14.2.2 Levels and Heads

a. Water Levels of Reservoir

Max. operating water level	: El. 151.60 m
Rated water level	: El. 148.90 m
Low water level	: El. 138.00 m

b. Water Levels of Tailrace

Flood water level	: El. 87.79 m
Low water level at no discharge	: El. 82.50 m

c. Heads

Maximum net head under full load

Operation	: El. 67.00 m
Design head	: El. 64.30 m
Minimum net head	: El. 53.57 m
Penstock	: 1.4 m x 403 m

d. Turbine Setting Level

The centre line of the spiral casing shall be set as shown on the drawing relative to the floor level of the power house. (Turbine inlet centre = EL.84.7 m, Turbine shaft centre = EL.85.8 m). The Contractor shall submit the proposed centre line of the turbine and generator with full descriptions and drawings including floor arrangement.

14.2.3 Hydraulic Turbine

a. Type and Rating

The turbine shall be of single runner, single flow, horizontal shaft Francis type suitable for direct coupling with a 50 Hz synchronous generator. The turbine shall have the rated output at the generator terminals when the turbine is operating at the rated speed, under the design head at full guide vane opening.

b. Output and Efficiency

The output of the turbine shall be guaranteed at the stated design head under the base guide vane openings. An efficiency curve and a capability diagram for the turbine offered shall be submitted in the Tender.

The efficiency curve shall show the guaranteed efficiencies and outputs in kW and range of discharges. The 100% guide vane position and cavitation limits shall be indicated on the capability diagram. The efficiency of the turbine shall be guaranteed at 100%, 90%, 70% and 50% rated load at stated design head.

The turbine shall be designed such that the maximum prototype efficiency is reached when operating at the rated speed under the design head.

The Contractor shall propose maximum value of efficiency where it peaks under design net head as well as the efficiency characteristics itself versus turbine output.

Turbine efficiency characteristics shall be so designed as to maximise the weighted average efficiency (η_{av}) at design net head as formulated below.

Weighted average efficiency =1/100(30 η_{100} + 10 η_{90} + 10 η_{70} + 10 η_{50})

Where η_{100}, η_{90}, η_{70} and η_{50} are the turbine efficiencies each corresponding to the % of the output against the maximum output of turbine p_{max} (kW) at design net head.

c. Rated Speed and Rotation

The Contractor shall propose the rated speed of the turbine. The rotation of the turbine shall be clockwise when viewed from the generator side.

d. Cavitation

The basic guarantee period for cavitation shall be (2) two years or 12,000 actual operating hours whichever is shorter. Should any runner suffered a loss of metal less than 0.5 kg during the guarantee period the Contractor shall repair the runner by welding, grinding and polishing.

If the loss of metal during the basic guarantee period is greater than 0.5 kg but less than 1.5 kg the Contractor shall repair the runner by welding, grinding and polishing. If after a further (2) years or 12,000 hours of operation the runner shall again have suffered a loss of metal in excess of 0.5 kg the Engineer may reject the runner in which case the Contractor, free of charge, shall design, manufacture and install a new runner with satisfactory cavitation performance.

e. Runaway Speed

All rotating parts of the turbine and generator and bearings shall be capable of withstanding for five (5) minutes the runaway speed determined for the turbine under the condition of maximum head with the guide vanes fully open and the generator disconnected and unexcited.

f. Hydraulically Induced Vibration and Speed Oscillation

The hydraulic turbine shall be free of injurious vibration or speed oscillation induced by hydraulic forces in the runner, draft tube, or spiral case, and the noise level shall be made as low as possible.

The Contractor shall provide, according to his practice, the air admission system to the draft tube if required. In case of the atmospheric air admission system, the air inlet shall be located outside the powerhouse building and above flood water level of the tailrace.

g. Mechanically Induced Vibration

The rotating parts including the runner, shaft and generator rotor shall be designed to withstand the torques and loads associated with sustained part and full load operation, and also the infrequent loading as occasioned by generator fault or overspeed.

The rotating element shall show torsional and transverse resonances sufficiently removed from exciting forces to preclude injurious vibrations or deflections. The first critical speed of the rotating assembly shall be

shown, at the design state, to be at least 25 percent higher than the runaway speed defined in item e. above.

h. Pressure Rise and Speed Rise

The maximum penstock pressure developed during load rejection or in any other circumstances shall be less than 150% of the design head when measured at the turbine inlet. The penstock pressure at any point shall not be less than atmospheric pressure during load acceptance or in any circumstance. The maximum speed rise upon full load rejection shall not exceed 40 percent of the rated speed.

The designs for governing system guide vane mechanism and generator flywheel shall be co-ordinated to ensure that above limits on pressure rise and speed rise shall not be exceeded. The Contractor shall guarantee the governing system is capable of stable governing and of meeting the above regulation limits.

i. Runner

The runner shall be made of a stainless steel with 13% chromium and 4% or more nickel alloy and shall be a monolithic casting. The blade surfaces shall have a hydraulically smooth finish.

The blade, inlet and outlet edges shall be dressed in accordance with Contractor's practice to minimise hydraulic losses and the risks of trailing vortex formation and of trailing edge cavitation.

The mechanical design of the turbine and runner shall permit its removal from draft tube end without disturbing the shaft and machine alignment. Means shall be provided for removal of the runner horizontally.

The runner shall be statically and dynamically balanced, independent of the turbine shaft.

j. Spiral Case and Stay Vane Ring

The spiral case and stay vane ring shall be made of welded steel plate and shall be designed to safely carry a maximum pressure of 150% of the design pressure resulting from the maximum head and pressure rise. The stay vane ring shall be integrated with the spiral case.

The spiral case and stay vane shall also be designed to withstand a hydrostatic test pressure of 150% rise of the design pressure without permanent deformation.

A tapered transition piece shall be provided at the inlet of the spiral case for connection and inlet valve and shall form part of the spiral case.

The transition piece shall be designed to transfer, in compression, the hydrostatic force occasioned by a closed inlet valve to the spiral case and spiral case anchorage.

The spiral case shall be provided with supporting pads designed to rest upon companion pads embedded in primary concrete. Jack bolts or suitable other devices shall be supplied for levelling and hold down for secondary concreting.

The spiral case will be supplied with suitable taps for the installation of pressure and water flow measuring devices.

The spiral case and all associated parts and welds will be inspected at the factory.

An air vent valve shall be provided to release air from the spiral case when filling with water. This valve is to be located at the highest point of the spiral case, and shall be of the ball type, bronze and rated for a pressure not less than the design pressure for the spiral case.

An outlet from the spiral case in the lowest part shall be provided for drainage of the spiral and residual leakage of the inlet valve.

k. Head Cover, Bottom Ring and Discharge Ring

The head cover, bottom ring and discharge ring shall be made of cast steel or welded steel plate and each shall be constructed in one piece.

