

SECTION 6
TESTS FOR MECHANICAL AUXILIARY EQUIPMENT

SECTION 6 - TESTS FOR MECHANICAL AUXILIARY EQUIPMENT

S6.01 TESTS DURING MANUFACTURE

(Except powerhouse crane)

The mechanical auxiliary equipment shall be subject to the following tests at the Contractor's premises.

(1) Material Tests

Material tests shall conform to the requirements of Clause S4.01 (1) (a).

(2) Hydrostatic Tests

Hydrostatic tests shall conform to the requirements of Clause S4.01 (1) (b).

(3) Performance Tests

(a) Operating tests on all electric motors under conditions simulating the actual service for output, efficiency, power factor, temperature rise including oscillograms of starting and running current voltage.

(b) Hydraulic, pneumatic and electric tests on all pumps, compressors, air-conditioning units and fans under conditions simulating the actual service to demonstrate that the performance complies with the Contract and to establish complete operating characteristics. Particular attention shall be paid to limiting noise and vibration levels.

(c) Performance tests on the air-conditioning units.

S6.02 TESTS AT SITE

(Except powerhouse crane)

(1) Preliminary Test

The preliminary tests for the mechanical auxiliary equipment shall include the followings:

(a) Hydrostatic pressure tests on all piping systems. The test pressures shall be respectively the same as specified in Clause S4.01 (1) (b).



- (b) Insulation and continuity tests on wiring including tests for correctness of connection.
- (c) Checking pipework for freedom from obstructions.
- (d) Checking for correct operation of each control, protection and indication device.
- (e) Checking the operation of all pump and compressor assemblies for vibration, overheating, leakage from joints, seals, glands, etc.

(2) Tests on Completion

For the mechanical auxiliary equipment, the Tests on completion shall include the followings:

- (a) Tests of the correct functioning of automatic and manual control and protection equipment. These shall include a demonstration of correct repetition of twenty consecutive operating cycles.
- (b) Tests to verify that the operation and system performance of all pumps and compressors are in accordance with the Contract.
- (c) Tests to verify the performance of the ventilation and air-conditioning plant shall include:
 - . The continuous operation of all equipment for at least 50 hours to demonstrate that it will operate without overheating.
 - . The measurement of air quantities flowing in each ventilated or air-conditioned room.
 - . The measurement of temperatures and humidity in each air-conditioned room at regular intervals during a test period of 50 hours. These tests shall if practicable be carried out on days when outside air conditions are close to design extremes. The outside air conditions shall be measured during the tests.
- (d) The measurement of noise levels during the running of the plant at maximum load.
- (e) Tests to verify that the operation and performance of other mechanical auxiliary equipment is in accordance with the Contract.



S6.03 TESTS DURING MANUFACTURE FOR POWERHOUSE CRANE

The power station crane shall be subject to the following tests at the Contractor's premises.

(1) Material Tests

Material Tests shall be as specified in Clause S4.01 (1) (a).

(2) Tests on Assembled Crane

All parts of the crane shall be fully assembled, wired and tested for correct operation at the Contractor's premises. For these tests the hoist ropes need not be fitted to the drums.

S6.04 TESTS AT SITE FOR POWERHOUSE CRANE

(1) Preliminary Tests

The preliminary tests on the powerhouse crane shall be carried out as soon as erection is complete and shall include the checking of connections and testing for correct operation of all equipment.

(2) Tests on Completion

The following tests shall be carried out regardless of any tests which may have been carried out at the Contractor's premises

- (a) Tests of the response to all controls, without load.
- (b) Tests of the operation of the hoist, travel and traverse limits, without load.
- (c) Tests of operation of the brakes on the hoist when loaded to 25 percent in excess of the rated load.
- (d) Measurement of the maximum deflections of the main beams of the crane under rated load and the overload conditions specified above.
- (e) Recording the travel and traverse speeds under the overload conditions specified above.
- (f) Measurement of the hook height from the assembly bay floor and total height of lift without load.



- (g) Measurement of the hook approaches to the walls without load, and the overrun remaining when the limits have tripped and the brake has applied.
- (h) Measurement of the hoisting and lowering speeds without load and with rated load.
- (i) Measurement of longitudinal travel and traverse speeds without load and with rated load.



SECTION 7
GENERATORS AND AUXILIARIES

SECTION 7 - GENERATORS AND AUXILIARIES

S7.01 GENERATORS

(1) Scope of Work

The work to be done under this section consists of the design, manufacture, supply, delivery to site, installation, commissioning and guarantee of synchronous generator Two (2) Complete Set, unit capacity not less than 3,150 kVA for 50 Hz operation, as specified herein.

(2) Purpose and Function

The generator supplied in this contract shall have single driven shaft and having enough extended length to mount Pelton turbine runner. The unit shall be used to generate 3-phase, 3,300V, 50 Hz electric power at generator terminal, which will be stepped up to 33 kV, for incorporation into existing 33kV high voltage systems.

(3) Responsibility of the Bidder

The Bidder shall guarantee and be responsible for the hydroelectric generator supplied under this project.

- The output and efficiency of the generator and temperature rises of the various parts as specified under this section.
- Generator bearing housings for both DE and NDE sides shall be fixed at the generator casing with its own external lubricating oil system so that separate bearing housing design is not acceptable due to limited dimensions inside power house.
- The Bidder shall submit with the Bid for the equipment layout drawings of synchronous generator, turbine runner, lubricating oil system and hydraulic oil pressure unit showing the actual dimensions of equipment to be located in turbine floor as preliminary design information to evaluate that the proposed equipment shall be installed inside the given dimensions.
- Furthermore, minimum dynamic forces such as axial, radial and thrust forces which are necessary for Civil Work Contractor to design the foundation of major equipment.
- To indicate the strength and forces of all extended parts to withstand all mechanical and electrical forces and other related forces which may be experienced in normal operation and emergency shutdown conditions as well as those caused by terminal and field short circuits, over speed conditions and any fault conditions.



(4) Standards and Codes

The work covered by these Specifications shall be designed, manufactured and tested generally in accordance with the following standards and codes or approved equivalent.

- | | |
|--|------------------------|
| - National Electrical Code | ANSI C2 |
| - AC generators | ANSI C50.10, C50.12 |
| - Standard Criteria and Definitions
of Excitation Systems for
Synchronous Machines | IEEE STD 421 |
| - Shaft | ANSI B49.1 |
| - Motors | MEMA MG 1 |
| - Control Cubicles | MEMA SG 5 |
| - Instrument Transformers | ANSI C57.13, NEMA EI 2 |
| - Relays | ANSI C37.90 |
| - Indicating instruments | ANSI C39.1 |
| - Wire | Metric standard |
| - Screw threads | Metric standard |
| - Transformers | ANSI C57 |
| - Definition of electrical items | ANSI C42 |
| - Test Code for Synchronous Machines | IEEE No. 115 |

Where reference is made to any of the above standards and codes, the issue current at the time of design shall apply.

(5) Description

The units shall be of the Vertical-shaft, revolving field, synchronous brushless type and shall conform to the latest standards of ANSI and IEC Standards unless otherwise specified herein.

The Pelton runner shall be equipped and mounted at synchronous brushless generator shaft with digital AVR excitation system of adequate capacity to meet all AC generation requirements under all possible service conditions.

(6) Capacity and Efficiency

The unit shall have a continuous rated output of not less than 3,150 kVA at 0.8 percent power factor (overexcited). The maximum temperature rise of both stator and rotor windings at rated output and normal conditions shall be 80°C based on ambient air temperature not exceeding 40°C in accordance with ANSI standards.

The units shall be capable of operation over the following conditions:-

- Generator output up to rated kVA continuously at voltages 5 percent above or below voltage for a range of power factors from 100 percent to 80 percent (overexcited) at 50 Hz system operation with a 40°C ambient temperature.
- Guaranteed efficiency shall not be less than 96.0% at 0.8 P.F. running at rated output not less than 3,150kVA.
- Short Circuit Ratio should be not less than 0.8 p.u.



(7) Speed, Direction of Rotation and Frequency

The Speed of unit shall be designed and selected based on turbine design for 50Hz operation, and shall be capable of operating continuously at a runaway speed to be determined by the turbine characteristics and shall be provided in the Bid.

The direction of rotation shall be clockwise when viewed from the top.

(8) Voltage and Phases

The unit shall be designed to deliver its rated capacity at a balanced 3-phase potential 3,300 V between phases. The tests and guarantees shall be based on this voltage and 50 Hz operation. The unit shall operate successfully at rated capacity at 5 percent above or below rated voltage.

(9) Insulation and Noise Level

The generator stator windings and all connections, main and neutral leads, etc., shall be insulated in accordance with ANSI C50.10 and the Coil shall be treated with VPI (Vacuum Pressure impregnation) and have Class B temperature rise and Class H insulation.

The noise level should not be more than 85 dBA measured from 1 meter distance around the generator.

Evidence of VPI shall be attached with the Bid.

(10) Harmonic Distortion, Wave Form and Telephone Interference Factor

The total harmonic distortion shall be not more than 5% according to IEEE standards. The potential wave form of the generator open-circuit terminal voltage shall not deviate from a sine wave more than 10 percent in accordance with ANSI standards.

The telephone interference factor shall be within the limits specified in ANSI standards.

(11) Flywheel Effect

The flywheel effect (WR^2) of the rotating parts of the combined turbine runner and generator shall be calculated as per the given information in the Bid

Failure to submit this information will subject to rejection of the Bid.



(12) Soleplates

The Contractor shall provide a Turbine Casing for mounting the generator. The Contractor shall be responsible for ensuring that the turbine casing are placed at the correct position and approval by DEDE Engineer. Means for adjustment shall be above the concrete surface.

(13) Stator

- (a) Stator Frame and Iron: The design of the stator frame, the soleplates and the means of attachment of the turbine casing shall be suitable to withstand all stresses to which they may be subjected in service as a result of all types of short circuits or faults.

Cast finger supports for the laminations will not be accepted.

To minimize the effects of end-iron heating during operation, adequate ventilation shall be provided and nonmagnetic materials shall be employed where necessary.

- (b) Stator Winding: The stator winding shall be made of copper conductors and the conductor strands shall be transposed to minimize stray losses. Facilities shall be provided for terminating the cable on the unit housing. Final details of the main lead termination at the unit shall be subject to approval by the DEDE Engineer. All bolted main current-carrying terminals shall be silver-plated.

The generator star neutral point shall be brought out and connected to the generator neutral resistance cubicle via MV cables. The location of the neutral resistor cubicle shall be installed nearby synchronous generator.

The stator winding shall be capable of successfully withstanding dielectric test in accordance with ANSI standards.

Adequate means shall be taken in the design and assembly of the stator winding to ensure the followings:

- The stator coils shall be adequately supported and braced to prevent dropping in the slots and to withstand the full stresses developed due to electrical fault conditions. Adjacent coil ends shall be held apart by spacers and bound to each other. Cording used to hold coils in position shall not be continuous (i.e. each coil shall be tied separately). The support rings to which the coils are lashed and supported shall be made of nonmagnetic material.
- The stator coils, when installed, shall fit firmly in the slots. A coil rejected because of slot fit shall not be used unless rebuilt.
- The stator coils shall be tightly wedged in the slots with wedges that will not buckle or shrink.



