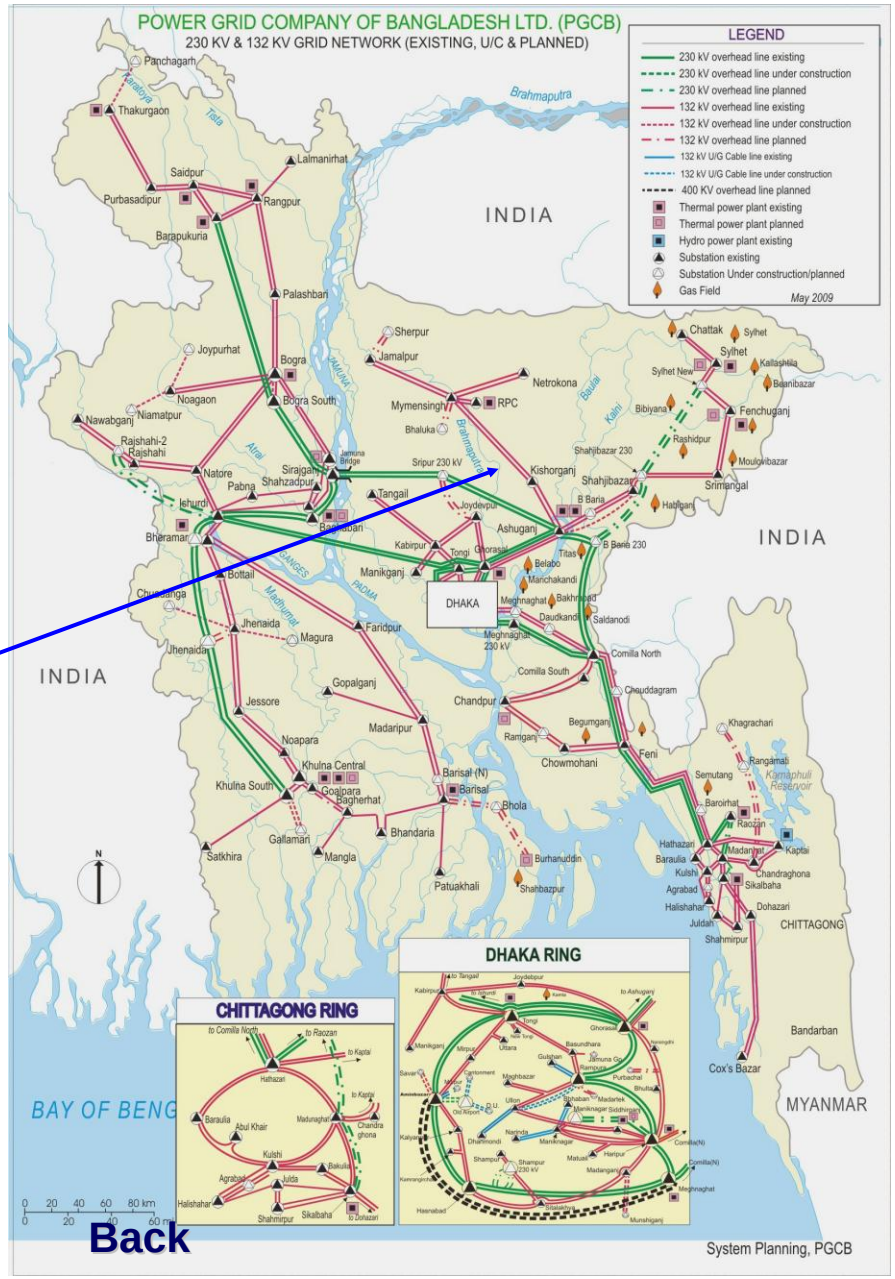
20.1 Site Layout


Barmj - Singhasree Rd
Gazi Auto Bricks
Barmj - Singhasree Rd
Sonali Bank Lt
Borama Singhasre
Sreepur 150
MW Site
3D
Google
Imagery ©2017 DigitalGlobe, DigitalGlobe, Map data ©2017 Google
Bangladesh
Terms
www.google.com/maps
Send feedback
50 m

