

SECTION -V

SPECIFICATIONS FOR ALTERNATING CURRENT GENERATORS, EXCITERS, VOLTAGE REGULATORS AND ACCESSORIES

5.1 SCOPE

This section of the specifications covers the design, manufacture, test at works, supply, delivery at site, erection, testing at site and commissioning of 2 (two) Nos. of horizontal AC synchronous generators complete with excitation system, voltage regulating equipment, neutral grounding and generator terminal equipments including CTs. PTs, (as per protection schemes) surge protection equipment, etc., and auxiliaries such as instrumentation, controls and safety devices (as required), spares for 5 years operation of the plant, special tools and testing devices as described and detailed in the specifications. The scope of supply shall include all parts, accessories, spares etc., which are essential for construction, operation and maintenance of the complete generator even though these are not individually or specifically stated or enumerated. Corresponding components of all the generators and associated equipments and the spares shall be of the same material, dimensions and finish and shall be interchangeable.

The generator manufacturer shall co-ordinate with the turbine supplier so that the generators to be coupled to the turbine is matched in respect of speed direction of rotation, runaway speed, moment of inertia, overload capacities, coupling and other relevant requirements.

The generator will operate in parallel with other generator.

5.2 TYPE AND RATING

The synchronous generators shall be of the horizontal shaft alternating current type. The direction of rotation shall be in accordance with turbine. The rating and other details of the generators are given below.

(i)	Rated output	160 KVA (128 KW)
(ii)	Power factor	0.8
(iii)	Frequency	50Hz
(iv)	No. of Phases	3
(v)	Rated terminal voltage between phases	415 V
(vi)	Range of voltage variation between phases for rated output	$\pm 10\%$
(vii)	Range of frequency variation	$\pm 3\%$
(viii)	Stator winding connection	star connection
(ix)	Speed	to match with turbine and gearbox.
(x)	Short Circuit ratio	not less than 0.8
(xi)	Inertia constant	not less than 1.0
(xii)	The Synchronous generator will have AVR with static brushless self excitation system.	

The generator shall be capable of delivering maximum continuous output of 110% of the rated output at rated power factor. The tenderer may offer his nearest standard. The generator will be connected to the turbine directly or through speed increaser (if required) which will be supplied by the turbine supplier. All generator terminals shall be brought out of the stator frame for insertion of current transformer for protection, metering and surge protection apparatus. The generator neutral shall be grounded suitably and the generators shall be designed to safely withstand any mechanical/magnetic stresses resulting from either a three phase or a single phase fault.

Each generator shall comply in all respects with the requirement of the latest issue of Indian Standard IS:4722 except where specified otherwise.

5.3 SPEED RISE AND RUNAWAY SPEED

The moment of inertia of the generator together with the moment of inertia of the turbine and flywheel (if any) shall be such that the maximum momentary speed rise shall not exceed 35 % of the rated speed. The generator manufacturer shall co-ordinate with the turbine manufacturer to limit the speed rise to this value.

Each generator shall be designed and constructed so as to be capable of running for a period of 15 minutes at the maximum runaway speed. The runaway speed test shall be considered successfully if after undergoing the test 'no injury' is apparent. The runaway speed test may be carried out at site for which the purchaser would provide suitable foundations that will withstand the test.

5.4 NOISE LEVEL

The noise level shall not exceed 90 db (A) when measured at a distance of 1m from any component of the generator.

5.5 INSULATION AND TEMPERATURE RISE

Insulation shall be provided as follows:

- | | |
|--------------------|------------------------------------|
| (i) Stator winding | material corresponding to class F. |
| (ii) Rotor winding | material corresponding to class F. |

The generator shall be capable of delivering rated output continuously at any voltage and frequency in the operating range at rated power factor without exceeding the following values of temperature rise over ambient temperature (30°C)

- | | |
|--------------------|-------|
| (a) Stator winding | 60° C |
| (b) Rotor winding | 60° C |
| Stator Core | 55° C |

The maximum temperature rise when the generator is delivering maximum output corresponding to continuous overload capacity for conditions stated above shall not exceed 60° C for both stator and rotor windings.