- The wedge in each slot shall be prevented from dropping out should it become loose in service.
 - The stator coils, including spares, shall be manufactured to fit the stator core and end deformation will be the minimum necessary during installation.
 - The insulation of the stator coils shall be sufficiently durable that, should it be necessary at any time to remove the coils, their removal and replacement may be carried out without damage to the insulation of any of the other coils. The quality and life of the insulation shall be impaired in attaining the above requirements.
 - The stator coil insulation, wedging, packing, bracing and typing shall be such as to minimize the effect of thermal shock and of additional differential expansion which may occur as a result of the overload conditions.
 - All possible measures shall be taken to maintain tight fit of coils in the slots to prevent vibration, loose wedges and consequent high intensity discharge in the slots.
- (c) Resistance Temperature Detectors: The Contractor shall supply 2 resistance temperature detectors per each phase, embedded in the various parts of the stator winding in accordance with ANSI C50.10.

The resistance temperature detectors shall be embedded in a suitable location, one at each end of the stator core for temperature measurement for the detection of end-iron heating.

The exact location of the resistance temperature detectors in the stator winding and core shall be subject to the approval of the DEDE Engineer. All resistor temperature detectors in and around the generator shall be wired to a terminal box mounted on the outside of the generator air housing. This terminal box shall be separated from other terminal boxes.

All connections from the resistance temperature detectors to the terminal boards shall consist of twisted leads in shielded instrument cables.

The resistance temperature detectors shall have a resistance of 100 Ohms at 0°C over a temperature range of 0°C to 120°C.

All of the resistance temperature detectors shall be connected to the Unit PLC Control Panel for monitoring and protection the Units.

(14) Rotor

The rotor winding shall be insulated with Class H insulation as defined in ANSI standards, and shall be designed to withstand 10 times rated field voltage or standard voltage dielectric test to ground for 1 minute.

Each field coil shall be fabricated that the space between adjacent turns is completely and solidly filled with insulating material to ensure uniform insulation thickness between conductors throughout the coil. Every effort shall be made to avoid excessive deformation or burring of the conductor during forming of the coil.



The design of the rotor shall be such as to permit the easy removal and replacement of the field poles. If tapered keys are used to secure the field poles to the rotor rim, the drive key shall project above the rotor rim a sufficient distance to facilitate removal of this key by means of a key puller and to permit checking for tightness after over speed tests have been performed.

(15) Reactance

The reactance values shall be provided in the Bid as manufacturer's preliminary design values such as the values for synchronous, transient, sub-transient and negative sequence reactance under unsaturated and saturated conditions with short circuit ratio values, armature time constants and armature resistance. The generator manufacturer's design curves such as Capability Curve, Short Circuit Curve, Efficiency Curve, and Transient Voltage Curve during load rejection, Stator Earth Fault Curve, shall also be submitted together with manufacturer's Drawings from factory having complete dimensions verifying such manufacturer is well proven and qualified manufacturer to produce the synchronous generator under European and American standards.

(16) Generator Enclosure

The generator enclosure shall provide an open-circuit ventilation system. The enclosure shall be arranged to permit easy removal for the purpose of inspection and maintenance.

No materials capable of supporting combustion shall be used within or in the construction of the generator enclosure. Anti-condensation space heaters, automatically controlled by thermostat shall be provided and the analog signal shall send to PLC for monitoring and protection.

(17) Cooling System

The generator shall be self-ventilating with its own fan cooling action being utilized the force air through the windings, ducts, etc. Fan blades on the rotor shall be given special care in their design and in securing them to the rotor so that they will be held rigidly in position at any speed which the rotor may attain.

The generator shall be of the opened air-cooled design. The generator cooling air, after passing over the field, stator iron and windings, shall be diverted through the generator housing and exhausted outside the powerhouse.

(18) Braking System

- (a) The braking system shall be of the hydraulic oil pressure operated friction brake type and it is to be supplied from governor oil pressure unit.
- (b) The brakes shall be interlock with digital input contact via limited switch to Governor PLC so that the brake unit will not be applied at speeds more than 10% (or) when the turbine guide vanes are in opened position.
- (c) Brake cylinder shall be provided with a limit switch, to provide status contact to Governor PLC for Brake Applied (or) Not Applied status. Governor PLC

will applied brake during the unit stop (or) shutdown sequence at that time of unit speed is less than 10% of rate. Unit shutdown shall occur when the status of brakes are applied during unit speed more than 10%.

- (d) To minimize scoring of brake tracks, ample area of brake lining shall be provided and the type of lining supplied shall be matched to the hardness of the brake track surface (which shall be checked by measurement) according to the followings:-

Brake Track Hardness (Brinell)	Brake Lining (Ferodo type, or Equivalent)
Less than 150	CR
150 to 200	MR, MZ or L
Greater than 200	BA

The brakes shall be located and arranged to minimize the entry of brake dust into the generator.

The evidence of Main Dimensional Layout of synchronous generator from Manufacturer's factory shall be submitted together with specific speed, rotational direction, material descriptions, GD^2 values, anchor bolts, etc. shall be submitted with the Bid to verify that the proposed manufacturer's design is complying with DEDE's specification and layout drawings attached in the Bid.

S7.02 SHAFT AND BEARINGS

(1) General

- (a) The arrangement of shaft and bearings shall be of the form as specified as above in Clause S7.01 with sleeve bearing type.
- (b) Bearing housing shall be directly fixed at Generator housing so that longer generator shaft and bearing operating life shall be properly designed to bear the weight of turbine runner and reliability of generating units.

The Bidder shall attach the generator layout drawings showing the above requirements with the Bid.

Failure to comply this requirement will subject to rejection of the Bid.

- (c) The separate bearing housing from generator housing is not acceptable and it will be subjected to the rejection of the proposed Bid.
- (d) The Contractor shall carry out a detailed mathematical analysis of the rotating parts of the turbine generator and their support systems to ensure stability, taking into account amplitudes and frequencies of transient axial and lateral thrusts and tensional vibrations together with steady-state loads emanating from the turbine and generator.
- (e) The Contractor shall be responsible for determining and applying the method of shaft and bearing alignment and for determining alignment tolerances.



- (f) The Contractor shall provide a bending diagram for the turbine and generator shafts and the relevant information shall be incorporated in the Operation and Maintenance Instruction.
- (g) The shafts, couplings and all rotating parts shall be designed to withstand any torque which the associated turbine can produce under any possible combinations of head, gate opening and speed.

(2) Shaft

- (a) The shaft shall be of forged steel machined all over. A central hole shall be bored throughout the length of the shaft in order to allow assessment of the quality of the interior material by examination of the bore. A secure means shall be provided to prevent water from entering into the shaft from the turbine end.
- (b) Shaft couplings shall not be used in this case. The turbine runner shall be mount directly on generator shaft

(3) Bearings

- (a) The bearings shall be heavy duty industrial type Roller ball bearing suitable for all operating conditions for starting and stopping, normal operation at rated generator output, and operation at up to the maximum runaway speed.
- (b) Provision shall be made to prevent the flow of electric currents through the bearings. The bearing insulation shall be arranged, by the use of an insulation/ metal/ insulation sandwich or similar method, so as to permit the insulation to be tested without dismantling any part of the unit.
- (c) **In case of lubricant is grease so that the contactor shall submit the automatic grease system with the bid.** The bearings housing shall be connected with automatic grease system
- (d) Alarm contact shall be provided at bearing housing to give an alarm and interrupt the starting sequences in the event of high bearing temperature. No water cooling pipes for bearing is allowed so that precautions shall be taken to prevent water oil from coming into contact with the circulating air system of the generator.
- (e) In case of external oil supply is used, bearing oil system shall be cooled by using external cooler with radiator (or) heat exchanger and shall meet the following requirements:
 - (i) The use of water cooled bearing will not be accepted.
 - (ii) Fouling of cooler tubes by algae and/or bacterial growth is expected.
 - (iii) The coolers shall be made of suitable material to permit periodic, low concentration acid injection (ten parts per million residual chlorine) into the cooling water system for algae and bacterial growth control purposes.



- (iv) Coolers shall be of sufficient capacity to allow the generator to run at full rated output with the coolers partly fouled and with one section of a cooler out of service for cleaning.
 - (v) Coolers shall preferably be so arranged that the water side of each section of a cooler can be safely drained, opened and cleaned in turn while the generator is in operation.
 - (vi) Pipe work shall be arranged to prevent emptying the cooling system when cooling water flow is stopped.
 - (vii) Cooling water shall be taken from penstock pipe and supply lubricating oil system and the Contractor shall provide the whole cooling system diagram of each turbine and generator unit shall be submitted for approval.
- (f) The design of the bearings shall preferably be such that neither high pressure oil injection nor low pressure oil overflow during starting and stopping sequence is required.
- The bearings shall not be damaged if the unit is stopped without the stopping and starting oil supply being available.
- (g) For the purpose of periodic oil purification, the sump tank of each lubricating system shall be provided with two pipe connections, terminated by stop valves and screwed caps, suitable for connecting the portable oil centrifuge unit.
 - (h) In case of lubricating oil pumping system is provided, it shall be supplied with enough capacity to circulate hydraulic oil having filters of sufficiently fine filtering capacity to prevent damage to any part of the bearing/ oil system by foreign matter.
 - (i) The oil temperature analog signals, starting and stopping digital signals of oil pump shall directly sent to PLC for Unit protection purpose to be included in Sequence of Unit Start and Unit trip.
 - (j) The filters shall be fitted with differential pressure indicators to give indication of the need for cleaning. Filters shall be capable of being individually cleaned without shutting down or reducing the output of the generator.
 - (k) All generator bearings shall be provided with a resistance temperature detector specified and the value shall be sent to PLC control system for protection and monitoring purpose. They shall be located at the parts most sensitive to the maximum temperature in the bearing housing.

The lubrication oil system (if applicable) diagram shall be submitted along with the Bid indicating all components and instruments for bearing protection.



S7.03 SIGNAL GENERATOR

(1) General

The Contractor shall provide all devices necessary for the PLC control system as specified in this Specifications and for the proper operation, maintenance and commissioning of the units.

(2) Speed Detector

- (a) The Contractor shall supply one speed detecting device for each generator which shall be directly sent speed analog signal to PLC Controller as speed detector. The detector shall be the speed measuring (or) sensing equipment which shall be a part of the unit control and indication system as specified in this Specification.
- (b) The output of the speed detector shall be wired to shrouded terminals in a junction box on the generator from which the Contractor shall connect instrument cables to the speed measuring equipment at PLC Panel.