The head cover and bottom ring shall be provided with replaceable stainless steel wearing rings within the range of the guide vanes. Replacement shall not require re-machining of the head cover or bottom ring. No joint rings or gaskets which cannot be renewed after completion of the installation shall be incorporated.

l. Guide Vanes and Operating Mechanism

The guide vanes shall be of stainless steel in one place and shall be designed to efficiently regulated the flow of water through the turbine and to give the minimal leakage of not more than 0.15 litres/minute when closed.

The guides vanes shall be linked with the regulation ring by means of safety devices such as friction devices or breaking links or shear pins designed to fail in the event of a foreign body becoming wedged between two guide vanes but to be capable of withstanding maximum normal operating forces without distortion.

The design of the guide vanes shall be such that, on the failure of a safety device, the effected guide vane shall be stable and not cause damage to adjacent vanes or other parts due to movement. In addition, substantial stops shall be provided to prevent over-travel of the vanes exceeding the normal fully opened and fully closed positions.

Suitable means shall be for easy adjustment of each linkage. The guide vanes shall be provided to indicate percent guide vane opening.

Hydraulic unbalance (self-closing nature) of the guide vane will not be acceptable method.

Bearings for each guide vane and regulation mechanism shall be of grease-less type.

m. Shaft, Couplings and Bearings

The arrangement of the turbine shaft, generator and flywheel and the location of bearings and couplings shall be established carefully in order to facilitate the installation, alignment, inspection and dismantling or replacement of the bearings and shaft steel.

A thrust bearing shall be provided to resist the maximum axial thrust imposed by the turbine. The thrust bearing shall be located at the most convenient place.

The main shaft shall be made of forged carbon steel and machined all over. The shaft shall be of ample size to operate at any speed up to maximum runaway speed without detrimental vibrations or distortions, and to operate at maximum output without exceeding acceptable design stresses.

Plain bearings shall be of the self-lubricating type. The bearings and oil system shall be designed so that neither the bearing nor the oil temperature will exceed 40^0 C above ambient temperature under continuous normal operation. If oil cooling is required corrosion resistant oil coolers of ample capacity shall be provided. Provision shall be made for draining and cleaning the oil and water circuits. All necessary valves, pipes and fittings shall be supplied. It shall be possible to run the machine at full load without cooling water for 5 minutes without causing any damage to the bearing.

Each plain bearing shall be fitted with an instrument for both temperature and oil level indication. This instrument shall have independently setable contacts for alarm and trip.

n. Shaft Seal

A shaft seal shall be gland packing type and shall be designed so that it can be adjusted and replaced without disturbing the shaft or bearings.

Shaft sealing water shall be taken from the penstock and discharged to powerhouse sump pit by piping supply.

The sealing water supply system shall be provided with duplex strainers, including all necessary piping and connections, and sand separator. A pressure gauge with pressure switch and a flow meter with no-flow alarm contact shall be provided on the sealing water supply line. The design of the sealing supply system shall take into account the water conditions that the penstock water will have a high solids content.

o. Draft Tube

The turbine shall be provided with draft tube which shall efficiently recover the residual energy at runner outlet and convey the water to the tailrace canal. The draft tube shall be of welded steel construction. The draft tube elbow or cone shall have flanges and/or a manhole at each end for bolt connection to the discharge ring and the draft tube liner, and shall be so constructed as to be easily removed for inspection and maintenance of the runner , guide vanes and inside of the draft tube liner.

A vacuum gauge connection for test and inspection purpose shall be provided at a section of the draft elbow adjacent to the runner discharge and on horizontal plane of the turbine coincident with the shaft.

Any connections required for air admission shall also be provided on the draft tube elbow or cone.

The draft tube shall be adequately stiffened and shall have provision for aligning and anchoring into the concrete foundation of the powerhouse. The draft tube shall be supplied until at least at the level lower than the tailwater level when the turbine is at a standstill.

The draft tube shall be complete with all necessary brackets, lifting lugs, stiffeners, foundation anchors fixing bolts, etc.

p. Guide vane actuator

An electric servomotor or hydraulic system shall be provided for opening and closing control of the guide vanes. The system shall have a sufficient capacity to ensure very smooth and efficient operation over all strokes at starting, ordinarily operating and also at transient movement.

A method shall be provided to retard the closing rate of travel near the fully closed position of the guide vanes to prevent causing abnormal pressure rise.

The system shall be also designed that it shall not cause any fluctuation or pressure rise due to hydraulic unbalance when the power source is failed during opening or closing operation.

The system shall be equipped with a mechanical locking device to lock it in fully closed or fully opened position. The locking device shall be of stout and durable construction enough for a mechanical locking against the driving force of the actuator.

The system shall be provided with manual operating handle, excessive torque releasing mechanism and all necessary limit switches for operation, control and protection, and other necessary accessories.

A suitable scale with a pointer to indicate the actuator position and stroke shall be provided.

14.2.4 Governor

The governor for turbine control shall be of electric, speed controller, electric servomotor or hydraulic oil operated actuator type with speed signal generator.

The governor shall be complete with all necessary equipment and devices for the governor and turbine control including speed detection, starting control, speed control, speed droop, load control, load limiter, guide vane closing/opening time control, etc.

The governor shall be capable of controlling the turbine speed in a stable manner when operated at speed no-load, or when operated at the rates speed with and isolated load at any power output, and also be capable of controlling the output when operated in parallel with other generator in the power system.

The governor shall be compatible with automatic or manual starting, synchronising and shutting down. The electric governor unit shall be housed in a self-supporting, metal enclosed panel.

The rotational speed of the turbine shall be detected by the speed signal generator to be directly coupled to the generator shaft. The speed signal generator shall be used exclusively for speed sensing and speed relaying.

The performance of the governor shall meet the following requirement:

a. Speed Regulation

The maximum momentary speed rise caused by sudden load shedding under the design head shall not exceed 140 percent of the rated speed.

The governor shall respond in consequence of speed variation of the turbine of 0.02 percent or less and effect corrective action by the governor relay for this turbine speed.

The time interval between a change in speed of the turbine and the first detectable movement of the servomotor which results from the change shall be 0.3 second or less.

The permanent speed drop of the turbine between full guide vane opening and full guide vane closing stroke shall be adjustable to any degree between 0 and 10 percent. Provision shall be made for manual adjustment of the speed drop at the governor cabinet, while the turbine is in operation.

The steady speed of the turbine shall adjustable between plus 8 percent and minus 10 percent of the normal speed at all loads between no load and full load.

The opening and closing times of the guide vane shall be adjustable but the adjustment shall be such that, once set, they cannot be readily or inadvertently altered.

b. Pressure Regulation

The maximum momentary pressure in the spiral case under any conditions shall not exceed 150% of design head when measured at the turbine inlet.