20.2 Grid Networks

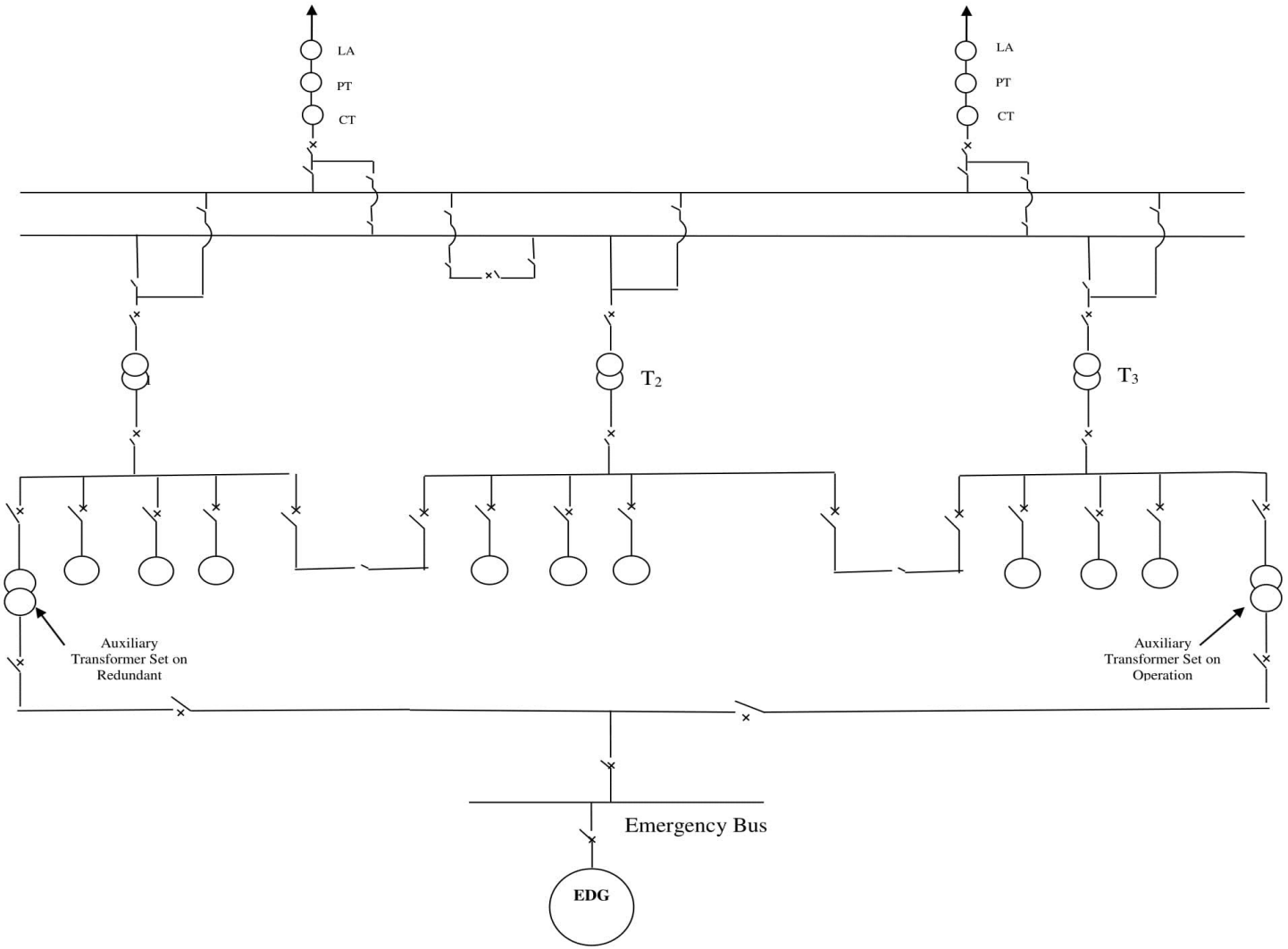
Location of Proposed Power Plant

Sreepur – 150 MW



Back

20.3 Sub-station Single Line Diagram


LA
PT
CT
LA
PT
CT
T2
T3
Auxiliary
Transformer Set on
Redundant
Auxiliary
Transformer Set on
Operation
Emergency Bus
EDG