5.6 EFFICIENCY AND OUTPUT GUARANTEES

Within the limits of temperature rise specified in clause 5.5 above, the rated continuous output of the generator shall be guaranteed under penalty with a rejection limit of minus 2% for the rated generator terminal conditions.

The weighted average efficiency of the generator shall be guaranteed under penalty with a rejection limit of minus 2%. The efficiencies shall be determined by the summation of losses method as specified in latest Indian Standard IS:4889. For any shortfall in the test value of output and weighted average efficiency (as determined below) from the guaranteed figures, the penalty shall be at the rate of 5% of the ex-works value of generator per generator for every 1% by which the test figure is less than the guaranteed figure. The weighted average efficiency = $K1 \times \text{efficiency at full load} + K2 \times \text{efficiency at 80\% full load} + K3 \times \text{efficiency at 60\% full load}$. The penalty on account of output and efficiency shall be computed separately and the total amount of penalty shall be the sum of the two. The ceiling on the total amount of penalty on account of shortfall in the weighted average efficiency and output will be 10% of the total unit price of the generators.

No tolerance shall be permitted over test figures of output. Tolerance in determination of efficiency shall be as per relevant Indian Standard.

5.7 BID EVALUATION

For the purpose of comparison of tenders, the equalization on account of differences in the weighted average efficiencies between various offers will be made on the same basis as indicated for penalties, i.e., the prices of generators with lower efficiencies will be loaded at the rate of 5(five)% of their ex-works prices for each 1(one)% difference in weighted average efficiency as compared with the highest weighted average efficiency.

5.8 VENTILATION SYSTEM

Cooling system for the generator shall be open ventilating type. Two fans of suitable design shall be provided at both ends of the generator rotor. These fans shall suck the cold air from sides and hot air after cooling stator winding & core shall be exhausted from the ducts provided on the stator frame

5.9 HEATING OF GENERATOR IN STAND STILL CONDITIONS

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At each end of the generator heating elements of suitable capacity shall be installed to avoid condensation when the unit is under shutdown. The temperature to be maintained shall be 5 C above the surrounding temperature. Necessary thermostat to be provided for auto on / off of the heating elements.

5.10 CONSTRUCTION

5.10.1 Stator

The stator frame shall be cast iron/fabricated steel construction. The frame shall be designed to withstand bending stresses and deflections due to its self-weight and weight of the complete core to be supported by it. The stator core shall be built up of segmental punching of low loss, non-oriented steel sheets and end plates. Each punching shall be carefully debarred and insulated on both sides with high quality varnish to reduce losses in the core.

The stator winding shall be multi-turn or single-turn type and shall be insulated with Class 'F' insulation. The stator winding shall be star connected with both ends of conductors of each phase brought out of stator.

6(Six) nos. embedded temperature detectors of resistance type shall be provided for stator winding located symmetrically.

5.10.2 Rotor

The design and construction of rotor shall be in accordance with the best modern practice. The factor of safety at maximum runaway speed based on yield point of material shall not be less than 1.5.

Necessary flywheel effect shall be incorporated into the rotating parts of the generator and shall be determined in consultation with turbine manufacturer. In case the requisite moment of inertia is not available from the rotor, a separate flywheel shall be provided, to furnish the additional flywheel effect required.

5.10.3 Field Winding

Field winding shall consist of fabricated field coils or any other type with adequate provision for cooling purpose. The insulation turns shall be of special epoxy impregnated asbestos paper.

5.10.4 Damper Winding

The field poles shall be provided with adequate damper windings to ensure stability under fault conditions.

5.10.5 Shaft

The generator shaft shall be made of the best quality carbon steel properly heat-treated. The shaft shall be of adequate size to operate at all speeds including maximum runaway speed and shall be able to withstand short circuit stresses without excessive vibrations or distortion. The generator shaft shall be accurately machined all over and polished where it passes through the bearings and accessible points for alignment checks. Generator shaft shall have suitable provision for coupling to turbine/gear box.

5.10.6 Fans

Axial flow centrifugal fans are to be mounted at each end of the rotor poles for ventilation purposes.

5.10.7 Bearings

The generator bearings shall be the Anti-friction ball/roller bearings grease lubricated. These bearings shall be guaranteed for minimum continuous working for 1,00,000 (One hundred thousands) hours and shall be of proven design and performance.