S7.04 EXCITATION SYSTEM

(1) Type and Performance

- (a) A complete brushless digital excitation system with floor mounted cubicle, including automatic voltage regulating components shall be supplied for each generator.
- (b) The excitation system shall comply with the following performance:
 - (i) The system shall maintain the generator voltage stable and equal to the value determined by the voltage setting device when the generator is operating connecting with the system (or) separated from the system.
 - (ii) The maximum variation in generator terminal voltage when the operating conditions change from no load to rated generator output shall not exceed 1 percent.
 - (iii) In the event of an increase in generator frequency up to that corresponding to the maximum rise resulting from the loss of the generator load, the excitation system shall remain stable and it shall rapidly restore the voltage back to normal.
 - (iv) During transient disturbances such as load variation (or) short-circuits in the system, the excitation system shall be capable of functioning correctly and, in addition, providing increased excitation as required.
 - (v) Damping of oscillations between the generator and the power system shall be positive at all times and for all operating conditions within the capability of the generators.



(2) Exciter

- (a) All equipment required for the excitation system offered shall be provided.
- (b) Static electronic equipment shall be constructed, to the maximum possible degree, as plug-in withdrawable modules.
- (c) The semi-conductor equipment shall contain a number of devices connected in parallel, so rated that continuous operation of the generator at rated load will be maintained despite failure of any one paralleled semi-conductor circuit. Protective devices shall be provided in the control and in the semi-conductor circuits to isolate a faulty device without interruption of the generator excitation. The Bid shall provide details of the measures taken to ensure the reliability of the excitation equipment.
- (d) The excitation equipment shall be protected from or shall otherwise withstand the maximum voltages and currents arising from short-circuits, out-of-synchronism operation of the generators, or failure of supply to the excitation system.

(3) Voltage Regulators

- (a) A digital type automatic voltage regulator (AVR) shall be provided for the generator excitation system. The excitation current capacity for the AVR shall be limited up to 10A where the other parts of the exciter system design shall be able to work with this arrangement.
- (b) Manual control facility shall also be provided for the generator excitation system. Facilities shall be provided at the excitation equipment, to enable changeover from AVR to manual control of the excitation level.
- (c) Besides Manual Control, the AVR unit shall have Open Loop Control mode where there is no feedback loop on the Generator Voltage (Auto Mode) or Excitation Current (Manual Mode). Selector Switches shall be provided in front of cubicle.
- (d) AVR control loop feedback algorithm shall be PID (Proportional, Integral and Differential) type only. Filter type algorithm, or any other algorithm besides the PID type is not acceptable.
- (e) The AVR unit shall have build in soft start function under Auto Mode; where the Start Frequency (Hz), Start Level (% of Rated Voltage), and Ramp Time (Seconds), shall be provided under this function. External switches, Timer relay, separated PLC to achieve this function is not acceptable.
- (f) Exciter Rotating Diode monitoring function shall be built into the AVR unit, where two dedicated switch outputs shall be provided in the event of Alarm and Trip, this is on top of the other AVR Alarm/ Trip outputs to main PLC.



- (g) The AVR shall be supplied power from 110Vdc Station service source (or) other factory standard voltage using converter is also acceptable. And 230Vac power is also available for other auxiliary components inside AVR and Excitation Transformer Panel.
- (h) The AVR shall be responsive to the positive phase-sequence component of the generator voltage, and shall be independent of frequency.
- (i) The voltage setting device for the AVR shall be suitable for operation by hand at the local control cubicle and by remote control. The device shall provide a settable range of $\pm 10\%$ (with adjustable) of nominal generator voltage.

The Bidder shall submit the manufacturer's catalogues and layout cubicle drawings for excitation system with component list with the Bid.

Failure to submit this information will subject to rejection of the Bid.

(4) Field Circuit Breaker and Switches

- (a) Field Circuit Breaker and switches required for the excitation system shall be mounted in the excitation system cubicles.
- (b) Field switches shall be generally in accordance with ANSI and shall be fitted with all necessary devices for control and indication.

(5) Excitation Transformer

Excitation transformer shall be provided if necessary as per design criteria and excitation DC current, so that excitation transformer shall be 3 phase, indoor cast coil, copper or aluminum conductor, dry type with class F insulation, self cooled 80 Celsius temperature rise at 40 Celsius ambient temperature connected to generator terminal of 3300Vac. Busbar support with insulator, MV cables and Fuses for each phase shall be used if necessary. The ventilation fans and filters for the excitation transformer panel shall be provided.

S7.05 INSPECTION AND TESTS

(1) Factory Test

Generator shall be tested at factory in front of DEDE Engineers and the test program with procedures shall be submitted to DEDE for approval.

The Bidder shall submit the list of Factory Witness Test items according to IEC and IEEE standards so that the evidence shall be submitted with the Bid.

Bidder (or) Contractor shall perform the combined test for Generator, excitation system, lubrication oil supply system at Generator factory to verify that these are able used together without any trouble. If there is any defect (or) rejection of



manufactured equipment, the Contractor shall perform the same test at factory again after correction with his own cost.

(2) Individual Parts

All stator and rotor coils for the generator shall be tested in the factory for grounds and short circuit between turns. In testing the generator field coils for shorted turns, readings shall be taken of ac amperes, volts and watts, preferably using the same value of current to test all coils. Certified test reports for generator current transformers, as specified elsewhere, shall be submitted to the DEDE for approval before Witness Test.

(3) Generator

Test for Generator Unit shall be done determine the performance to determine the guaranteed efficiency as per Contract. The tests shall be done at manufacturer factory together with Excitation System and Lubrication System.

All tests shall be performed in according with IEEE Test Procedures for Synchronous Machines No.115 (or) IEC Test Procedures for Synchronous Machine so Contractor shall submit the test items, procedures to DEDE Engineer's Approval.

(4) Excitation System

Tests on the excitation system including tests on the components shall be proposed by the Contractor, incorporating with the reputable international standards, for the approval of the DEDE Engineer.

Functional tests shall be done combined with Generator so that the other internal test shall be done at excitation system factory and test reports shall be submitted to DEDE for approval.

(5) Performance of Tests after Installation

All tests made at the Site shall be performed by the Contractor. The Contractor shall submit to the DEDE Engineer for the method of performing tests. The Contractor shall ensure that all necessary precautions are taken to guard against accident or damage to persons or property in performing the tests and shall arrange for the supply and erection of all necessary barriers, guards and danger signs for safety purpose.

The Bidder shall submit the Field Test Procedures of Turbine and Generator Performance according to the applicable IEC Standards showing the diagrams, measuring methods with instruments and calculation criteria of efficiency together with Bid.

Failure to provide information may subject to the rejection of Bidder's Proposal.



Furthermore, for the completion of Testing and Commissioning, The Contractor shall perform the following tests for the generating units by connecting to the PEA power grid system:

- Dummy Load Test with heater load (in case of Grid is not ready) or the test can be performed with the PEA grid belong to the permission of the PEA
- Operation of complete excitation system including automatic voltage regulating equipment at various loads and including load acceptance and rejection.
- Continues Load Test for 50 hours to the PEA Grid



SECTION 8
AC STATION SERVICE TRANSFORMER
AND AC SWITCH BOARD

SECTION 8 - AC STATION SERVICE TRANSFORMER AND AC SWITCH BOARD

S8.01 SCOPE OF WORK

The work to be done under this clause consists of the design, manufacture, supply, delivery site, installation and guarantee of the following equipment:-

- One (1) set of 160 kVA, 3300/400Vac, 50Hz, Dry type metal-enclosed indoor, station service transformer
- One (1) set of 600 Vac, AC Distribution Board, metal-enclosed, indoor station service LV switchgear

S8.02 PURPOSE AND FUNCTION

Station service transformer (SST) shall be provided and to be used for step down the system voltage from 3.3 kV to 400/230 V to use for Station Service AC and DC Power Supply through AC distribution board. The transformer shall supply power to the units and powerhouse auxiliary services.

In case of the loss of generating power (or) in case of Unit Black start, the standby diesel generator shall be started automatically to supply AC power to the plant auxiliary equipment.

S8.03 STATION SERVICE TRANSFORMER

The transformer shall comply with TIS 384 and Provincial Electricity Authority's standard. The continuous rating of the transformer shall be 160 kVA based on an average copper temperature rise of 80°C over the ambient of 40°C. No-load losses and load losses shall not be more than 860 and 2,600 watt respectively.

The main characteristics of the transformer shall be as follows:-

Type	- Indoor metal-enclosed
Class	- Dry type, epoxy cast resin encapsulated,
Rating	- 160 kVA, 3-phase, 50 Hz
Primary voltage	- 3.3 kV, delta-connected
Tap range	- 4 Full-capacity, off-load, High Voltage taps at $\pm 2 \frac{1}{2} \%$ and $\pm 5 \%$
Secondary voltage	- 400/230 V, wye-connected, grounded neutral
Cooling	- Self-Cooled (AA)
Basic insulation level of HV/LV Windings (minimum dry 1 min)	
Power Frequency Test (1 min)	- 19 kV (Primary), 4KV (Secondary)
Basic Impulse Level Test (BIL)	- 40 kV (Primary), 10 KV (Secondary)



The high voltage bushings shall be connected to Load Break Switch and Lightning arresters as shown in Single Line Diagram. The connection cable to the low voltage bushing terminals of the transformer shall be with 600V power cable. The Contractor shall supply for the required current-carrying capacity and braced for the required fault levels for all phases and neutrals.

Ground Connections

The transformer shall have clamp type terminals for connection to the powerhouse ground system. Clamps and bolts, to accommodate a 95 mm² stranded cable, shall be provided for ground connections to the transformer core and to 2 points on the transformer enclosure.

Tap Changer

The transformer shall be equipped with a selector for off-circuit changing of the taps. This device shall have a lockable handle and position indicator external to the transformer enclosure.

High Temperature Detection

The transformer shall be equipped with oil temperature-sensing element with alarm contacts and it shall be send status to HMI PLC Monitor for alarm and trip.

Auxiliary Power

Power from the station battery at 125 V dc (nominal) will be available for transformer auxiliary circuits.

Details of the tests to be performed by the Contractor on the various components of the equipment shall be stated in the Bid and, in general, shall be as follows.

Factory Tests

Complete tests on the equipment shall be made at the factory by the manufacturer in accordance with ANSI standards for dry type, indoor type transformer, to determine the performance and operating characteristics and to confirm that the equipment functions properly. In addition to these tests, the following test shall be performed.

Standard insulation withstand tests on all small wiring and on all auxiliary devices at 1,500 V to ground, 50 Hz, for 1 minute.

Site Tests

The Contractor shall check the operation of all auxiliary circuits such as gauges, etc.

The Contractor shall carry out any other tests recommended to prove that the transformer is properly installed and adjusted to operate correctly and safely.

Tests shall be in accordance with Provincial Electricity Authority (PEA)'s regulation or ANSI C37.34.



S8.04 HIGH VOLTAGE LOAD INTERRUPTING SWITCH (Not applicable)

The high voltage fuse load interrupting switch (3P-PF) shall be 3-pole group operate for the voltage and basic impulse level specified, and shall be rated for 100-A continuous and 16,000 A interrupting current (momentary). The switches shall be mounted on NEMA rated porcelain insulators for the voltage and basic impulse level specified. Operating mechanism shall include porcelain linkage connections to switch blades with porcelain having a basic impulse level rating at least equivalent to the switch insulators. Switch mechanisms shall be operable externally from the front of cubicle and be equipped with a quick make-and-break device to open and close the switch independently of the speed with which the operating handle is moved. The load break switches shall be capable of closing in on at least 40,000 A asymmetrical fault current without impairing the ability of the switch to carry its full rated continuous current.