The characteristics of the governor and turbine system shall be in accordance with the completed Form of Technical Particulars submitted by the Contractor with his bid and approved in the Letter of Acceptance.

In addition to the essential speed governing devices, the governor shall be provided with the following equipment and instruments:

(i) On Governor Panel

- Manual control with switch two positions of "RAISE' and "LOWER" for speed setter. (7-65F)
- Manual control switch with two positions of "RAISE' and "LOWER' for load setter. (7-65P)
- Manual control switch with two positions of "RAISE' and "LOWER' for load limited. (7-77M)
- Guide vane opening and load limited position indicator. (GPI/LPI)
- Speed indicator. (N)
- Selector switch with two position of "AUTO" and "MANUAL" for the turbine control. (43-65)
- Pushbutton switches for manual electrical control of inlet valve.

(ii) On Main Control Panel

- Manual control switch with two positions of "RAISE" and "LOWER" for common use to speed setter and load setter.

- Manual control switch with two positions of "RAISE" and "LOWER" for load limited.
- Guide vane opening and load limited position indicator.
- Speed indicator.
- Turbine discharge
- Penstock pressure

(iii) On Relay Panel to be Supplied

- It speeds relays including overspeed relay, synchronous speed relay and underspeed relay.

14.2.5 Inlet Valve

The inlet valve shall be butterfly type or biplane type and shall be operated by an oil hydraulic system or an electric servomotor system. Closure of butterfly valve shall be by counterweight.

The inlet valve shall be designed and constructed so as to operate smoothly without causing excessive vibration and dangerous pressure fluctuation in the penstock.

The inlet valve shall be capable of opening against the maximum gross head without equalising pressure and shall be capable of closing against the maximum gross head and maximum flow corresponding to the guide vane fully open. The inlet valve shall be capable of opening and closing within 180 seconds under above conditions.

The inlet valve shall be equipped with an automatic bypass system for filling the spiral casing before starting up the turbine.

The valve body shall be of cast steel, welded steel plate or combination of both and shall be provided with two horizontally-aligned bearing housing for valve plug trunnions. The bearing housing shall be equipped with grease-less guide bearing for the valve plug.

The valve disc shall be lattice or open disc design to allow the following water to pass through and around the disc, resulting in low head loss and minimal flow disturbance. The valve disc shall be leakage water from the inlet valve shall be less than 0.15 litres/min.

The downstream end of the inlet valve shall be flange connected to the spiral case extension.

The upstream end of the inlet valve shall be connected to the make up pipe by the loose flange of approved type. The other end of the make up pipe shall be connected to the penstock by field welding. The make up pipe will be provided with a suitable tap for pressure measuring.

14.2.6 Gauge Panel Stand

The Contractor shall supply and install a self-supporting, neat and attractive design, gauge panel stand suitable for mounting the following gauges and meters:

a. Spiral case pressure gauge

b. Turbine bearings thermometers

c. Shaft sealing water pressure gauge

d. Generator thrust bearing thermometer

e. Generator journal bearing thermometer

f. Generator stator temperature thermometer

The gauge panel stand shall be located at a convenient place near the turbine and generator unit.

Suitable provisions shall be made to gauge the following items for test and maintenance:

a. Runner back-pressure

b. Draft tube vacuum pressure

c. Penstock pressure gauge pressure switch.

14.2.7 Protection and Alarm

The Contractor shall be provide the protective relays devices necessary for the following protection and alarm items:

a. Protection, high (2^{nd} stage)

(i) Turbine bearing temperature

(ii) Guide vane servomotor, trouble

(iii) Inlet valve servomotor, trouble

(iv) Overspeed

(v) Governor fault

(vi) Protection

b. Alarm

(i) Turbine bearing temperature, high (1^{st} stage)

(ii) Turbine starting trouble

(iii) Shaft sealing water, no flow

(iv) Cooling water, no flow

(v) Bearing lubricating oil level, low

(vi) Stator high (2^{nd} stage)

14.2.8 Cooling and Shaft Sealing Water Supply System

If necessary, the Contractor shall supply and install a cooling and/or shaft sealing water supply system for cooling of the bearings and/or shaft sealing by water.

The temperature of cooling water taken from the inlet portion of the spiral case shall be taken as 30° C for the design.

14.2.9 Drainage and Dewatering Pumping System

The Contractor shall supply and install a drainage and dewatering pumping system in the drainage pit. The system shall be controlled automatically according water level of drainage pit.

The system is consist of follows :

(i) Two (2) sets of drainage pump and check valve with fittings.

(ii) Two (2) sets of stainless drainage pipe and stop valve with fittings.

(iii) One (1) set of control Plant including water level detectors.

14.2.10 Oil Storage and Transfer System

If necessary, the Contractor shall supply and install an oil storage and transfer system for guide vane operation and/or inlet valve operation.

14.2.11 Compressed Air Supply System

If necessary, the Contractor shall supply and install an oil storage or compressed air supply system for the braking system.

14.2.12 Flow Meter System

The Contractor shall supply and install an ultrasonic flow meter system at the penstock.

The system shall consist of, and comply with, the following list of component and requirements :

		(Quantity)
(1) Items	Ultrasonic Flow Meter Main Unit	1
	Sensor (including fixtures and 2 sensing terminals with connecting cable)	2
	Junction Box	2
	Coaxial Cable (length : 15m)	1
	Analogous Panel Meter	1
	Digital Out Box	1
	Digital Panel Meter	1
(2) Flow Pipe	Type	Steel Pipe
	Normal Diameter	800 mm
	Outer Diameter	818 mm
	Pipe Thickness	9.0 mm
(3) Liquid to be measured		Water
(4) Measurement Range		4.0 m^3/s

(5) Accuracy (excluding pipe conditions)		±1% of full scale
(6) Output Signal	Instantaneous Flow Rate : 4 – 20 mA DC	
	(Allowable load resistance : 1 k ohm or less)	
	(Damping : 3, 10, 30, 100 sec)	
	(90% response time)	
	Integrated Flow Rate : 100 m^3	
	(Output Type : Non-voltage dry contact)	
	(Contact Capacity : 250 V AC, 1A)	
(7) Indicating Instrument	The indicating instrument shall be installed on Recording panel which supplied by the contractor of control equipment.	
	a. Indicating meter for instantaneous flow.	
	The same type of other meters (cf.14.6.9)	
	b. Digital panel meter for integrated flow BCD 6 digitd	
(8) Power Supply	AC 220 V 50 Hz 1 PHASE 2 WIRE	
(9) Environmental	Temperature Range	-10 to 60 degree
	Humidity Range	less than 90%
(10) Option	2-channel method	
	Output Signal	Integrated Flow Rate: BCD

14.2.13 Erection and Maintenance Tools and Accessories

a. Erection Tools and Equipment

The Contractor shall supply any special tools and special equipment or devices that may be required or which may be useful in assembling or disassembling any parts of the turbine. The tools and equipment referred to in this Sub-Clause 14.2.13 shall be delivered concurrently with the turbine.

b. Maintenance Tools and Equipment

The Contractor shall supply the following maintenance tools and equipment which shall be delivered to the Site prior to the commencement of commissioning of the turbine:

(i) One complete set of high quality single-ended spanners, ring spanners, socket wrenches and standard and special tools for the turbine, all marked as for size and purpose, and mounted on a suitable shadow type tool mounting board.