Bearings shall be adequately insulated to prevent any harmful circulating currents. The bearings shall be designed to withstand operation of runaway speed for a period of 15 minutes. Thermometers, pressure gauges, flow relays, etc., as required, shall be provided.

5.10.8 Ventilation

The generator shall be provided with enclosures for closed ventilated type machines.

5.10.9 Heaters

Space heaters of adequate rating shall be provided for maintaining stator surrounding air temperature above the ambient during prolonged shutdown period.

5.11 OIL AND GREASE

The tenderer shall indicate this requirement and give his recommendations with detailed specifications regarding type of oil/grease to be used for lubrication of generator bearings. The oil if used for generator bearing lubrication, etc., shall be identical with that used for the pressure oil system of governor. The generator and turbine manufacturers shall cooperate to ensure that their recommendations regarding oil are identical. The first filling of oil with 10% extra shall be supplied alongwith the generator.

5.12 THE FLYWHEEL

A separate flywheel of ample dimensions shall be supplied in case the required movement of inertia for limiting the speed rise/runaway speeds in case not available from the generator rotor exciter (through the speed increaser, if envisaged).

Necessary provision for receiving the piston of the brake cylinder on application of brakes shall be made in the flywheel.

5.13 EXCITATION SYSTEM

Brushless, self excited complete with electronic AVR

5.14 LINE TERMINAL AND NEUTRAL GROUNDING CUBICLES

The generator suppliers shall supply 1 no. terminal cubicle for each machine housing surge capacitor, potential transformers, current transformers, lightning arresters, cable boxes, etc. The cubicle shall be complete with necessary tappings for excitation system, etc. The rating of the CTs for AVR shall be decided by the supplier taking into account the requirements of AVR.

The generator supplier shall neutral grounding cubicle one for each machine housing single phase distribution transformer, secondary loading resistor, current transformer, cable boxes, etc.

The cubicles shall be sheet suitably compartmentalized with doors and shall be furnished complete with base mounting arrangement, foundation bolts, etc. The internal illumination for cubicles shall be provided with guarded lamps with on/off switches. Copper/Aluminum conductors of appropriate size shall be used for bus bars and connections in the cubicles. The bus bar and main connecting conductors shall be suitably insulated to make them compatible with generator temperature rise and insulation. The support insulators for the bus connection will be provided as necessary. GI earth bus of adequate cross section will be provided in the cubicle.

5.15 POTENTIAL TRANSFORMERS

The potential transformers will be single phase, epoxy cast, dry type units. Potential transformer will be protected on primary and secondary side by current limiting fuses. The PT shall conform to IS:3156. The potential transformers shall be rated as given in the drawing.

5.16 CURRENT TRANSFORMERS

The current transformer will be epoxy cast, dry type unit conforming IS:2705. The current transformer shall be designed to withstand the thermal and magnetic stresses resulting from the maximum short circuit current.

The current transformers should be suitable for metering and protection.

The following protections are recommended:

- (i) Three-pole differential relay (87 G)-3 CTs on the neutral of the generator and 3 CTs on the phase.
- (ii) Over-current and earth fault relay (51 and 64)
- (iii) Over voltage protection (59)
- (iv) Field failure protection (40)
- (vii) Negative phase sequence (46)
- (viii) Reverse Power Protection (32)
- (ix) Over speed (Mech./Elect.)

5.17 LIGHTNING ARRESTORS

The lightning arrestors shall be heavy duty indoor station class non-linear resistor type suitable for repeated operation to limit voltage surges on alternating current power circuits and to interrupt power follow current. The arrestors shall conform to IS:3070 (latest edition) Part-I. The nominal discharge current of lightning arrestor shall not be less than 10KA.

5.18 SURGE CAPACITORS

The surge capacitors shall conform to the latest edition of IS:2834 and shall be rated 0.25 microfarad. The capacitors shall be connected in parallel with lightning arrestors and shall be provided with a built-in discharge resistor. The capacitor shall be suitable for indoor mounting.