Six-pole, auxiliary switch shall be provided for alarm and interlocks.

Switch Ratings

SST Interrupting - 100 A, 3-pole, 3.3 kV, 40 kV basic impulse level (minimum) with current limiting fuses

Tests

Tests shall be in accordance with ANSI C37.34. The following tests shall be made on each load interrupter switch:

- dielectric
- short-time current
- interrupting
- Corona.

S8.05 AUTOMATIC TRANSFER

All necessary sensors, relays and controls, etc., shall be provided to automatically transfer the load to the alternative source upon failure of the normal source. It shall also be possible to connect a diesel generator unit to the LV switchgear.

The preferred source for station service requirement will be the 3.3 kV supply to transformer (SST) which is fed from the 3.3 kV side of main transformers.

The automatic transfer and sequence of operation shall be as follows. Refer to Drawing for the station service, single-line diagram.

When transformer SST is de-energized and SST will open, then the diesel generator set will start. When diesel is up to full speed and voltage required, DG breaker will close to energize.

When normal power is restored from SST breakers, DG breaker will open first and breaker SST will close to re-energize. The diesel generator will shut down after DG breaker is opened.



The Contractor shall supply all the controls, relays and equipment required to carry out automatic transfer of power sources as described.

Power Source	SST	MCCB (DG)
SST	E	E
Diesel gen.	X	O
	O	X

Operating Sequence

- X = closed
O = open
E = electrically operated

Annunciation

The following operation shall be annunciated.

- Transfer from SST to diesel generator
- Return to SST from diesel generator
- Blocked auto transfer caused by selector switch in manual or withdrawal of supply or tie bus breakers.

The annunciation of all the above conditions is primarily to notify the operator of the status of the breakers and shall be alarmed on the control room annunciator.

Test

A test switch which located on the main control board shall allow the testing of the Automatic transfer scheme by simulating an under-voltage condition of the preferred and alternative power source and causing an actual transfer of power sources.

Selection of Manual Control

Placing the selector switch in the manual position shall make the automatic transfer scheme inoperative and will allow each individual breaker to be operated by its own control switch.

S8.06 NO-FUSE BREAKER

No-fuse breakers shall be molded case, manually operated, quick make, quick break with both thermal and magnetic trip elements on each pole. All breakers shall be rated for 600 V and shall have an interrupting rating not less than 30,000 rms A asymmetrical at 400 V.

S8.07 SECONDARY WIRING AND TERMINALS

The switchboards shall be complete with all accessory secondary wiring. All wiring shall be switchboard type stranded copper conductors. Conductor insulation shall be flame-retardant, heat-and moisture-resistant and shall be of the thermoplastic or thermosetting type. The insulation shall be rated at 600 V with a temperature rating of 90 °C.



Wire sizes shall not be less than 6 mm^2 for current transformer wiring and 2.5 mm^2 for control, metering, annunciation, and potential circuits.

The secondary leads of instrument transformers shall be brought out through test blocks with molded phenolic covers which have internal plug contacts and make a through connection when the cover is in place. The test block contacts shall be of the live pressure type to provide positive contact with minimum contact resistance and make a through connection when the cover is in place.

The test blocks of current transformers shall be provided with auxiliary contacts which automatically short circuit the current transformers when the cover or plug is removed. The test block contacts shall be rated 250 V, 10A continuous.

All wiring shall be run in plastic wiring duct or shall be formed into compact flat groups suitably bound together and properly supported. The group shall be run straight, horizontally or vertically, with short-radius right-angle bends. There shall be no splices in the wiring and all connections shall be made at 600V, 25A terminals. Suitable provision shall be made for training and supporting incoming cables from the point of entrance to the termination on the terminal blocks.

All wiring shall be identified at both ends with PVC cable markers which resist grease, oil, acids and abrasion.

The arrangements and locations of all terminal blocks shall be subject to the approval of the DEDE Engineer. Circuit on the terminal blocks shall be marked with permanent marking fluid and shall be subject to the approval of the Engineer. A minimum of 20 percent spare terminal blocks shall be furnished.

S8.08 CONTROL SWITCHES AND INDICATION

One (1) selector switch for selecting Remote and Local Control for the breakers mentioned above.

Indicating Lamps for all phases, annunciator window for Fault and Trip of Breakers showing clear wording shall be installed in front of Annunciator Window.

Mimic Indication in Single Line Diagram in front of AC Distribution Front Door and the mimic graphic shall be submitted to DEDE for approval.

S8.09 INTERLOCKING

All circuit breakers controlling supply points shall be electrically interlocked to prevent the interconnection of supplies. Breaker auxiliary contacts and auxiliary relays shall be used in the interlocking circuit.



Lockout devices shall be provided if applicable so that if a breaker is tripped by its own over current protection scheme, other breakers feeding into the same bus cannot be closed.

Remote Indication

The LV switchgear shall have incorporated in the metering and control circuitry, provision for remote indication of the followings:-

“Open” “Close”	Circuit Voltmeter	Indication	Ammeter	Voltmeter
	Breaker SST	X	X	X
	Breaker DG	X		

S8.10 CURRENT TRANSFORMERS

Current transformers shall be supplied in each of the transformer secondary breaker sections of the station service switchboard. The current transformers shall be of the 55°C rise dry type, used for metering and protective relaying and shall be supplied as follows in accordance with the latest edition of ANSI C57.13 for instrument transformers, or DEDE approved equivalents.

- | | | | |
|-----|------------------|---|------------|
| (a) | Purpose | - | Metering |
| | Quantity | - | 3 |
| | Ratio | - | 250/5A |
| | Frequency | - | 50 Hz |
| | Accuracy | - | metering |
| | Insulation class | - | 0.6 kV |
| (b) | Purpose | - | Protection |
| | Quantity | - | 3 |
| | Ratio | - | 250/5A |
| | Frequency | - | 50 Hz |
| | Accuracy | - | 0.5 |
| | Insulation class | - | 0.6 kV |

S8.11 VOLTAGE TRANSFORMERS (If require)

Voltage transformers shall be indoor dry type, single-phase with both windings connected in open delta. The voltage transformers shall be rated as follows.

Three voltage transformers shall be provided for metering and undervoltage relaying on each incoming bus section.



Voltage	-	400 - 110 V
Capacity	-	as required for metering and relaying
Accuracy	-	metering
Insulation class	-	600 V
Impulse test	-	10 kV
Quantity	-	6

S8.12 INSTRUMENT SECTIONS

The station service switchboard shall be provided with the instrument sections. The instrument sections shall house the instruments, protective relays and voltage transformers as specified.

AC Ammeters

Ammeters shall be flush-mounted, taut-band suspension type, not less than 110 mm square with circular scale not less than 180 mm in length for 250-deg rotation, black figures on white background, 1 percent accuracy class, 0 to 200A scale for 5A, 50Hz circuit.

AC Voltmeters

Voltsmeters shall be taut-band suspension type, flush-mounted, not less than 110 mm square with circular scale not less than 180 mm in length for 250 deg rotation, black figures on white background, 1 percent (%) accuracy class, 0 to 600 V for 110V, 50-Hz circuit.

Watt Hour Meters or Power Meter

Polyphase watt hour meters, for a 3-phase, 4-wire circuit, current transformer rating 900-5 A, voltage transformer rating 400-110 V, 50 Hz, to read and indicate kilowatt hour and kilowatt demand, complete with mechanical demand register, 5 dials, with anti-reverse device for unidirectional operation.

AC Voltmeter Switches

Voltmeter switches shall be rotary, panel-mounted type, enclosed contact mechanisms with removable cover, renewable, self-cleaning, maintained 6 normally open and 6 normally closed contacts, rated 600 V, 20 A continuous, 50-A make and 30-A break at 120 V, 50-Hz inductive load, pistol-grip handle, 4 positions with escutcheon plate engraved "OFF", 1-2, 2-3, 3-1", and wired for 3-phase, 4-wire circuit.

Relays

- 51, inverse time over current phase consisting of 3 single-phase relays, semiflush mounting in draw out case
- 51N, inverse time over current, semiflush mounting in draw out case.

It is intended that this relay, upon sensing a ground fault, shall trip the incoming breaker. If the fault persists it shall then trip 52G. This same sequence of operation shall apply to new Unit.



- 27S/59, Under and Overvoltage relay for use with automatic transfer scheme, semi flush mounting in draw out case
- Auxiliary relays as required for automatic transfer scheme.

The number of instruments and relays which shall be provided for the AC station switchboard shall be as follows.

Frequency meter	1
Wattmeter	2
Ammeters	2
Voltmeters	2
Kilowatt hour meters (or power meter)	1
Voltmeter switches, Ammeter Switch	2
All meters can be use two sets of power meter.	
51 relays	3
51 N relays	1
27/59 relays	1

All meters can also be integrated in Digital Multimeter and provide two sets of power meters.

All protection relay shall also be combined and in Multifunction Relay and comply relaying functions as per the single line diagram.

S8.13 GROUNDING

A grounding copper bus bar not less than 5 mm by 50 mm shall be provided along the front and rear of the switchgear. The ground bus shall be solidly bolted to the steel framework so as to make good electrical contact. Provisions shall be made at both ends of the switchgear for connection of the ground bus to cables from the station ground mat. Two clamp type terminals suitable for 95-mm² stranded bare copper conductor shall be provided. All non-current carrying parts shall be connected to the ground bus.

S8.14 NAMEPLATES

Nameplates of black background with white lettering and shall be provided for all LV. Switchgear identifications. Transformer nameplates shall be 22 cm wide by 4 cm high, with letters 19 mm high, centered on the plated.

All nameplates shall be attached to the switchgear with rust-resistant steel, self-tapping screws. The transformer, switchgear and all switchgear appurtenances shall be identified and all nameplates shall be subject to the DEDE Engineer's approval.



S8.15 CHANNEL BASES AND BOLTS

The Contractor shall provide the foundation bolts and channels necessary for holding down of fixing the equipment to the concrete foundations. Where the design of the equipment requires special clamps to be used with the foundation bolts, these clamps shall be provided by the Contractor.

S8.16 TESTS

The assemblies and their individual components shall be factory and field tested by the Contractor in accordance with the test specifications outlined herein.

Factory Tests

The following tests shall be made according to the appropriate standards to ensure compliance with specifications.

Switchgear Assemblies

- Standard production tests as specified in NEMA SG 5 and ANSI C37.20 or approved equivalent
- Impulse and thermal tests as specified in NEMA SG 5 and ANSI C37.20 or approved equivalent.

Operational Checks

- Continuity and polarity tests on all coils and circuits
- Functional tests on the automatic under-voltage transfer scheme, and on the over current protection.

Field Tests

Such tests shall be carried out in the field, as are necessary in the opinion of the Engineer, for the satisfactory start-up and operation of the apparatus. These will normally comprise

- Control and secondary wiring check of complete installation
- Dielectric tests on control and secondary wiring using 1,000V megger
- Functional tests of the breaker operation, metering, relaying and the automatic transfer scheme.