(ii) All necessary lifting tackle

(iii) Other recommended by the manufacturer

c. Accessories

The Contractor shall supply the accessories for the turbine and ancillary plant generally listed below and in accordance with the accessories

proposed by the Contractor in his Bid and as approved in the Letter of Acceptance:

(i) All necessary sole-plate, foundation, anchor bolts, channel steel and shim plates for the turbine and associated Plant.

(ii) All necessary lifting lugs, eyebolts and other items required to facilitate handling and serving the installation.

(iii) All necessary turn buckles, pipe jacks, liners, etc, required for the installation.

(iv) A rating plate for each component of plant, showing the manufacturer's name, serial number, year of the manufacture, type, rating, capacity and other main characteristics.

(v) All necessary gauges for runner back-pressure, draft tube vacuum pressure and penstock pressure.

14.2.14 Machine Shop Equipment and Tools

The machine shop repair equipment and tools shall be ready for operation prior to the installation of the turbine.

The Contractor shall provide machine shop equipment and tools as listed below. The Contractor may use such tools during the installation and commissioning of the Works provided that, on completion he shall be responsible for such equipment, shall maintain it in good condition and shall replace any item that may be damaged or lost.

Minor variation from the size and capacities below will be acceptable. The machinery and tools shall include, but not be limited to, the following :-

a. Machining tools

(i) Drilling machine	610mm, motor driven	1 set
(ii) Band sawing machine	400mm, high speed motor driven	1 set
(iii) Grinder	305mm, floor type, motor driven	1 set
(iv) Work bench	L:1.8m D : 1m H : 0.85m	3 pcs
(v) Steel cabinet	Height: 2m, Width: 1m, Depth: 0.5m	4 pcs

b. Bench tools

(i) Leg vise	150 mm	1 pce
(ii) Parallel vise	150 mm	1 pce
(iii) Parallel vise	100 mm	1 pce
(iv) Pipe vise	10 mm – 77 mm	1 pce

c. Portable Equipment

(i) Portable dirt water pump	discharge 0.5m3/min, head 20m, motor driven, 20 m hose	2 sets
(ii) Blower	114 mm(4*1/2"), motor driven	1 set
(iii) Electric welder	300A, with accessories	2 sets

(iv) Gas welder	complete with accessories	1 set
(v) Surface plate	500m m500mm (20"20")	1 pce
(vi) Pipe bender	Portable hydraulic type with formers suitable for pipes from 10 mm to 100 mm nominal bore	1 set
(vii) Anvil	100 kg	1 pce
(viii) Swage block	55 kg	1 pce
(ix) Blower type drier20 kW with accessories		1 set
(x) Chain block	5 ton, 3 ton, 1 ton	each 2 sets
(xi) Iron block	150 mm, 3-wheel	2 pcs
(xii) Snatch block	200 mm, 2-wheel	2 pcs
(xiii) Wooden block	100 mm, 2-wheel	2 pcs
(xiv) Ball and pinion jack	10 ton	4 pcs
(xv) Portable electric drill	20 mm (3/4") with drill stand	1 set
(xvi) Portable electric grinder	180 mm (7"),1/2HP motor driven	1 set
(xvii) Chain tong	38 mm – 200 mm	2 pcs
(xviii) Bolt clipper	13 mm	1 pce
(xix) Centrifugal oil purifier	1,000 (l/h)	1 pce
d. Hand tools		
(i) Screw plate	metric size, 6mm-21mm.	1 pce
(ii) Hand tools including files, emery-cloth, punches, saw, hammers, screw drivers, pipe threaders, taps, drills, reamers, cramps, wrenches, etc.	sufficient for five years	
e. Measuring instruments		
(i) Iron bench level	450mm	1 pce
(ii) Dial indicator	0.01mm-20mm	3 pcs
(iii) Straight edge	I beam type, 1,000 mm	1 pce
(iv) Thermometer (Alcohol)	0 - 100 deg 1 deg.	20 pcs
(v) Portable voltmeter	AC 0 – 30/150/300/750 V	1 pcs
(vi) Ammeter, tong tester	AC 0 – 15/ 75 – 150/300 A	1 pcs

14.2.15 Spare Parts

The Contractor shall furnish the spare parts listed below and shall quote unit prices should the Employer wish to purchase additional quantities over and above those supplied under the Contract:

a. One (1) set of guide vanes

b. One (1) grease-less bearing of each type used

c. One (1) complete set of safety device of friction device or breaking link or shear pin.

d. One (1) set of gland packing or seal for turbine shaft.

e. One (1) set of turbine bearing metal.

f. One (1) set of wearing rings.

g. One (1) set of gaskets and sealing materials of each type and size used.

h. One (1) set of pressure gauge and vacuum gauge of each type used.

i. One (1) set of filter or strainer replacement element of each size and type and two years supply for all disposable filter elements.

j. One (1) set of replaceable valve seat for inlet valve.

k. One (1) complete assembly of each type of relay, contactor, switch, etc. used in electrical Plant.

l. One (1) set of spare plug-in type printed circuited board (PCB) of each type for electrical governor.

Any additional spare parts, if recommended by the manufacturer, shall be listed and quoted in the Tender.

14.2.16 Tests

a. Test at Manufacturer's Equipment

The following tests shall be carried out at the manufacturer's Workshop before shipment.

(i) Trial assembly of turbine main parts

- Dimensional inspection
- Gap measurement between guide vane and cover plates
- Gap measurement between guide vanes in closed position
- Gap measurement between turbine shaft bearing surface

(ii) Runner inspection

- Dimensional inspection
- Static balance check

(iii) Turbine shaft inspection

- Deflection check
- Dimensional inspection
- Shaft alignment check with generator shaft

(iv) Inlet valve inspection

- Dimensional inspection
- Operation test
- Water tightness check
- Hydraulic pressure test

(v) Non-destructive inspection of welding parts of the following component :

- Spiral case and stay vane ring
- Turbine shaft
- Runner
- Guide vane
- Inlet vane
- Other main component

(vi) Material test for following component :

- Spiral case
- Runner
- Turbine shaft
- Stay vane ring
- Guide vanes
- Inlet valve body, disc and plug

(vii) Governor check

- Construction check
- Performance and characteristic test with servomotor
- Measurement of insulation resistance

(viii) Drainage Pumping System

- Construction check
- Performance and characteristic test
- Measurement of insulation resistance

(ix) Compressed Air Supply System

- Construction check
- Performance and characteristic test
- Measurement of insulation resistance

b. Test at Site

The hydraulic turbine and its ancillaries supplied and installed shall be tested at the Site in accordance with the requirements of all the "Primary test" and the "Test on Completion" specified in Sub-Clause 14.1.19.