20.4 Fuel Analysis

Specification of HSD

Tests	Method	Limit
Density at 15°C, kg/L	ASTM D 1298	Max.O.890
Neutralization value	ASTM d G64	
a) Strong acid no. , mg KOH/g		Nil
b) Total acid no. , mg KOH/g		Max. 0.5
Ash, % mass	ASTM D 482	Max. 0.02
Carbon residue (conradson),% mass	ASTM D 189	Max. 2.0
Pour Point, °C	ASTM D 97	Max. 12 for Winter* use Max. 18 for Summer* use.
Flash point PM (cc), °C	ASTM D 93	Min. 66
Cinematic Viscosity at 38°C, cst	ASTM D 445	Max. 16
Sediment, % mass	ASTM D 473	Max. 0.1
Water content , % vol	ASTM D 95	Max. 0.25
Sulphur, total, % mass	ASTM D 2622	Max. 1.8

*** Winter shall be the period from November to February (both months inclusive) and rest of the months of the year shall be called as Summer.**

Specification of HIGH SULPHUR FURNACE OIL

Tests	Method	Limit
Density at 15°C, kg/L	ASTM D 1298	Min. O.890 Max. O.960
Flash Point PM(cc), °C	ASTM D 93	Min. 66
Sediment, % mass	ASTM D 473	Max. 0.25
Water Content	ASTM D 95	Max. 0.5
Kinomatic Viscosity at 50 °C, cat	ASTM D 445	Min. 45 Max. 180
Pour Point, °C	ASTM D 97	Max. 33
Sulphur content, % mass	ASTM D 2622	Max. 3.5
Carbon residue (conradson),%mass	ASTM D 189	Max. 10
Calorific Valuc (HHV), Kcal/kg	ASTM D 240	Min. 10250