SECTION 9

***TRANSFORMER TERMINAL CUBICLES, GENERATOR
TERMINAL CUBICLES, BUS DUCTS
AND NEUTRAL CUBICLES***

SECTION 9 – TRANSFORMER TERMINAL CUBICLES, GENERATOR TERMINAL CUBICLES, BUS DUCTS AND NEUTRAL CUBICLES

S9.01 SCOPE OF WORK

The work of be done under this section consists of the design, manufacture, testing, delivery to site, installation, placing in successful service, and guarantee of:

- 2 generator circuit breaker cubicles
- 2 generator excitation transformer cubicle (if applicable)
- 2 generator PT, CT cubicles
- 2 station service disconnecting switch cubicle
- 2 generator neutral cubicles

S9.02 PURPOSE AND FUNCTION

Generator Circuit Breaker Cubicles

The generator terminal cubicles shall contain generator circuit breakers, surge arresters, current and voltage transformers for protection and regulation of the generators.

Generator Excitation Transformer Cubicles (if applicable)

The Generator Excitation transformer cubicles shall contain excitation transformers to supply the generator excitation systems.

Generator CT, PT Cubicles

The generator CT, PT Cubicle shall contain CTs and PTs for measuring and protection function as well as Lightning Arrester. And the Components shall also be installed in Separate Cubicle (or) Built in at Generator Circuit Breaker Cubicle.

Station Service Disconnecting Switch Cubicle

The Station Service Disconnecting Switch Cubicle shall contain disconnecting switches or circuit breaker for switching to station service transformer.

Generator Neutral Cubicles

The neutral grounding equipment is to be used for grounding the stator winding neutrals of the generators. The stator winding neutral grounding equipment shall be suitable for limiting damage and detection of stator ground faults.

S9.03 STANDARDS

The equipment and accessories shall be designed, manufactured and tested where applicable, in accordance with the following standards.



Requirements, Terminology and Test	IEEE 32
Procedure for Neutral Grounding Devices	
High Voltage Metal Enclosed Switchgear and Control Gear	IEC 62271-200

9.04 GENERATOR CIRCUIT BREAKER CUBICLES AND BUS DUCTS RATINGS

The generator circuit breaker cubicles shall be of metal-enclosed construction in accordance with the requirements of IEC 62271-200, unless otherwise stated herein. Type test report and calculation for selection of the proposed switchgear and generator circuit breaker shall be submitted together with the Bid.

The rating of the generator terminal cubicles and accessories shall be as follows:

- Voltage	3.3 kV (nominal)
- Frequency	50 Hz
- Phases	3
- System	3-wire delta
- Continuous current (minimum)	800 A (minimum)
- Short-time (3 seconds) current	31,500 A _{rms} asymmetrical
- Momentary (1 second) current	31,500 A _{rms} asymmetrical
- Standard low frequency (50 Hz) insulation withstand strength	38,000 V _{rms}
- Standard 1.2 by 50 µs, full-wave impulse withstand strength	95 kV crest
- Temperature rise (above 40°C ambient outside of the enclosure for the generator terminal cubicles)	65°C indoor

S9.05 EQUIPMENT DETAILS

Generator Circuit breaker Cubicles

The Contractor shall supply two generator circuit breaker cubicles, one each for transformer and generator, and each shall consist of the followings.

Quantity	Descriptions
1	A type tested metal-clad compartments (Circuit breaker compartment, busbar compartment, cable compartment and low voltage compartment) shall be supplied to house the generator circuit breaker. The circuit breakers to be supplied shall be draw-out type, three poles, and single throw having the following minimum ratings.
Type	Air Circuit Breaker or SF6 (or) Vacuum type With drawable.
Voltage	3.6 kV

Frequency	50 Hz
Continuous current	800 A
Interrupting capacity at	31.5 kA
Short-time (4 s) withstand strength	31.5 kA _{rms} asymmetrical
Short-time (momentary) withstand strength	31.5 kA _{rms} asymmetrical
Operation Supply Voltage	125 V DC supply

Quantity	Descriptions
3	Voltage transformers, single-phase, dry type, rated as follows. - Ratio 3.3/ $\sqrt{3}$ kV to 110/ $\sqrt{3}$ - Capacity To be specified for synchronizing - Accuracy 0.5 - Basic impulse level 40 kV
6	Current transformer for relaying single phase, dry type rated as follows: - Ratio 800/5A (or) suitable - Accuracy 5P20 or better - Capacity Specified by manufacturer
3	Lightning arrester, 3 kV gapless type

Buses and connections for the generator circuit breakers, voltage transformers required current transformers, surge arresters excitation transformers, and ratings as stated in Clause S9.04 except for the continuous current rating, which shall be as required.

Generator PT, CT Cubicles

Quantity	Description
1	A type tested metal-clad compartments (Circuit breaker compartment, busbar compartment, cable compartment and low voltage compartment) shall be supplied to house the voltage transformers, current transformers, surge arresters, and ratings as stated in Clause S9.04. The PT and CT cubicle can be combined into Generator circuit breaker cubicle (or) transformer circuit breaker but to serve the same function and electrical location.
6	Voltage transformers, single-phase, dry type, rated as follows. - Ratio 3.3/ $\sqrt{3}$ kV to 110/ $\sqrt{3}$ - Capacity To be specified for metering, relay and voltage regulating - Accuracy 0.5 - Basic impulse level 40 kV



Quantity	Description
4	Current transformers, single phase, dry type for protection rated as follows. - Ratio 800/5A - Accuracy 5P20 or better - Capacity To specify by manufacturer
3	Current transformers, single phase, dry type for metering rated as follows - Ratio 800/5A - Accuracy Class 1.0 - Capacity To specify by manufacturer
3	Surge arresters, station type, as specified by generator manufacturer
1	Surge capacitor, 3-pole, as specified by generator manufacturer

Sufficient quantity of terminal boards to accommodate external wiring required.

Nameplates for identifying the cubicle and all control devices operated from required outside of the cubicle

Identification tapes, Dymo embossing type, 13mm wide or equivalent, affixed to required the interior of the cubicle for identifying fuses, test switches and test links

Station Service Disconnecting Switch Cubicle

The Contractor shall supply one (1) Station service transformer and the rating and details are specified and shown in SECTION 8 together with one (1) Station Service Disconnecting Switch Cubicle and the Ring Main Unit (Load Break Switch) type can also be supplied and having the following ratings as minimum.

Quantity	Description
1	Circuit breaker (or) Disconnecting Switch - Type Air Circuit Breaker or SF6 (or) Vacuum type - Voltage 3.6 kV - Frequency 50 Hz - Continuous current 630 A - Interrupting capacity at 3.6 kV 31.5 kA - Short-time (4 s) withstand strength 31,500 A_{rms} asymmetrical - Short-time (momentary) withstand strength 31,500 A_{rms} asymmetrical - Operation Voltage 125 V DC supply
3	Lightning arrester, gapless type

Buses and connections for the generator circuit breakers, voltage transformers required current transformers, surge arresters excitation transformers, and ratings as stated in Clause S9.04 except for the continuous current rating, which shall be as required.

Generator Neutral Cubicles

The Contractor shall supply one (1) generator neutral grounding cubicle and shall consist of the followings:-

Quantity	Descriptions
1	Isolating switch, single-pole, and hook-stick operated, suitable for 3.3 kV, 600 A min.
3	Current transformer, dry type, for protection shall be rated as follows:- - Ratio 800/5A - Accuracy class 5P20 or better - Voltage 3.3 kV
1	Current transformer, dry type, for protection shall be rated as follows:- - Ratio 200/5A - Accuracy class 5P20 or better - Voltage 3.3 kV
1	Single Phase Neutral Grounding Transformer, dry type, with the rated voltage of 3300/220V and the transformer and resistor shall be designed by Contractor for such that maximum line to ground fault current not to be exceed 20 Ampere and shall be capable of carrying the maximum line to ground fault current for 10 seconds and in accordance with IEEE Standard C62.92 so that calculation sheet shall be submitted to DEDE for approval.

S9.06 DESIGN AND CONSTRUCTION OF GENERATOR TERMINAL CUBICLES

The Generator terminal cubicle shall be indoor, air-insulated, metal-enclosed and metal-clad switchgear with withdrawable circuit breaker devices. The switchgear shall be complete, ready for installation, with all components furnished unless specifically excluded herein.

The switchgear shall be type tested and designed and tested as per the latest updated IEC 62271-200 with the circuit breaker as per the latest updated IEC 62271-100 and each cubicle shall consist of switchgear enclosure, and the power equipment contained within the housing shall be of dustproof construction.

The housing, partitions, etc., shall be fabricated from sheet steel panels having a minimum thickness of 3 mm, structural shapes and nonmagnetic materials where required, in such a manner that the complete structure shall be rigid, self-supporting and free from magnetic vibration, twist and weave.

The switchgear shall have 4 compartments that are Busbar compartment, circuit breaker compartment, Medium Voltage Cable compartment and Low voltage compartment. There shall be a partition to separate each busbar compartment between the adjacent compartments.

The shutter between circuit breaker and busbar compartment shall be made of metal. All sheet steel panels used in the construction of the walls, partitions, hinged doors and removable panels, etc., shall be adequately supported and stiffened to prevent flexing and excessive vibration.

Each cubicle shall be provided with a steel channel base frame with provision for bolting it to the concrete floor and placed adjacent to the panel of the station service transformer cubicle. The switchgear shall be of the same type and model for transformer and generator circuit breaker cubicles.

An opening shall be provided in the bottom of the housing to permit the entrance of instrument transformer secondary and miscellaneous cables which will be terminated in the auxiliary compartment.

An electric heater to prevent condensation shall be provided in accordance with Clause S1.23 (10).

The Contractor shall be responsible for the coordination, proper physical fit and other interfacing functions, including the location and phasing of bus terminations. The surge protectors, voltage transformers, 3.3 kV buses and bus connections in each cubicle shall be installed in cable compartment of the same panel and the auxiliary compartment shall be provided containing the voltage test devices, voltage transformer secondary fuses, current test link blocks and termination boards.

A hinged door shall be provided on the front of the auxiliary compartment. All hinged doors shall be equipped with semi-concealed hinges and suitable locks. Similar locks shall also be provided on the voltage transformer drawers.

All compartment doors shall be so constructed that they will not seize in the event of a fire within the cubicle.

Ventilating louvers shall be provided in the hinged doors, and in other locations where required, to prevent undue temperature rise. The ventilating louvers in the hinged doors and in other locations of the housing shall have openings small enough to prevent the entrance of rodents and insects. Openings between adjacent compartments for ventilation purposes will not be permitted.

Entrance bushings shall be used for insulating and supporting the buses and bus connections that pass from 1 compartment into another. Where the use of bushings is not practical due to space limitations, panels of approved insulating materials may be used instead for this purpose. The arrangement chosen shall ensure a reasonably tight seal between compartments.

All materials used in the cubicles, such as bus insulation, bus supports, etc., shall not independently support combustion.

Equipment and connections within each compartment shall have their mounting bolts arranged so that it will be possible to replace them without removing from service equipment in adjacent compartments.