14.3 GENERATOR AND EXCITATION SYSTEM

14.3.1 Scope

This Paragraph covers the design, manufacture, tests before shipment, transport to site, installation, commissioning and test at the Site of:

One (1) 2000 kVA synchronous generator.

14.3.2 Generator

a. Type and Rating

The generator shall be of three-phase, horizontal shaft, rotary field, salient pole type synchronous generator, and shall be of air duct ventilation type.

The maximum continuous output of the generator shall be 2000 kVA under the following conditions:

(i)	Rated voltage	6.6 kV
(ii)	Frequency	50 Hz
(iii)	Rated power factor	0.80 lagging

The generator shall be suitable for direct coupling to the horizontal shaft Francis turbine specified in Clause 14.2.

The generator shall be suitable for operation in parallel with the other generators in the existing power system.

b. Speed

The rated speed of the generator shall be same as for the turbine.

c. Direction for rotation

Generator rotation shall be anti-clockwise as viewed from the turbine.

d. Efficiency

If shop tests prove that the generator output or efficiency is less than that guaranteed, the Contractor shall modify or replace the item of Plant of his own cost until the guaranteed output efficiencies are met.

The generator shall conform to the efficiency curves submitted with the Tender showing generator efficiency over a range of 25 to 100% rated output at rated voltage.

e. Voltage regulation

The inherent voltage regulation (without AVR) of the generator at 0.80 power factor shall no be greater than ±30 percent, and guaranteed values at 0.80 and 1.0 power factors shall be given in the Tender.

f. Insulation

Insulation of the windings of generator shall be classified as Class F as defined in IEC-85, 1957.

g. Generator connections

The generator shall be star connected with three (3) terminals brought out at the neutral side and three (3) terminals at line side of the stator winding. Both the line and neutral terminals shall be insulated for full line voltage.

h. Temperature Rise

The following limits of temperature rise shall apply to the windings of generator when delivering rated output continuously at rated voltage, power factor and frequency, with cooling air temperature entering the generator at and ambient temperature not exceeding 40°C.

Method of Measurement	**Temperature Rise**	
Embedded temperature detectors	Stator	Rotor
Between coils	80°C	-
Resistance	80°C	80°C
Thermometer	70°C	70°C

The maximum temperature of each bearing shall be less than the following values:

Method of Measurement	**Temperature Rise**
Thermometer	40°C above ambient
Embedded detector in metal	40°C above ambient

i. Temperature Detectors and Thermometer

The generator shall be provided with the embedded temperature detectors of at least six (6) for stator winding and one (1) for each thrust and journal bearing.

The generator shall also be provided with the dial type thermometers with contacts for alarm and tripping protection. The thermometers shall be mounted on the gauge panel stand to be provided.

j. Flywheel Effect

The generator shall have a sufficient flywheel effect (GD^2) required by the turbine and governor supplier for stable governing.

The total flywheel effect (GD^2) of the turbine and generator units shall be not less than 4.5 ton-m^2. A separate flywheel may be employed to meet the requirement. If the separate wheel is supplied, it shall be balanced and provided with a totally enclosed removal wire mesh guard.

The separate flywheel Shall have function of braking system.

k. Ventilation and cooling

The generator shall be air duct ventilation type. The cooling system shall be such that cooling air shall be taken from the machine room and effectively circulated trough the generator rotor and stator by fans attached to the rotor and then the hot air shall be exhausted outdoor by air duct. The Contractor shall supply and install one (1) lot of air duct. The size and structure of the air duct shall be suitable for purpose and shall be subject to approval of the Engineer. The location of air duct is shown on the Drawings.

The air intakes of the generator shall be provided with the washable dry type filters secured by wing nuts or other means so that they can be easily removed for cleaning.

The suitable provisions shall be made on the air outlets to prevent entering of dust and any particles into the generator.

l. Structural Design

The generator shall be designed so that it is possible to replace the winding at the Site.

(i) Stator

The stator frame shall be made of welded steel plate with sufficient reinforced ribs. The stator cores shall be built up with high-permeability and low specific loss silicon steel lamination. The stator core shall be adequately keyed or dovetailed to the stator frame. The air ducts in the stator core shall be arranged to make the flow of air smooth and quiet and to minimise friction losses. The stator frame shall be provided with lifting lugs suitable for applying slings for lifting the stator or generator assembly by crane or lifting gear.

Within the generator housing, terminals shall be copper, and shall be of the bolt-clamped type for connection to the power cable terminals.

The stator coil conductor shall be electrolytic copper with conductivity not less than the value for annealed copper specified in the approved standard. The coil insulation shall be properly vacuum and pressure impregnated with high-grade resin so that the insulation becomes a dense, homogenous mass free from voids. The insulation shall become reasonably plastic by the application of heat or shall otherwise be of such nature that the coil can be placed in or removed from the slot without injury, shall have adequate corona shielding with a semi-conducting compound, and shall withstand specified continuous temperature without injury. The coils shall be form-wound and interchangeable.

The end portions of the coils and the connection shall be rigidly supported and braced to prevent vibration and distortion under stresses caused by the most severe short-circuit condition to which the generator may be subjected.

(ii) Rotor

The pole pieces shall be built of thin lamination secured by bolts and shall be fastened to the rotor rim by means of dovetails and held in position by tapered keys. The keys shall be locked in place on both sides of rotor rim so as to prevent the key from coming out in the event they should become loose.

The entire rotor shall be designed to safety withstand all mechanical stresses to be imposed by the maximum runway speed of the turbine. Special care shall be taken to prevent the end turns from deforming or slipping due to the centrifugal stresses on the interconnections. The poles shall be provided with copper dampers-bars and a complete damper winding. The rotor leads shall be connected to the brushless exciter mounted on the generator shaft.

m. Shaft

The generator shaft shall be forged carbon or alloy steel properly heat-treated. The shaft shall be of ample size to operate safely in combination with the turbine shaft supplied at any speed up to the maximum runway of the unit without detrimental vibration or distortion.

The exterior cylindrical surface of the shaft and couplings shall be accurately and smoothly machined all over and polished at bearing surfaces. The end of the shaft shall be arranged for suitable direct coupling to the turbine shaft. The Contractor shall provide both halves of coupling, complete with all necessary bolts and nuts.