5.19 UNIT CONTROL BOARD AND GENERATOR INSTRUMENTATION AND CONTROL

The generator supplier shall supply all equipment and devices for control, instrumentation and safety relating to the generator. These together with the equipment supplied by the turbine supplier shall constitute a complete and coordinated set of instruments, gauges, control and safety devices for control of the units during normal running and in emergencies.

Indicating instruments, gauges, control and safety devices will be mounted on the unit control board to be supplied by the generator supplier. The turbine supplier shall supply necessary loose items for mounting on the unit control board. The generator manufacturer shall fully coordinate with the manufacturer of turbine to ensure a neat and functional arrangement of the cubicles. A tentative list of indicating instruments, controls and safety devices to be supplied by the generator supplier is given in Tables A, B, and C. The generator manufacturer may increase/decrease items according to requirements to suit the type and design and also for proper and satisfactory operation of the units. The alarm and annunciation panel with all necessary annunciation relays, aux relays, alarm bell, terminal bolts etc., and adequate number of alarm annunciation fascia windows for both

turbine and generator shall be provided. The generator manufacturer shall fully co-ordinate with the turbine manufacturer in this regard.

5.20 SPARES

The unit rates shall be quoted for the spares. The tenderer shall also indicate in the tender any additional spares that he would recommend for 5 years' operation and furnish item wise unit prices for the same.

5.21 TESTS

The first generator shall be completely assembled at works and types tests as specified below shall be conducted on the assembled unit and auxiliaries as per the latest edition of IS:4722.

5.21.1 Type Test on First Generator

- (a) Temperature rise test.
- (b) Dielectric test.
- (c) Efficiency test.
- (d) Excess current test.
- (e) Runaway speed test.
- (f) Moment of inertia of rotating parts (by mutual agreement between the purchaser and the contractor)
- (g) Wave form
- (h) Determination of characteristic:
 - (i) Reactances – Synchronous, transient, subtransient, negative phase sequence and zero phase sequence.
 - (ii) Rated current, zero power factor lagging saturation curve.
 - (iii) No load and short circuit saturation curve.

5.21.2 Routine Tests on all the Generators

- (a) High voltage test on stator coils and stator sections and on assembled stator.
- (b) High voltage test on field coils and poles.

- (c) Insulation resistance tests.
- (d) Impedance and voltage test on field coils.
- (e) Accuracy test for RTDs and dial type thermometers.
- (f) Hydraulic tests on oil, and air coolers.

5.21.3 Tests on Exciters and Regulating Equipment (For Rotating Exciters)

- (a) High voltage test.
- (b) Temperature rise test.
- (c) Measurement of resistances.
- (d) Measurement of insulation resistance.
- (e) Regulation test.
- (f) Commutation test.
- (g) Excitation response ratio.
- (h) Routine tests on static excitation equipment.

5.21.4 Additional test, if any, as recommended by the supplier.

5.21.5 Tests At Site

Site test for each generator shall include the following:

- (a) Mechanical run.
- (b) Measurement of stator and rotor winding insulation resistance.
- (c) High voltage dielectric test.
- (d) Measurement of shaft voltage (if applicable)
- (e) Measurement of stator and rotor winding resistance.
- (f) Phase sequence test.
- (g) Load acceptance and rejection test at selected loads from no load to full load.

- (h) Overall response of machine and excitation system to system voltage changes.
- (i) Adjustment of AVR.
- (j) Synchronising test.
- (k) Checking and commissioning of various other auxiliary equipment.

5.21.6 Test on other equipment like CTs, PTs, Las shall comply with the routine tests, etc., as per relevant standards.

Test report for all type tests on the generator, CTs, PTs, etc., carried out on similar equipment already supplied shall be furnished for approval.

5.22 TESTING EQUIPMENT

A list of field testing equipment along with item-wise rental prices shall be indicated in the tender.

5.23 SPECIAL TOOLS

The contractor shall supply a complete set of special tools and other equipment that may be necessary or desirable for operation and maintenance of the generator and auxiliary equipment of his supply. The tenderer shall submit a list of the above and include the price in tender.

Any special reamers or broaches and brazing equipment for all work which must be done in the field, shall be provided by the contractor.

5.24 ERECTION

The contractor shall depute experts in erection, testing and commissioning of generators, excitation equipment and other associated equipment for erection, testing commissioning of generators, and associated equipment. The daily rates for supervision personnel shall be quoted by the tenderer.