The voltage transformers shall be mounted on smooth-rolling, draw-out carriages. The voltage transformers shall be single-phase, and each voltage transformer shall be furnished with primary current-limiting fuse.

Provision shall be made for a maintenance check on the primary contact alignment of the voltage transformers by providing a wire-glass window (s) in the back plate that can view the voltage transformer and fuses.

The voltage transformers and fuses shall be completely disconnected and visibly grounded when in position to permit inspection or to permit access for removal or replacement of fuses.

The voltage transformer core shall not saturate at voltages lower than 110 percent of system voltage. The voltage transformer assembly shall have provision for padlocking in the disconnected position, and it shall be possible to close the outer door with the voltage transformers left in the disconnected position.-

The buses and bus connections shall be of copper bar, and supported on suitable insulators and properly braced to withstand the short-circuit forces. The bus bars shall be fully insulated throughout and also at tap-off points using flame-retardant, track-resistant, non-hygroscopic materials.

Joints between bus sections, etc. shall have their contact surfaces silver-plated, and shall be fastened with bolts, nuts and locking devices.

Bus bar supports between panels shall be tightly sealed between compartments. Means of linear expansion shall be provided.

Means shall be provided for permanent grounding of all exposed non-current-carrying metal parts of the generator terminal cubicle and secondary neutrals of the instrument transformers as required by the specified standards. All parts of the framework shall be in good electrical connection with one another for grounding purposes.

A continuous ground bus, 50-mm by 6-mm copper bar, extending the full length of each cubicle, shall be provided. A non-solder lug, suitable for connection of external 96-mm² stranded copper conductor, shall be provided at each end of the ground bus.

S9.07 DESIGN AND CONSTRUCTION OF GENERATOR NEUTRAL CUBICLES

Each cubicle shall be fabricated from sheet steel panels generally as specified in Clause S9.06.

The incoming cable from the generator stator will enter through the bottom of the cubicle via conduits.

Each cubicle shall be provided with hinged door(s) at the front of the cubicle, each door complete with 3-point latching device and lock. A wire-glass window shall be inserted in the front door, located so that the position of the isolating switch may be observed without opening the door.

An electric heater to prevent condensation shall be provided. Means shall be provided for permanent grounding of all exposed non-current-carrying metal parts of the generator neutral grounding cubicle as specified in Clause S9.06 and required by the specified standards.

S9.08 WIRING AND WIRING TROUGHS

Care shall be exercised in routing and clamping the switchboard wiring to prevent damage to the cotton-braid covering and thermoplastic insulation.

Circuits of different voltages shall not be run in the same wiring trough. Separable wiring troughs or ones with barriers shall be used for this purpose.

Connections for termination boards shall be readily removable for test purposes.

Secondary devices shall be adequately protected from possible faults on the power circuits.

S9.09 TESTS

Complete tests shall be made at the factory by the Contractor on the various components of the equipment, in accordance with the appropriate standards, to determine the performance and operating characteristics, and to determine whether or not the guarantees have been met. The following tests shall be included for each of the components as outlined below.

Generator and Transformer Terminal Cubicles

- Mechanical operation of all components to ensure that all parts operate properly.
- Electrical operation and continuity tests of all circuits and isolating switches.
- Standard 50-Hz insulation withstand test of each switchgear assembly at 19kVrms for 1 minute. The voltage transformers may be disconnected for this test, but shall be subjected to individual tests as covered by the applicable standards.
- Standard 1.2 by 50-microsecond full-wave impulse withstand tests at 60 kV crest on one of each representative switchgear assemblies. The voltage transformers shall be left connected for this test.
- Standard temperature test on one representative generator terminal cubicle only.



Qualification and factory tests on voltage transformers shall be in accordance with ANSI C57.13.

The factory tests shall be made on each voltage transformer including type test and routine test reports shall be submitted to DEDE for approval before delivery.



<i>SECTION 10</i> <i>DC STATION SERVICES</i>
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SECTION 10 - DC STATION SERVICES

S10.01 SCOPE OF WORK

The work to be done under this section consists of the design, manufacture, testing, delivery to site, installation placing in successful service and guarantee of: -

- 1 (one) 125-V battery with racks and fuses, 400 AH minimum
- 1 (one) Battery Charger
- 1 (one) DC distribution panel board with instruments and circuit breakers

S10.02 PURPOSE AND FUNCTION

The DC station service system, comprising of Lead-acid vented type battery, battery charging equipment and dc distribution panel board, shall be used for instruments and component power supply at PLC Controlled Automation System, Protection Relay, Metering and Alarm System, Governor System, Lubricating Oil System, AC Switchboard, Motor Control Centers, MV and LV Switchgear, 33kV Switchyard Equipment, Annunciator System, emergency lighting and other essential DC loads which are to be used during shutdown and start-up of the generating unit.

S10.03 BATTERY

The batteries shall be 125-V, lead-acid vented type in shock-absorbing, translucent polypropylene plastic containers, in order to check the electrolyte level and manufacturer shall be certified according to ISO 9001 series quality standard complete with intercell connectors and standard accessories.

Battery shall consist of battery cells for minimum capacity 400 AH, 10 hrs rated with the following sequence of operation during trip, shutdown and start-up of the generating unit as minimum: -

- Both generator breakers and one-line breakers (total 3) trip simultaneously.
- Generator and line breakers reclosing sequentially.
- Both reclosed breakers trip simultaneously.
- No generation or other AC Supply is not available for 5 hours.
- Emergency Lamp for 5 hours.
- Indicating lamps, annunciation inside Control Room
- Continuous DC Supply for PLCs, protection relay, meters, HMI PC, Touch Screens, etc.

This duty cycle, together with an allowance of 10 percent for design margin, shall be used as a minimum to determine the battery capacity.

Bidder shall submit the Battery and Battery Charger Sizing according to IEEE 485-“Recommended Practices for Sizing Lead Acid Batteries for Stationary Applications” and the Design Load Profile and Calculated Battery and Charger Sizing shall be submitted with the Bid verifying the proposed capacity is enough for equipment supplied under this contract.

The battery (lead-acid) shall have a capacity to supply the duty cycle given above, without assistance from the charging source and without the battery dropping below 1.8 Volts/cell. The battery (lead-acid) shall be constructed using the best industry practice. It shall have the polarity permanently and legibly marked on each terminal or on the cover adjacent to the terminal.

The battery shall be supplied complete with lead-covered copper intercell and connector ratings shall suit the maximum discharge current of the battery.

Cells shall have sufficient sediment space so that cleaning during the normal life of the battery may be avoided.

S10.04 BATTERY RACKS

Freestanding steel battery racks with lead-liner trays shall be provided for supporting the complete battery. The racks shall have a maximum of 2-3 tiers. They shall be sized and arranged to allow sufficient clearance for battery maintenance inside the battery room.

The battery racks shall be constructed from angle steel. The trays shall be fabricated from sheet steel and lined with sheet lead.

All surfaces shall be free from sharp edges and burrs, and the trays free from dents and bulges.

The lining of each tray shall be so fabricated that it overlaps the edges of the tray, and the only joints shall be at the corners. These joints shall be watertight.

S10.05 INSTRUMENTS ON DC DISTRIBUTION BOARD

The DC station service installation shall include a panel for the followings:

- DC ammeters complete with shunt and fuses (to measure total DC load and battery current)
- Non-automatic circuit breaker to disconnect battery from load
- Voltmeter and fuses to measure battery voltage
- Undervoltage relay to detect loss of dc with an ac alarm contact
- Ground detective relay with an alarm contact.

In case of DC Distribution Panel Board is attached in Battery Charger, all instruments shall be installed at Charger Panel.

S10.06 BATTERY CHARGER

The battery charger shall be fully automatic, rectifier controlled design for automatic float and boost charging of batteries, to be enclosed inside a metal cabinet suitable for floor mounting. The charger is to supply DC at constant voltage for the average dc powerhouse load and for maintaining the battery, connected in parallel with the load, in a fully charged floating state. The ac supply source will be three-phase, 400-V nominal rating, 50 Hz.

Voltage regulation shall be ± 1 percent, with ac supply voltage variation of 10 percent and frequency variation of 5 percent from 0 to full load of the charger.

The nominal output of the charger shall be 125 V dc, with the battery voltage range of 105 V to 140 V dc.

The equipment shall be of the static type, with no moving parts. It shall be equipped with automatic float-equalizer, 28-d timer and with protection against sudden line voltage variations. Protection shall also be provided against damage due to overload.

The charger shall be connected with PLC Controller by using LAN (or) RS 232 (or) RS 485 cable to send the real time status of information about the battery, charger and load information.

The charger shall have manual switching to the high rate charge mode. Switching from high rate to float charge mode shall be automatic.

The charger shall be equipped with the following protective devices.

- Circuit breaker with thermal magnetic trip unit for dc output. Its current rating shall be 1.5 to 2.0 times the charger rated current.
- A reverse current limiting device to protect the battery in the event of ac failure.
- Annunciator Lamps shall show indication under the following conditions:-
 - a) Opening of the DC output breaker
 - b) Failure of the ac supply
 - c) Loss of charger control voltage
 - d) Battery charger failure
 - e) DC output under voltage
 - f) AC output overvoltage
- Each of the annunciator circuits shall be wired to terminal blocks for connection to a remotely located annunciator. Alarms at the charger are not required.

The charger shall automatically return to service on restoration of ac supply after an interruption.

Indicating lamps equipment status indications shall be provided.

The battery charger and auxiliary equipment shall be contained in a single, general purpose, ventilated enclosure, suitable for floor mounting indoors. The enclosure shall be fabricated from sheet steel panels. It shall be rigid, self-supporting and free from magnetic vibration, twist and weave. All panels used in the construction of the enclosure including partitions and doors shall be adequately supported and stiffened where necessary to prevent flexing.

Components shall be arranged within the enclosure, with access via a hinged front door, for convenient inspection and maintenance and for making external connections.

Meters, indicating lamps and other externally accessible devices shall be located for convenient viewing or operation.

A copper clamp type connector having a conductor range of 25 mm² shall be bolted to the enclosure for connection to the station ground system.

The enclosure shall have a nameplate giving charger input and output ratings and other pertinent information.

Identification tapes, Dymo embossing type, 13 mm wide or equivalent, shall be used for identifying fuses.

S10.07 DISTRIBUTION PANEL BOARD

The distribution panel board shall be suitable for floor mounting. The panel board shall have sufficient capacity for containing a main circuit breaker and up to thirty 2-pole branch breakers. The panel board shall have a voltage rating of 250 V dc and a short circuit capacity of 10,000ADC. Its current-carrying capacity shall be sized for the maximum discharge capacity of the battery and shall be a minimum of 400 ADC.

The main breaker shall be a molded case type, 2-pole. It shall have a voltage rating of 250 V dc and an interrupting capacity of 10,000 A DC. Its frame size shall be rated to suit the maximum discharge capacity of the battery and shall be a minimum of 400 ADC. This breaker shall have a thermal magnetic trip unit.

The panel board shall have 30 branch circuit breakers, molded case type, 2-pole, each with a thermal magnetic trip unit and 1 set of Form C auxiliary contacts. Each breaker shall have a voltage rating of 250 V DC, an interrupting capacity of 10,000 A DC and a frame size of 100 A DC.