20.5 Seismic Zone Map of Bangladesh

BANGLADESH SEISMIC ZONE MAP

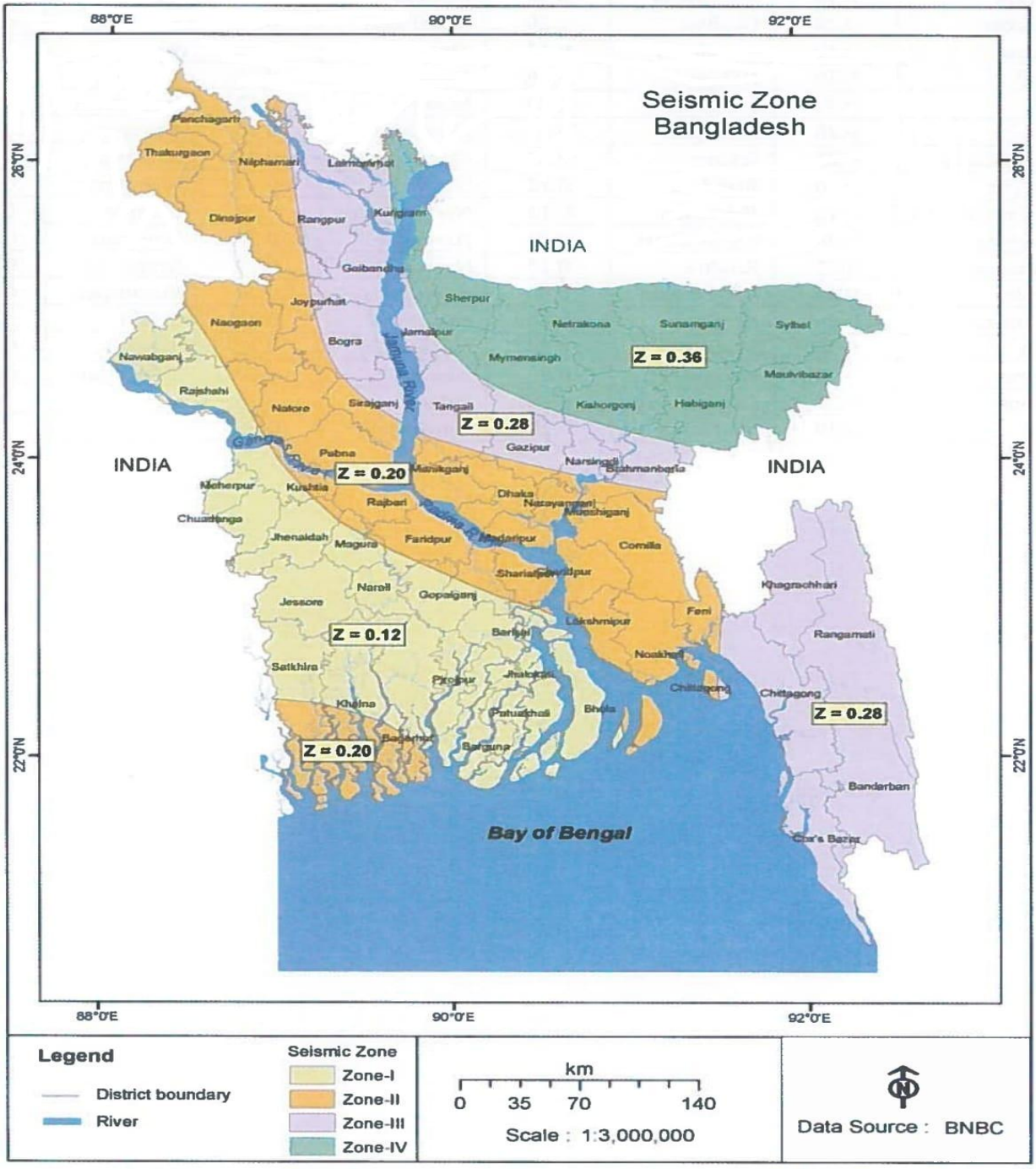


Figure 2.2 Seismic Zoning Map of Bangladesh (BNBC 2015, Figure 6.2.24)

Table 6.2.14: Description of Seismic Zones

Seismic Zone	Location	Seismic Intensity	Seismic Zone Coefficient, Z
1	Southwestern part including Barisal, Khulna, Jessore, Rajshahi	Low	0.12
2	Lower Central and Northwestern part including Noakhali, Dhaka, Pabna, Dinajpur, as well as Southwestern corner including Sundarbans	Moderate	0.20
3	Upper Central and Northwestern part including Brahmanbaria, Sirajganj, Rangpur	Severe	0.28
4	Northeastern part including Sylhet, Mymensingh, Kurigram	Very Severe	0.36

Table 6.2.15: Seismic Zone Coefficient *Z* for Some Important Towns of Bangladesh