All coupling dimensions shall be agreed by the turbine and generator manufactures, and shall substantially conform to ANSI Standard B49.1 FOR "Shaft Couplings, Integrally Forged Flange Type for Hydroelectric Units". The Contractor shall supply all bolts, tool and special equipment necessary for field assembly of the coupling.

The Contractor shall make all necessary provisions to install on the shaft the speed signal generator for the governor, the brushless exciter and the separate flywheel if required. The Contractor shall also install in the generator all wiring and piping for above Plant.

The shop alignment test of the combined generator and turbine shafts shall be carried out by the Contractor with the witness of the Engineer. Any corrections to the generator or turbine shaft for proper alignment shall be made immediately, if necessary. The Contractor shall co-operate to effect this so as to minimise any delay and to adhere to the schedule.

n. Bearings

The generator shall be provided with the thrust bearing and journal bearings. The thrust bearing shall be located at the turbine side of generator.

The thrust and journal bearing shall be of forced-oil lubrication type. If oil bath type bearings with self-lubrication system are offered, the Contractor shall ensure that the bearings shall be adequately lubricated during starting after long periods (more than four months) of shutdown and shall not rely on the inherent oil film remaining from the last run. The bearings and lubrication oil system shall be designed so that neither the bearing nor the oil temperature shall exceed 40 ° C above ambient

temperature under continuous normal operation. If oil cooling required for the lubrication system, suitable resistant oil coolers of ample capacity shall be provided in the system.

All necessary apparatus including forced pumping system, piping, valves etc. to complete the lubricating oil system shall be provided. And oil sight gauge shall also be provided on each oil reservoir.

The thrust and journal bearing shall be designed to withstand safely and without damage the natural retardation of the turbine-generator unit from the maximum runaway speed to rest without the use of the generator brakes, and shall be tested on Site.

Sufficient lubricating oil to fill the generator bearing system plus and additional 50%, shall be furnished with the generator.

o. Generator Housing

A steel plate housing shall be furnished for the generator and shall be sufficiently rigid to prevent objectionable vibrations.

The generator housing shall be designed suitable for air duct ventilation system and shall be arranged to permit easy removal for the purpose of inspection and maintenance.

p. Generator Heaters

Generator shall be provided with suitable type space heaters of adequate capacity to prevent moisture condensation while the generator is shutdown. The space heaters shall be arranged to be energised automatically when the generator is not running. Power supply to the heaters shall be three-phase 380 volt or single-phase 220 volt AC

q. Bedplate

The generator components shall be mounted on a common bedplate to facilitate site alignment. The generator shall be fully assembled and aligned and doweled on the bedplate at the manufacturer's shop.

r. Neutral Grounding Resistor

The generator shall be provided with a suitable grounding resistor to be connected to the generator neutral point to limit the neutral grounding fault current to 100 A.

s. Accessory Leads Control Cabling

Leads within, or on the generator and housing including leads for excitation, search coil, controls, space heaters, temperature detectors, speed signal generator, current transformer secondaries and other accessories shall be furnished and installed in rigid galvanised steel conduits complete with necessary mounting clamps and fittings. Leads shall terminate with terminal blocks in the connection box to be placed at one convenient location on the generator housing.

14.3.3 Excitation System

a. Type and Performance

The brushless excitation system shall be supplied and installed for the generator. The brushless excitation system shall consist of an alternating

current exciter (AC exciter), rotating rectifiers, and excitation transformer, field flashing system, field switch, voltage regulating equipment and other accessories.

The capacity of the excitation system shall be more than 110% of capacity required for the generator. The ceiling voltage of the excitation system shall not be less than 150% of the rated field voltage under the field winding temperature at 75° C. The response ratio of the system shall be not less than 1.0.

The excitation system and voltage regulating equipment shall be able to operate safety at any speed up to the frequency corresponding to the maximum momentary speed rise of 140% of the rated speed when full load rejected.

All equipment for the brushless excitation system except for the rotating parts shall be constructed, to the maximum possible degrees, and shall be housed in a metal enclosure.

b. AC Exciter

The AC exciter shall be coupled directly with the generator shaft. The AC exciter shall be three-phase, air-cooled, rotating armature type generator. Circulation of cooling air and ventilation shall be made by means of fan blades attached on the exciter. The field current of the AC exciter shall be energised from the section-service supply system via excitation transformer.

The AC exciter compartment shall be sealed from the generator housing, but opened to the generator room. Openings in compartment shall be covered by punched metal sheets to prevent entering any articles into the machine. The AC exciter shall be fully accessible from outside of servicing and inspection.

The exciter winding shall be insulated with class F insulation, although temperature rises and total temperatures shall not exceed those permitted for class B insulation.

The capacity of the AC exciter shall be more than 110% of the rated capacity required for the generator. The AC exciter shall be designed to withstand the maximum runway speed without damage.

c. Rotating Rectifier

The rotating rectifier shall be of three-phase full bridge silicon diode type and connected with the AC exciter.

The rectifier shall be provided with protection device to suppress overvoltage and transient voltage in the rectifier circuit. The rectifier diodes and protection device shall be mounted rigidly on the holder ring so as to withstand centrifugal force of the maximum runway for all site ambient temperatures.

The rectifier shall be so designed that even when one diode is fault, the generator shall be able to keep running safety under the guaranteed generator ratings until the next scheduled servicing shutdown. Diode failure detector shall be provided to give protection and alarm for the excitation system.

Suitable means shall be provided for measurement and indication of main generator field current and voltage and for main generator field ground detection.

d. Excitation Transformer

The excitation transformer shall be of three-phase, 50 Hz, self-cooled, dry type epoxy resin moulded coil construction. It shall have an ample capacity for the operation of excitation system, Full rated capacity taps shall be provided on the primary winding enough to cover the complete range of regulator operation. The secondary winding shall be shielded suitably from the primary winding and the shielding device shall be solidly grounded.

The transformer shall be equipped with standards accessories including a transformer temperature indicator with adjustable high temperature alarm contact as approved by the Engineer. The contacts for the thermometer shall be normally opened and shall close in the event of abnormal conditions, and shall be insulated from ground and suitable for use at 110 V.D.C. Provision shall be made for overcurrent protection in the excitation transformer circuit. All contacts shall be wired to terminal block for interconnection to external circuit.

The excitation transformer shall be housed in the low voltage switchgear cubicle.

e. Voltage Regulating Equipment

The voltage regulating shall consist of and automatic voltage regulator (AVR) and a manual voltage regulator, complete with all auxiliaries such as control transformers, resistors, rheostats, necessary shunts, contractors, relays and their control equipment for full voltage regulation of the brushless excitation system.