The breaker trip ratings are provisional. The Contractor shall determine final ratings according to design requirements.

The main and branch breaker auxiliary switches shall be wired to separate terminal blocks. The normally closed auxiliary contacts of the branch breakers shall be connected in parallel and wired to 1 pair of terminal blocks. The contacts of each spare breaker shall be wired to 1 set of terminals.

S10.08 CABLE INTERCONNECTION

The Contractor shall supply properly sized cables between the battery, the instrument panel and the battery charger. The Contractor shall also supply and coordinate cable size between the battery circuit breaker and the distribution panel.

S10.09 TESTS

Complete tests on the equipment shall be made at the factory by the Contractor to determine the performance and operating characteristics and to confirm that the equipment function properly. Details of the tests to be performed on the various components of the equipment shall be submitted, and the following tests shall be done as follows:-

Battery Charger

- Mechanical operation of the components to ensure that all parts operate properly.
- Standard insulation withstand tests on all circuit breakers, relays, switches and other devices and on all wiring at 1,500 V to ground, 50 Hz for 1 minute.
- Continuity and polarity test on all circuits.
- Functional and operational checks of all equipment and all control, metering and protection circuits.
- Load simulation under various input voltages.

Distribution Panel board, Instrument Panel and Circuit Breakers

- Mechanical operation of all circuit breakers to ensure that they operate properly.
- Standard insulation withstands tests on all circuit breakers and on all wiring at 1,500 V to ground, 50 Hz for 1 minute.



SECTION 11
CONTROL, PROTECTION AND ALARM SYSTEM

SECTION 11 -CONTROL, PROTECTION AND ALARM SYSTEM

S11.01 GENERAL

(1) Responsibilities

- a) The Contractor shall design, supply, procure, delivery to site, installation, testing and commissioning the control; monitoring and protection system for the turbine, generator, governor, transformers, switchgears and other related station auxiliaries including all interfaces and associated equipment.
- b) The contractor shall supply, deliver, install, testing and commission all control, protection and alarm system equipment and have overall responsibility for successful start-up, commissioning of turbine-generator units, governor, inlet valves, transformers, MV switchgears and other station auxiliaries which are to be supplied under this contract.
- c) **For Protection, Metering and Alarm System, the Bidder shall provide overall electrical single line diagram with complete relay numbers, meters for electrical protection and metering according to ANSI, IEC and IEEE Codes and the description detail for the Bidder's proposed system to be submitted together with Bid.**

For Control, Monitoring and Alarm System, the Bidder shall submit together with the Bid for Control and Monitoring System Configuration Diagram together with Normal Start, Stop and Emergency Shutdown Sequence for Unit as well as logic diagram (or) flow diagram for Generating Unit Operation.

Failure to submit this information will subject to rejection of the Bid.

- d) Equipment and Components, which are to be used in Automation Control System, shall be submitted in the Bid together with manufacturer's product catalog such as PLC CPU modules with redundancy, I/O modules, Power Supply Modules, Ethernet Modules, HMI Touch Screen, Notebook and Controller Chassis together with Licensed Software used for controlling and monitoring of Generating Unit operation.
- e) The protection system of the station of based on the principle of local back up. In other terms, any fault occurring anywhere on generator feeders, outgoing line, line transformer or on bus bar shall be detected and cleared locally by relays and breakers located in the substation (or) switchyard. In the event of failure of battery, instruments or relays, the system should detect and enable to clear all failures of equipment.

(2) Requirements for Systems

- a) Each system shall be designed to have high reliability and availability and however it shall be simple to operate and maintain by DEDE operator. The failure of any equipment or the loss of power supply to equipment shall not jeopardize the plant and shall initiate an alarm.

- b) The normal control shall be operated at operator control station in the control room and for the purpose of system maintenance, commissioning or testing, it shall be done by via both engineering PLC and local control graphical HMI Touch Screen at Governor PLC control panel.
- c) The control system shall comprise a number of programmable logic controllers (PLC), a digital PLC governor system, an excitation with digital automatic voltage regulator (AVR), a digital protective relay and synchronizing system. This PLC shall be connected to the human-machine interface (HMI) via of data communication cable. The metering and instrumentation of equipment and the related system shall be provided information for operator including annunciation system.
- d) The operation for Generating Sets shall be by both automatic mode and local manual mode. A typical automatic mode shall be a programming control sequence stored and programmed in the PLCs. The control functions shall be included supervising, controlling and monitoring to the unit conditions, recording the sequence of events, periodically fault and alarm events, providing integration of historical trending display, bar chart display and guidance messages.

The Bidder shall submit PLC Manufacturer's Letter of Confirmation for PLC Control System stating that the PLC manufacturer will design, supply and supervision for commissioning start-up and guarantee performance for their Supplied Products with Licensed Software complying with DEDE Specifications specified under this section 11.

The scope of supply for PLC control system of this power station shall be to control and monitoring of two (2) Sets of generating unit with station auxiliaries and it shall be comprised of the following equipments.

- (a) Operator Control Station 1 Set (Including software same brand name with PLC to control operate the TG unit and Dongle or USB key licensed)
- (b) Laptop/ Notebook computer (Industrial Type) for engineering work station 1 set (Including Dongle or USB key license software tool for engineering work station notebook to adjust or modified system configuration, changing parameters and to perform commissioning and testing for the unit)
- (c) Programmable logical controller (PLC) with software in unit control PLC cubicle for each unit and shall be comprised of:
 - Redundant central processing units (CPU), power supply modules, IO Modules and Communication Modules
 - Redundant Digital Excitation System for each unit
 - Redundant Ethernet Bus to communicate and control Digital Governor
 - Redundant Ethernet Bus to communicate and control multifunction protective relays & all meters
 - Redundant Ethernet Bus to communicate and control with Excitation system
 - Redundant Ethernet Bus to communicate and control Synchronization unit
 - I/O modules to interface with equipments to perform unit control function
 - HMI Touch Panels with 12" screen (Built-in two (2) individual Ethernet port) same brand name with PLC Controller for both Unit PLC and Governor PLC for local operation.
 - Interfacing ports with engineering station (Notebook Computer)
 - Licensed Software for Governor and Unit PLCs, which shall be same Brand with PLC Module manufacturer.
- (d) Automatic Synchronization including synchroscope completed with accessories 1 set

- (e) Digital protective relay system two (2) sets including software for engineering laptop
- (f) Local Area Network (LAN) System including switching hubs 1 lot (Including interfacing port)
- (g) Metering, instruments and annunciation display unit including transducers for two (2) generating sets, auxiliary and switchyard equipment.
- (h) Periphery equipment such as 2 sets of LCD monitor (24" or Larger), 1 Set of Laser Printer (with LAN Port), 1 set of operator control desk (heavy duty type, steel structure construction) with chairs, etc.
- (i) All design documents and drawings including equipment sizing, calculations, relay coordination study, relay settings, system block diagrams, layout; schematics; and wiring diagrams.
- (j) Logic flow charts or descriptions for control sequences.
- (k) Control system input and output and alarm list
- (l) Format of predefined reports

Bidder shall submit the complete information and documents with the Bid indicating all scopes, component model/ type complying with the requirements as stated in this section clearly submitting all related evidences to verify that the Proposed Control System meets the DEDE requirements.

Failure to comply, submit, indicate the required items in this clause will subject to rejection of the Bidder Proposal.

- (m) Branch circuits for each function shall be individually protected. Provision shall be made to enable isolation of each circuit separately.
- (n) Control, annunciation, alarm and protection circuits shall operate at 125VDC and the consumable capacity for Battery and charger sizing calculation shall be submitted with the Bid (Section 10 – DC Station Service).
- (o) All indicating and pilot lamps shall be of the low power, cool operating with DC, switchboard type, with color caps and mounted resistors integrally. All indicating lights shall be suitable for operating at 125 V DC.

(3) Requirements for Devices

(a) Programmable Logic Controller (PLC)

A programmable logical controller shall be a well-proven 32-bit processor design with wide range of I/O modules accepting discrete, analog and RTD inputs and shall have flash card for data and parameter storage. The PLC shall provide on-board self-diagnostics, with on-board LED indicators defining processor controller status. As a minimum, the process controller shall support the following attributes:

- Built-in minimum RAM 64MByte and Flash 64MByte
- Processor speed minimum 1GHz
- Built-in One RS-485 port and one RS-232 port
- Analog loop shall be processed at operator tunable rate down to 10 times per second
- Binary loop shall be processed at operator tunable rate down to 10 times per second
- A full range of preconfigured algorithms that can be used to implement control strategies

- Capable of being configured in ladder logic or capable of executing higher level programming languages such as BASIC, C or capable of executing operator-defined functions not included in the standard function
- Capable of executing any combination of the above functions, i.e., Standard algorithms, ladder, higher level programming languages, etc.
- Capable of peer-to-peer communication with any of additional Operator Control Stations and every other module in the system
- Support Ethernet TCP/IP communication to Remote I/O unit
- Storing control configurations (software) on-board in non-volatile memory and capable of retaining configuration information for at least 1 year. The system shall alarm when the battery reach a low-voltage condition before failure.

Controller Redundancy: The Controller shall be redundancy of the Central Processing Unit (CPU) and Power Supply redundancy for Unit Controller, Governor PLC, digital excitation AVR system. The evidences such as product catalogs, configuration diagram and CPU specifications proofing for system redundancy shall be submitted with the Bid.

As the primary module executes the control function, the backup module shall wait in hot standby mode. In case of the primary module fails, the backup module shall take over the primary module's job without any interruption. Redundancy switchover time will be maximum 5.16 msec. Failed module shall be replaceable on-line without disturbing (Hot swap) the process.

Maximum Processing Time: The processing time of the particular controllers shall be dedicated to the requirement of the controlled technological process and shall be in accordance with the following three categories, with maximum processing time not exceeding the specified limits:

- 50 ms for quick-acting process, e.g. Electrical processing system
 - 150 ms for normal sequential controls, e.g. Pump control or valve actuator control
 - 250 ms for modulating control
- The above processing times included input operation, logic or function processing' and output operation.