Town	Z	Town	Z	Town	Z	Town	Z
Bagerhat	0.12	Gaibandha	0.28	Magura	0.12	Patuakhali	0.12
Bandarban	0.28	Gazipur	0.20	Manikganj	0.20	Pirojpur	0.12
Barguna	0.12	Gopalganj	0.12	Maulvibazar	0.36	Rajbari	0.20
Barisal	0.12	Habiganj	0.36	Meherpur	0.12	Rajshahi	0.12
Bhola	0.12	Jaipurhat	0.20	Mongla	0.12	Rangamati	0.28
Bogra	0.28	Jamalpur	0.36	Munshiganj	0.20	Rangpur	0.28
Brahmanbaria	0.28	Jessore	0.12	Mymensingh	0.36	Satkhira	0.12
Chandpur	0.20	Jhalokati	0.12	Narail	0.12	Shariatpur	0.20
Chapainababganj	0.12	Jhenaidah	0.12	Narayanganj	0.20	Sherpur	0.36
Chittagong	0.28	Khagrachari	0.28	Narsingdi	0.28	Sirajganj	0.28
Chuadanga	0.12	Khulna	0.12	Natore	0.20	Srimangal	0.36
Comilla	0.20	Kishoreganj	0.36	Naogaon	0.20	Sunamganj	0.36
Cox's Bazar	0.28	Kurigram	0.36	Netrakona	0.36	Sylhet	0.36
Dhaka	0.20	Kushtia	0.20	Nilphamari	0.12	Tangail	0.28
Dinajpur	0.20	Lakshmipur	0.20	Noakhali	0.20	Thakurgaon	0.20
Faridpur	0.20	Lalmanirhat	0.28	Pabna	0.20		
Feni	0.20	Madaripur	0.20	Panchagarh	0.20		

2.5.4.3 Design response spectrum

The earthquake ground motion for which the building has to be designed is represented by the design response spectrum. Both static and dynamic analysis methods are based on this response spectrum. This spectrum represents the spectral acceleration for which the building has to be designed as a function of the building period, taking into account the ground motion intensity. The spectrum is based on elastic analysis but in order to account for energy dissipation due to inelastic deformation and benefits of structural redundancy, the spectral accelerations are reduced by the response modification factor *R*. For important structures, the spectral accelerations are increased by the importance factor *I*. The design basis earthquake (DBE) ground motion is selected at a ground shaking level that is 2/3 of the maximum considered earthquake (MCE) ground motion. The effect of local soil conditions on the response spectrum is incorporated in the normalized acceleration response spectrum C_s. The spectral acceleration for the design earthquake is given by the following equation:

$$S_a = \frac{2}{3}\frac{ZI}{R}C_s \qquad (6.2.34)$$

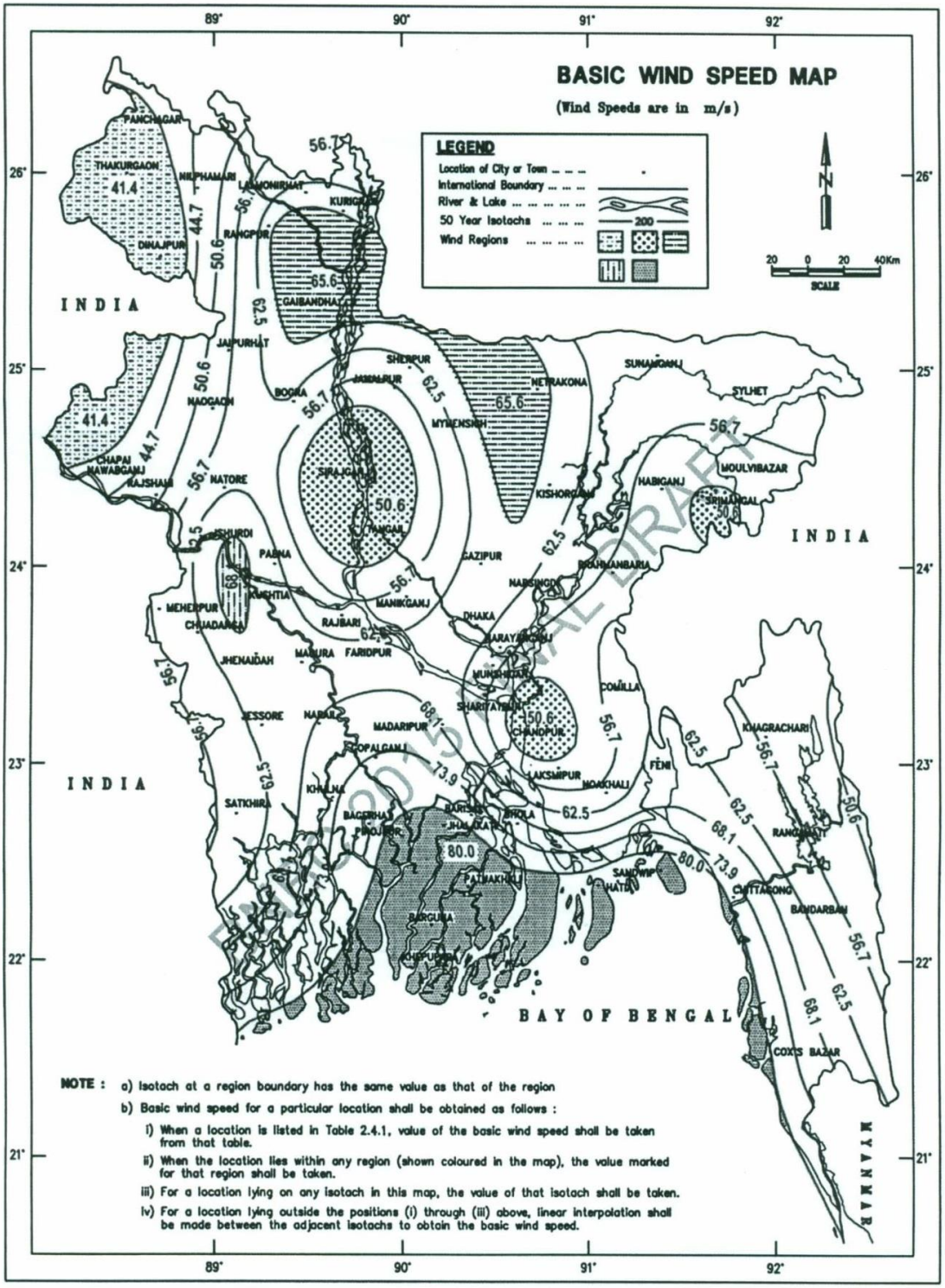


Figure 6.2.1 Basic wind speed (*V*, m/s) map of Bangladesh

Table 6.2.8: Basic Wind Speeds, *V*, for Selected Locations in Bangladesh

Location	Basic Wind Speed (m/s)	Location	Basic Wind Speed (m/s)
Angarpota	47.8	Lalmonirhat	63.7
Bagerhat	77.5	Madaripur	68.1
Bandarban	62.5	Magura	65.0
Barguna	80.0	Manikganj	58.2
Barisal	78.7	Meherpur	58.2
Bhola	69.5	Maheshkhali	80.0
Bogra	61.9	Moulvibazar	53.0
Brahmanbaria	56.7	Munshiganj	57.1
Chandpur	50.6	Mymensingh	67.4
Chapai Nawabganj	41.4	Naogaon	55.2
Chittagong	80.0	Narail	68.6
Chuadanga	61.9	Narayanganj	61.1
Comilla	61.4	Narsinghdi	59.7
Cox's Bazar	80.0	Natore	61.9
Dahagram	47.8	Netrokona	65.6
Dhaka	65.7	Nilphamari	44.7
Dinajpur	41.4	Noakhali	57.1
Faridpur	63.1	Pabna	63.1
Feni	64.1	Panchagarh	41.4
Gaibandha	65.6	Patuakhali	80.0
Gazipur	66.5	Pirojpur	80.0
Gopalganj	74.5	Rajbari	59.1
Habiganj	54.2	Rajshahi	49.2
Hatiya	80.0	Rangamati	56.7
Ishurdi	69.5	Rangpur	65.3
Joypurhat	56.7	Satkhira	57.6
Jamalpur	56.7	Shariatpur	61.9
Jessore	64.1	Sherpur	62.5
Jhalakati	80.0	Sirajganj	50.6
Jhenaidah	65.0	Srimangal	50.6
Khagrachhari	56.7	St. Martin's Island	80.0
Khulna	73.3	Sunamganj	61.1
Kutubdia	80.0	Sylhet	61.1
Kishoreganj	64.7	Sandwip	80.0
Kurigram	65.6	Tangail	50.6
Kushtia	66.9	Teknaf	80.0
Lakshmipur	51.2	Thakurgaon	41.4