The automatic voltage regulation shall be of high speed, quick response.

The generator voltage control shall be accomplished by the continuous comparison of the average three-phase voltage of the generator with a reliable and stable reference voltage source in the control.

The automatic voltage regulator shall continuously respond with high speed to correct any change in generator voltage and maintain the generator terminal voltage under steady state conditions within plus or minus 2.5 percent (±2.5%) without hunting for any excitation value within the normal operating range.

On overvoltage resulting from sudden load rejection or successive overspeed up to 150% of the rated speed, the automatic voltage regulator shall limit the instantaneous output voltage change of overvoltage or overspeed.

Provision shall be made for rapid field de-magnetisation whenever the generator lockout relay is operated.

Necessary device for parallel operation with the existing power system shall be provided.

The automatic voltage adjusting device shall provide a voltage control range from minus 20% to plus 10% rated voltage.

The manual voltage regulator shall be provided to regulate the excitation system output D.C. voltage stability from about 30% of the rated

generator voltage to that required for generator operation at 100% rated load at rated power factor, rated frequency and 105% rated voltage.

Necessary current transformers and voltage transformers shall be provided in the Indoor cubicle (detail is described on 14.5.5) to be provided with the following functions :

(i) Placing the regulator in manual or automatic operation, including test before transfer.

(ii) Placing the regulator in or out of service during automatic starting or stopping control sequence of turbine generator unit.

(iii) Automatic positioning follow-up of the excitation system manual regulation at the setting from no-load to full load during automatic voltage regulation.

(iv) Indication of excitation system voltage and current outputs, and all quantities pertinent to operation.

(v) All necessary indication equipment.

f. Protection and Alarm for Excitation System

The protection for the excitation system shall be classified into two groups by the nature and extent of failures or troubles when heavy troubles or faults occur, the excitation system shall be tripped out and the generating unit shall be brought to Emergency stop operation. When troubles or faults are not so serious, faulted devices shall be isolated from the system without interruption of the generator excitation and alarm shall be given.

The protection and alarm system for the excitation system shall be designed to be compatible with the protection and alarm system for the generating Plant. The protection and alarm shall be provided for, but not limited to, the followings:

(i) Protection (Trip)

- AVR power source, failure
- Thyrstor on static circuit, failure
- Two (2) diodes on one phase of rotating rectifier, fault
- Circuit breaker in the excitation transformer circuit, trip
- AVR, fault
- Field overvoltage

(ii) Alarm

- One (1) diode on one phase of rotating rectifier, fault
- Field circuit, ground

All items for protection and alarm shall be indicated on the group annunciator provided on the excitation control panel

g. Excitation Control Panel

A self-supporting, indoor use, metal enclosed panel shall be provided for excitation control Plant, containing all necessary components with indication and control Plant completely wired and mounted on the panel. The following equipment shall be furnished and mounted in the panel in an approved manner :

(i) Power rectifier equivalent

(ii) Voltage regulator equipment

(iii) One (1) selector switch for generator voltage control with Two (2) positions of "AVR" and "MANUAL"

(iv) One (1) generator field circuit breaker with auxiliary switches

(v) One (1) field discharge contact and resistor

(vi) One (1) initial excitation contactor with resistor

(vii) Group fault indicator

(viii) One (1) initial excitation contactor with resistor

(ix) Necessary relays, control transformers, resistors, rheostats, instruments, D.C. shunts, contactors, etc.

(x) Terminal blocks and other necessary accessories to make a complete working excitation control system.

14.3.4 Erection and Maintenance Tools (include Accessories)

a. Erection Tools and Equipment

One (1) complete set of case hardened wrenches and any special wrenches, tools, slings, and other special equipment that may be necessary or convenient for assembling for dismantling any parts of the generator or auxiliary Plant, shall be supplied. A complete detailed description and itemised list of the tools and equipment proposed to be furnished shall be submitted with the Tender. All such tools and equipment shall become and remain the property of the Employer. The wrenches and tools shall be mounted on neat shadow board arranged for wall mounting and provided with means for ready identification.

b. Accessories

The following accessories shall be supplied for the generator and excitation system.

(i) All necessary foundation and anchor bolts for the generator and associated Plant.

(ii) All necessary lifting lugs and eyebolts required for installation or removal of machine and Plant.

(iii) All necessary bolts and nuts of each size used.

14.3.5 Spare Parts

The following spare parts shall be furnished and quoted:

a. One (1) set of each bearing metal

b. One (1) complete set thrust bearing number and pad

c. One (1) set of spare parts for the voltage regulator and excitation control Plant for 5 years operation.

d. Two (2) set of rectifying element for exciter

e. Two (2) dial thermometer for thrust bearing, two(2) dial thermometer for journal bearings.

f. 500% of actual use of lamps and fuses

g. One (1) glass for each type oil level sight gauge

h. One (1) complete assembly of each type of flow relay, timer, rheostat, rectifier and other special devices.

i. One (1) complete assembly of each type of relay, contactor, switch, print-circuited board, etc., used in the equipment.

j. One (1) set of O-rings, seals and gaskets for lubrication oil system

k. Any other spare parts if any, shall be recommended by the manufacturer and shall be listed and quoted in the Tender.

14.3.6 Tests

a. Tests at Manufacturer's Workshop

The following test shall be carried out at the manufacturer's workshop before shipment.

(i) Material test

(ii) Shaft run-out check

(iii) Check of the dimensions

(iv) Resistance measurements for field and stator windings

(v) Insulation resistance measurement

(vi) High voltage test for stator and rotor

(vii) Loss angle measurement of generator stator

(viii) Characteristics of static excitation system with AVR

(ix) Test for all auxiliary Plant

After assembly at the manufacturer's workshop, the generator shall be subjected to the following tests :

(i) Characteristic curves of main generator for open circuit (up to 125 percent rated voltage) and short circuit (up to 120 percent rated current) performance

(ii) Determination of:

- Direct axis synchronous reactance
- Direct axis transient reactance
- Direct axis sub transient reactance
- Negative sequence reactance by sustained phase to phase short circuit
- Zero sequence reactance by sustained phase to phase natural short circuit
- Capacity of winding

(iii) Determination of looses and calculation of efficiencies, short circuit ratio and voltage regulation

(iv) Phase sequence test

(v) Shaft voltage test

(vi) Phase balance test

(vii) Temperature rise test

(viii) Wave from test at no load, normal speed and normal voltage

(ix) Overspeed

(x) Retardation test to determine flywheel effect (GD^2) of rotating parts

b. Test at Site

The generator and its auxiliary Plant supplied and installed shall be tested at the Site in accordance with the requirements of the preliminary test and the test on completion as specified.