(b) I/O Modules

The I/O modules shall be able to support process signals from various types of sensors and contact devices without requiring external or auxiliary signal conditioning devices. The Digital modules shall include the following features:

- Binary input: capable of receiving 24 V dc, 125 V dc
- Binary output: Isolated contact rated at least 0.75 A, 24 V dc, 125 V dc and user selectable as normally open or normally closed
- Support minimum 32 points / module
- Signal isolation and Operate either signals are Positive or Negative logic
- Output provided with Electronic Short Circuit Protection (ESCP)
- Detection of the quality and presence of input signals (e.g. open thermocouple detection).
- Detection of the quality and presence of input signals (e.g. open thermocouple detection). The quality of each input point shall be determined and classified as either goods, questionable, substituted or bad. When bad, the value shall have bad quality indication
- Surge, over current and reverse polarity protection

- Card failure detection. Each I/O card within the system shall be monitored for proper operation. The system shall alarm indicating the card failure, and the system shall take appropriate safety action, e.g., transfer to manual, etc.
- Individual input shall be fused or feature current limiting. If fuses are provided, a common alarm contact for the fuse failure shall be provided.
Analog input and output signals shall include the following:
- Signal conditioning including linearization, scaling to engineering units, a minimum of 16 bits analog to digital (A/D), and a minimum of 15 bits digital to analog (D/A) conversion
- Analog input channels can be configured for these ranges: 4 to 20 mA, +/-, 10V, +/-, 5V, 0-5V (or) Pt 100 with individual A/D conversion
- Analog output channels can be configured for these ranges Analog output: 4 to 20 mA, +/-10V. Capable of driving 1350 ohms of current and 2K ohms of voltage
- RTD input: Capable of receiving 100 ohms platinum

(c) Turbine Control Unit

The turbine control units shall be by unit control PLC having functions to operate generating set including turbine, generator, governor, digital AVR, valve and related auxiliary equipment and it shall be included functions of turbine controller, synchronizing, electrical protection, control sequence, load set point (MW and MVAR), emergency shutdown functions, etc. and it shall be located in either Control Room or machine room.

(d) Operator Control Station

Operator control station shall be 64-bit multiprocessor and providing Ethernet communication ports to connect Existing Control Room PC and New Turbine Control via Ethernet switching hub so that it shall be equipped with minimum 4B of RAM, 2 x 1TB HDD (hard disk drive), multilayer DVD writer, 3D graphic VGA card at least 2 GB and sound cards including speaker, and internal latest version of Modem, min. 24 inches WUXGA LCD color monitor with adjustable stand DVI/ DP interface and Ethernet interface cards and other periphery for complete installation to operate generating units and satisfactorily monitoring according to the specifications in this section. Communication to PLC shall be Peer-to-Peer architectures.

In order to supervise the operator to control the units, the Contractor shall provide a real time data to display on LCD monitor of operator station as a minimum of the following items, such as Unit kW, kVAR, energy kWh, Unit Voltage, Current, Frequency, Line current, Line Voltage, Status of all switching devices, status of governor, status of digital AVR exciter, temperatures of generator windings, bearings, battery status, lubricating and governing oil pressure status with temperature, inlet valve position and tail race and reservoir water levels, etc. Database (History) type shall be Industrial Database (non RDB) 64 bits architecture and shall support OPC A&E Collector, OPC DA collector and Redundant Data Collector.

On operator keyboard, it shall be possible to call displays by via of optical mouse. All displays shall be updated at least once every 5 seconds. Response time to an operator command to completely generate or cancel displays shall not be exceeding 1 second. It shall be possible to access any displays by entering a tag name or tag index number. Manual substitutions for input data shall be possible on a point-by-point basis through the operator station.



Group/Faceplate Displays (on LCD monitor) shall be detailed control display for a related group of binary signals, process variables, set point and output indicated by tag name and point text description. The operator shall be able to select point for control action, change the mode of control or set point.

The laptop computer shall be supplied as the engineering work station heavy duty type at least 64-bit multiprocessor; min. 2GB RAM, min. 256 GB SSD (or) 1 TB HDD, multilayer DVD reader/ writer, and 24" color LCD display, communication ports to connect and access existing Operator PC, other control modules and equipment with IEEE outlets to suit with the communication to all field equipment supplied for this contract.

(e) Local Area Network (LAN) and Interfaces

The local area network shall be a 10/100 base T Ethernet TCP/IP system and switching hub linking the existing Operator Control PC, New Operator control station PC and turbine control board (Unit PLC). The communication software and licensed shall be provided.

The communication between existing Operator Control PC and New Operator control station PC, and Unit PLCs shall be through local area network (LAN) conforming to IEEE 802.3/802.2, 802.1 Q and the protocol shall be complied IEC 60870-5-101/104 standard or equivalent. The communication between CPUs for all control units and Intelligent Electronic Devices (IEDs) such as Digital governor, AVR excitation system, digital protective relaying system, automatic synchronizing unit, digital metering equipment shall be MODBUS (TCP/IP). All status, alarm, condition of the unit and control signals shall be relayed to operator control station through the LAN. RS 485, RJ 45 or RS 232 communications are not allowed to use so that the **Bidder shall submit the communication system and protocol to be used shall be submitted with the Bid.**

Failure to submit this information will subject to rejection of the Bid.

Remote Process Input and Output (for future)

Remote process input/ output cards included in PLC cabinet shall be used for collecting the signal for inlet valve (if applicable) or switchgear in case of the equipment is too far from the PLC by via of Remote Ethernet TCP/IP bus from main control center in future but Contractor shall provide all necessary components and PLC communication modules for future purpose.

(f) Protective Relaying System

The protective relaying system shall be an integrated system of IEDs consisting of multi-functional digital relays, high-speed lockout relays, shutdown relays, blocking and test switches and auxiliary relays mounted in one or more cubicles.

Protective Relays

The Protective Relays for the Generator and Line Transformer shall be provided with reliable and longer life protection relay with minimum 5 years warranty directly from the manufacturer to ensure that the quality and reliability of the generating unit are assured.



The protective relays shall be microprocessor-based using digital signal processing technology and software to provide the protection functions, alarms and trip command, fault recording and communication to turbine control board via MODBUS protocol or CAN bus with TCP/IP (for Generator Protection). Each digital relay shall be provided with a port for communication with a laptop computer. The contractor shall design the protection system for generating unit, turbine unit, speed increaser (if applicable), generator transformer, station service transformer, switchgear and others equipment.

Major protective relays for the generating set such as Generator and Transformer Protective relay shall be well proven by the reputable international certification such as: -

- 10 CFR 50 Appendix B Nuclear Quality Program
- ABS Marine Type Approval
- CE (Europe)
- CSA (Canada)
- ENA (UK)
- IEC, including IEC 61850-10 Conformance
- IEEE, including IEEE 1613 Reliability
- ISO 9001:2008
- ISO/IEC 17025
- KEMA
- RUS (for rural electric cooperatives)
- UL
- VPP Star Safety

Each relay system shall be provided with test facilities for secondary injection testing and current circuits, potential circuits, tripping circuits' and all other output contacts. All test switches shall be arranged so that the current transformer secondary circuit cannot be opened circuit in any position while the test plugs or cover plugs are being inserted or removed. Test plugs shall be furnished with each type of test switches. All digital relays shall be adequately protected against damage from incoming surges and shall meet ANSI SWC test standard.

Each relay shall utilize a DC-to-DC converter type regulated power supply to provide high voltage and transient surge isolation between the station battery and the electronic components of the relay system. And each DC-to-DC converter shall be provided two electrically separate contacts for remote annunciation of output voltage failure. Each power supply shall be designed for continuous operation at any voltage from +/- of rated DC voltage and at range of ambient temperature of 10°C to 85°C and 0% to 95% humidity.

All modules of digital type protective relays consist of highly reliable logic circuits and circuit components. All modules shall be mounted on plug-in circuit cards. Wiring boards shall be epoxy-fiberglass construction. Printed circuit wiring shall be employed with soldered or weld connection to circuit components. Wiring board shall be provided with heavy-duty circuit connectors with gold-plated contacts.

The instruction manuals shall be prepared with the object of providing sufficient detailed technical information of each type of protective relay to enable DEDE to efficiently carry out commissioning and routine testing, to provide guidance in the tracing of faults and to permit order of replacement parts. In this regard, each instruction manual shall give full details of circuit operation, circuitry and components. All technical data, operating time curves, sample calculations and other characteristics shall be based upon 50 Hz. Operation.

The settings for the relay functions shall be programmed by via laptop computer using Original Software from manufacturer. And the method of uploading and correction shall be trained to DEDE operator before commercial operation of the plant.

Lock-out and Non-lockout Relays

Lock-out relays shall be high speed half-cycle type, solenoid operated, mechanically latched, with pistol grip manual reset handle. Non- lockout relays shall be similar but without the latch and reset features. Output contacts shall be rated for 2A at 125Vdc so sufficient contacts shall be supplied for all stated functions.

Auxiliary Relays

Auxiliary relays shall be rail-mounted socket type with sealed case and coils and contacts rated for 125 VDC.

Protection Circuits

Relays and protection circuits for shall be rated for 125 VDC and shall be supplied from separate dedicated fused DC circuits. Loss of supply relays shall monitor the supply and shall alarm the control system upon loss of DC. All VTs and CTs circuits shall be supplied with test switches for isolation and tests. In case of the maintenance, cut-off switch shall be provided for circuit protection to ensure that the breaker failure relay (50BF) will not be operated.

Metering

Active and reactive energy metering shall be provided for revenue, statistical and efficiency measurement. High accuracy metering of kWhr and kVARhr are required at control room. Metering shall comply with IEC 60687. Metering test block shall be provided in the CT and VT circuit to provide isolation and testing connection facilities for the meter.

All metering shall be a digital type meter with Ethernet communication and can be recording information and shall be shown on operator control station and shall be print out the information when required Meters shall have backlit LCD screen for display of quantities and phase vectors, and controls for selection of measured and calculated quantities. Meters used for monitoring distribution line electrical quantities shall be of revenue metering accuracy class. The meters shall include software to allow the control system to perform:

- Waveform capture
- Waveform record harmonic analysis
- Total harmonic distortion (THD) analysis
- Typical history and real time trends

Unit Synchronization

A digital synchronizer shall be supplied to permit manual or automatic synchronizing of the unit(s) output to the PEA grid. The system shall include interfaces with the governor and digital AVR for speed and voltage matching.

The synchronization unit shall include the following:

- Synchronization indicating lights
- Auto/ Manual Synchronizer
- Synchronization check relay (if necessary)

- (g) All electrical devices shall comply with the Standard International Technical Specifications such as IEC or NEMA or JIS standards.
- (h) The Contractor shall use devices whose ratings exceed the rating required by the function and duty of the device in order to increase the reliability of the plant.
- (i) Control, Monitoring & Protection Cabinet Construction
The system shall include Two or more cabinets each for the:
 - Unit protection and transformer protection relays, lockout and non-lockout auxiliary relays, and digital multi meters.
 - Line protection relays, auxiliary relays, and revenue meter
 - Unit control system, PLC and I/Os
 - Remote I/Os
 - Push Buttons, Switches Annunciators, etc.
- (j) Where possible on electrical devices, the Contractor shall supply one spare contact of each type used.
- (k) Devices shall have adequate range of setting to allow for possible changes during commissioning. The setting shall be readily adjustable and lockable in situ. The Contractor shall provide the DEDE Engineer with revised device setting schedule before the commissioning of plant.

(4) Solid State Systems

- (a) All solid-state equipment shall be built up from proven modules and components. Unproven equipment will not be accepted and bidders shall include with their bids details of the history of any solid-state equipment offered. Modules performing identical functions shall be designed to be interchangeable. Each module shall have sufficient test points to fault finding and calibration.
- (b) The electronic components used in the modules shall be of the highest quality, having a design in-service life of at least 20 years; this requirement applies particularly to capacitors.
- (c) Indication by means of light emitting diodes or other methods shall be provided on the digital inputs and outputs of solid-state equipment to indicate the logic state. Outputs shall be protected against short-circuits.