20.6 Environmental Standards

Environmental Standard

1. Flue Gas Emission Regulation

The environmental conservation regulation defines different flue gas emission standards according to output scale of power plants. The power plant considered have to comply with the standard shown in table-1 if not updated by new regulations:

Table 1: FLUE GAS EMISSION STANDARD

Smoke Type	Emission Standard	Remark
NOx	30 ppm	Power Plant Smaller than 200 MW
SOx		A coal-burning power plant is regulated but a gas turbine power lant is not.
Dust	350 mg/Nm2	Power Plant smaller than 200 MW

2. Noise Regulation

The environmental conservation regulation defines noise standards according to the type of use of the area. The power plant site is classified in residential area and must comply with the standard shown below if not updated by new regulations:

Table 2: NOISE STANDARD

Area	Standard (db)	
	Day	Night
Quiet area	45	35
Residential Area	50	40
Complex area (Complex of residential commercial and industrial area)	60	50
Commercial area	70	60
Industrial area	75	70

Note 1: Day is 6 a.m. to 9 p.m.
Note 2: Night is 9 p.m. to 6 a.m.

3. Effluent Regulation

The environmental conservation regulation defines *effluent* standards according to area where the power plant's effluent is discharged the Power Plant have to comply with standard shown in Table -3 if not updated by new regulations:

TABLE 3: EFFLUENT STANDARD

No	Item	Unit	Standard
1.	Nitrogen including ammonia (N molecule)	Mg/l	50
2.	Ammonia (Free ammonia)	Mg/l	5
3.	Arsenic (As)	Mg/l	0.2
4.	$BGD^{rv}20^0$ C	Mg/l	50
5.	Boron	Mg/l	2
6.	Cadmium (Cd)	Mg/l	0.05
7.	Chloride	Mg/l	600
8.	Chromium (Total Cr)	Mg/l	0.5
9.	COD	Mg/l	200
10.	Chromium (Hexavalent chromium)	Mg/l	0.1
11.	Copper (Cu)	Mg/l	0.5
12.	Dissolve Oxygen (DO)	Mg/l	4.5-8
13.	Conductance	Micromho/cm	1.200
14.	Total soluble matters	Mg/l	2.100
15.	Fluoride (F)	Mg/l	7
16.	Sulfide (S)	Mg/l	1
17.	Iron(Fe)	Mg/l	2
18.	Total Kjeldahi nitrogen (N)	Mg/l	100
19.	Lead (Pb)	Mg/l	0.1
20.	Manganese (Mn)	Mg/l	5
21.	Mercury (Hg)	Mg/l	0.01
22.	Nickel (Ni)	Mg/l	1.0
23.	Nitrate (N molecule)	Mg/l	10.0
24.	Grease	Mg/l	10
25.	Phenol compound (C_6H_6OH)	Mg/l	1.0
26.	Dissolve phosphorus (P)	Mg/l	8
27.	Radio active substance : Defined by Bangladesh nuclear Committee		
28.	P^H	Mg/l	6-9
29.	Selenium	Mg/l	0.05
30.	Zinc(Zn)	Mg/l	5.0
31.	Total dissolve evaporation residue	Mg/l	2.100
32.	Temperature Summer Winter	Celsius	 40 04
33.	Suspended solid (55)	Mg/l	150
34.	Cyanide (CN)	Mg/l	0.1

20.7 Manufacturer List

Annexure A :
General Layout (Sreepur 150 MW Dual Fuel (HFO/Gas) Power Plant Project)