14.4 TRANSFORMER

14.4.1 Scope

The transformer to be supplied and installed in the power station and shall be as follows

2000 kVA three-phase main transformer for stepping up the rated generator voltage to 20 kV, oil immersed, self cooled, outdoor use type.

14.4.2 Temperature Rise

The maximum temperature rise for oil immersed type transformer shall not exceed the following values at the rated output:

- 40° C above ambient temperature in oil by thermometer
- 40° C above ambient temperature in winding by resistance measurement

14.4.3 Frequency

The transformer shall be designed for the frequency of 50 Hz

14.4.4 Insulation Levels

The transformer shall be designed to withstand continuous operation at 20 kV and momentary higher voltages induced by lightning.

14.4.5 Insulating Oil

Insulating oil shall be non-sludging and of medium viscosity. The characteristics of oil shall comply with IEC 296 Class I and shall be equivalent to "shell Diala B" which is available in Indonesia or equivalent with shell Diala B.

14.4.6 Main Transformer

a. Type and Ratio

The transformer shall be of three-phase, oil immersed, self cooled, outdoor use type with off circuit tap changer.

b. Rated output

The continuous rated output of the transformer shall be stated kVA rating on any of the taps on the 20 kV side winding of the transformer.

c. Impedance

Impedance voltage at the rated output shall be not less than 5 percent

d. Core

The transformer cores shall be built up of thin laminations of the best quality no ageing silicon steel. Lamination shall be coated with insulating material and clamped securely with insulated bolts.

The design of the core and the method of clamping shall be such as to ensure it free from excessive noise and vibration. The clamping framework shall be built up of structural steel members.

The core shall be provided with lifting eyes or other approved arrangements to permit easy and ready access, and so designed that the core windings can be lifted from the tank with as little dismantling as possible.

Suitable means shall be adopted to prevent circulating current being set up within the core.

The core and windings shall be so located within the tank as to prevent movement. The core shall be electrically connected to the transformer tank.

e. Winding and Insulation

The windings shall be of high conductivity copper or aluminium.

The amount of insulation shall be determined not merely by normal voltage per turn, but also by due consideration of the line voltage and the service conditions and other associated fault conditions.

The insulation of the end turns of each winding adjacent to the transformer terminals shall be reinforced between turns or provided with suitable means to protect the winding against surges and transients.

The windings shall be so arranged and so firmly clamped in position that they will withstand the mechanical stresses to which they might be subjected on short circuit.

f. Bushing

All bushings shall be of solid single-piece porcelain type.

The terminal of each bushing shall be bolted with compression type terminal for cross-linked polyethylene (XLPE) insulated cables with a copper conductor of the proper size.

All bushings shall be brown or white glazed.

g. Tank

Cores and windings shall be enclosed and securely held in a tank made of stout steel plates. The tank shall be of welded construction, suitably stiffened by means of channel or angle section welded to the tank, and shall be absolutely water and hot oil tight and suitable for vacuum drying. It shall be designed so as to permit convenient handling. Necessary lugs and shackles shall be provided to enable the whole transformer to be lifted bodily by truck crane or other means.

The base of the transformer shall be of skid type.

The tank cover shall be designed so that the bushings can be easily removed and connections to the windings easily made.

The inside of the tank and all the steel connections shall be sand or shot blasted. All mill scale shall be completely removed from the outside of the tank before painting.

Two grounding pads for 95 mm^2 copper conductor shall be welded to the base of the tank.

h. Radiator

The transformer shall be provided with radiators of sufficient capacity to prevent overheating the transformer when operated continuously at the rated output of the transformer.

i. Tap Changer

The off circuit tap changer shall be provided on 20 kV side with taps at 21 - 20.5 - 20.0 - 19.5 and 19 kV. The tap changer shall be capable of operating under off circuit condition from the outside of transformer. Tap position must be clearly indicated and means of locking shall be provided. All taps shall be rated for full output.

j. Protection

The following protection shall be provided on the transformer:

(i) Oil temperature high; alarm

The dial type indicating thermometer calibrated in centigrade and equipped with alarm contacts shall be supplied for indicating the oil temperature.

k. Skid Base

Skid base shall be locked after positioning on foundations by means of appropriate devices.

l. Accessories

The following accessories shall be provided for the transformer:

(i) Oil valves for oil handling and sampling

(ii) Explosion vent

(iii) Oil level gauge

(iv) Pressure gauge

(v) Dial thermometer with alarm contact

(vi) Hand hole

(vii) Lifting lugs

(viii) Rating plate and connection diagrams with full details of rating

(ix) Necessary terminal connections

(x) Two grounding pads

(xi) Foundation bolts and nuts

(xii) Cover plates for high voltage and low voltage bushings

(xiii) Other necessary accessories

m. Spare Part

(i) The following items shall be furnished and quoted as spares:

(i) One (1) bushing of each type with conductor and terminal

(ii) One (1) set of gaskets

(iii) One (1) oil level gauge

(iv) Two (2) bursting plates

(v) One (1) pressure gauge

(vi) One (1) dial thermometer

n. Test

The following tests shall be carried out at the manufacturer's workshop before shipment:

(i) Appearance check

(ii) Measurement of ratio on all taps

(iii) Check of polarity and phase relationship

(iv) Measurement of winding resistance at each tap

(v) Measurement of no-load current and losses

(vi) Measurement of load losses at rated current

(vii) Measurement of impedance voltages on all taps

(viii) High voltage test

The certificates of the following type test items shall be submitted with the test report:

(i) Temperature rise test

(ii) Impulse voltage test

14.5 CUBICLES AND EQUIPMENT

14.5.1 Scope

The cubicles to be supplied and installed are as follows :

a. Three (3) Outdoor metal-enclosed cubicle include 20 kV equipment.

b. Five (5) Indoor metal enclosed cubicle include station service equipment and 20 kV equipment for the Krapyak substation.

14.5.2 General Arrangement

This will be determined by the Contractor conforming to the tender drawings in principle.

14.5.3 Electrical and Mechanical Design

Cubicles shall be electrically designed to avoid local corona formation and discharge likely to cause radio interference, and shall be designed to mechanically endure short-circuit current without thermal and mechanical failure for one (1) second. All enclosure shall be of dust proof and vermin-proof, and where required weather-proof.

The enclosures shall be totally enclosed, by sheet steel panels not less than 2.3 mm thick, with angle or channel edge bent, seam-welded at corners, and ground smooth. Panels shall be bolted at the bottom to suitable steel channel sills with necessary framing which will hold the structure rigidly together to form a self supporting dead front type of structure. Outside panels shall not be drilled or welded for attaching wires, resistors, of instruments.

Space heaters for 220 volt ACC shall be provided inside the cubicles to prevent moisture consideration. A manual switch to control the heaters shall be provided in the cubicles.

Lighting fittings for 220 volt ACC with door switches shall be provided inside the cubicles.