5.25 DRAWINGS

In addition to the drawings called for in Section II the following drawings and data shall be submitted with the tender.

The drawings containing all the information required for designing the civil works shall be supplied within 60 calendar days of the placement of letter of intent:

- (i) The general arrangement and overall dimensions of the generators, exciters (where applicable) and bearings, and showing positions of main and neutral terminals.
- (ii) Description of lubrication system alongwith drawings.

- (iii) Physical and schematic drawings of excitation system and AVR alongwith descriptive literature.
- (iv) Graphs showing predicted characteristic of the generator.
- (v) Generator layout drawings showing overall dimensions and layout of all ducts, cables, piping, relative positions of auxiliaries, etc.

5.26 GUARANTEED TECHNICAL PARTICULARS

The guaranteed and technical particulars of generator and associated auxiliary and ancillary equipments shall be furnished in the tender as per schedule of Guaranteed Technical Particulars.

5.27 SCHEDULE OF REQUIREMENT

2 (Two) Nos. 160 KVA (128 KW) 0.8 Pf 415 V 50Hz +3%, 3 phases horizontal synchronous generators with excitation system. Each generator shall be equipped as follows and in accordance with the specifications described in the preceding clauses.

- One No. Generator stator complete with frame, soleplates, core, winding with accessories and terminals.
- One No. Generator rotor complete with shaft, spider rim, poles with windings and accessories.
- One set Bearings.
- One set Anti-condensation space heater.
- One set Excitation and voltage regulation equipment (Brushless excitation with AVR).
- One set Fabricated base plate for generator and its bearings (for horizontal machines).
- One Neutral grounding cubicle.
- One Line terminal cubicle.
- One set Unit control boards and alarm annunciation panels.
- One set Mechanical overspeed devices with electrical contacts.
- One set Top and bottom brackets, (if applicable)
- 5.27.1** One set of instruments, controls and safety devices for generators.
- 5.27.2** One set of special tools.
- 5.27.3** One set of testing devices.
- 5.27.4** One set of spares for five years' normal operation of the generator.

TABLE - A**INDICATING/RECORDING INSTRUMENTS**

Sl. No.	Description	Qty. per unit	Location
1.	Generator heater ON/OFF indicating lamps.		
2.	Unit output meter kw		
3.	Unit voltmeter		
4.	Unit ammeter		
5.	Unit power factor meter		
6.	Unit frequency meter		
7.	Unit energy meter kWh (digital trivector meter)		
8.	Main CB open/close indicating lamps		
9.	Field voltmeter		
10.	Field ammeter		
11.	Balance indicator of AVR.		
12.	Indicating lamps for field breaker ON/OFF		
13.	AVR auto/manual (indicating lamps)		

TABLE– B**CONTROLS**

Sl. No.	Description	Qty. per unit	Location
1.	ON/OFF Control for anti-condensation heaters		
2.	Excitation ON/OFF push button.		
3.	Auto/Manual selection for AVR.		
4.	Voltage raise/lower auto potentiometer.		
5.	Voltage raise/lower manual potentiometer.		
6.	Field breaker ON/OFF.		

TABLE – C**SAFETY DEVICES (FOR ALARM)/SHUTDOWN**

Sl. No.	Description	Device type	Qty.	Annunciation at UCB
1.	Control scheme supply fail	Under voltage relay		Alarm
2.	Machine shutdown under fault	High speed tripping relay		Trip Alarm
3.	Oil level low/high	Level relay		Alarm
4.	AVR overcurrent	AVR overcurrent relay		Trip Alarm
5.	AVR control supply failure	Under voltage relay		Alarm

Note :- Tenderer may propose additions / deletions in the above list which shall be finalised in consultation with the Engineer-in-Charge.

TABLE –D**LIST OF SPARES**

The spare parts for the generator and associated equipment considered necessary for 5 years of operation of the generating units shall be supplied by the contractor along with the generator. The unit prices of the spares shall be indicated as per enclosed Table –D and additional spares if considered necessary by the Engineer i/c shall be provided by the contractor within the overall contract price. Over and above those listed in Table – ‘D’ and list provided by contractor.