



Exploration & Production

GENERAL SPECIFICATION

ELECTRICAL

GS ELE 115

AC generators driven by diesel engines

02	09/03	Change of Group name and logo
01	10/02	General review
00	03/01	First issue
Rev.	Date	Notes



Contents

1. Scope	3
2. Reference documents.....	3
3. Environment conditions	4
4. General.....	5
4.1 Materials, workmanship and suitability	5
4.2 Specification deviations.....	5
4.3 Rating and performance.....	5
5. Construction requirements	8
5.1 General.....	8
5.2 Terminal boxes	9
5.3 Rotor.....	10
5.4 Excitation system	10
5.5 Maintenance access	11
5.6 Earthing	11
5.7 Instrumentation	11
5.8 Control and protection panels	11
5.9 Generator protection	13
5.10 Engine starting (essential and emergency generating unit only).....	13
5.11 Labels	14
6. Inspection and testing	14
6.1 Qualification tests.....	14
6.2 Factory acceptance tests (FAT)	14
6.3 Test reports.....	15
7. Drawings to be supplied.....	16

1. Scope

This specification covers the design, manufacture and performance of AC generators, associated excitation systems and accessories driven by diesel or gas reciprocating engines.

It covers the requirements of normal, essential or emergency supply application.

2. Reference documents

The reference documents listed below form an integral part of this General Specification. Unless otherwise stipulated, the applicable version of these documents, including relevant appendices and supplements, is the latest revision published at the EFFECTIVE DATE of the CONTRACT.

AC generators shall conform in design, materials and performance with the appropriate sections of the latest editions (with amendments) of the relevant IEC and CENELEC standards.

The following order of preference applies specifically to electrical equipment:

- COMPANY Specifications
- Data sheets
- IEC Publications
- European Standards by CENELEC
- Standards and codes (UTE, BS, VDE, etc.) when IEC publications have not yet been issued.

Standards

Reference	Title
EN 50014	Electrical apparatus for potentially explosive atmospheres
IEC 60034	Rotating Electrical Machines
IEC 60044	Instrument transformers
IEC 60079	Electrical apparatus for explosive gas atmospheres
IEC 60186	Voltage transformers
IEC 60255	Electrical relays
IEC 60332	Tests on electric cables under fire conditions
IEC 60529	Classification of Degree of Protection Provided by Enclosures
IEC 60801	Electromagnetic compatibility for industrial process measurement and control equipment
IEC 60947	Low voltage switchgear and control gear
IEC 62262	Degrees of protection provided by enclosures for electrical equipment against external mechanical impacts (IK code)
ISO 10816	Mechanical vibration

Professional Documents

Reference	Title
Not applicable	

Regulations

Reference	Title
Not applicable	

Codes

Reference	Title
Not applicable	

Other documents

Reference	Title
Not applicable	

Total General Specifications

Reference	Title
GS ELE 079	Electrical apparatus for explosive gas atmospheres

3. Environment conditions

Outdoor installation: refer to project data sheet.

The associated equipment located indoors (e.g. control panels) shall be installed within air conditioned rooms with an ambient air temperature of 25°C but shall be able to operate as long as room temperature does not exceed 40°C.

The minimum degree of protection of enclosures shall comply with the following (according to IEC 60529):

- Indoor equipment IP 23
- Outdoor equipment IP 55
- Exposed deck (FPSO) IP 56
- Indoor or outdoor equipment IK 08

4. General

4.1 Materials, workmanship and suitability

All materials and parts included in the construction of the specified AC generator or of their related or ancillary equipment, shall be new and unused, of current manufacture, of the highest grade, and free from all defects and imperfections likely to affect their performance.

The generating units shall be the produce of a COMPANY regularly engaged in the manufacture of alternating-current generators and shall be of modern design, of proven performance and in regular production at the MANUFACTURER's place of business.

4.2 Specification deviations

The SUPPLIER shall advise COMPANY of any deviations made in respect of this specification at the time of tendering. Should this Specification conflict with requirements of the listed standards, the SUPPLIER shall request clarification from the COMPANY.

4.3 Rating and performance

4.3.1 General

Generating units shall be rated on a continuous full load service basis, duty type S1, at the rated power and specified ambient conditions without harmful effects.

The rated power of the generating unit shall exceed the installed capability of the associated prime mover under all conditions and at all temperatures in the specified range.

The generating unit shall have a high accuracy governor providing close control over the speed.

The generators, excitation systems and all accessories shall be designed and constructed in accordance with good engineering practices which should result in an expected lifetime of at least 20 years. The machines shall be suitable for at least three years uninterrupted operation under the conditions specified.

4.3.2 Auxiliary supplies

The voltages (provided by COMPANY unless otherwise specified in project particular specification) for auxiliary equipment shall be:

- 400 V AC - 3 phase from normal supply (earthed through a 150 mA high impedance)
- 230 V AC - 3 phase from normal supply (earthed through a 150 mA high impedance)
- 230 V AC UPS - 1 phase floating
- DC voltage - 24 or 48 V DC floating.

The auxiliary power shall be included into the power balance.

4.3.3 Short time overload (for emergency/essential generating units only)

Emergency generating units shall be capable, from normal full load operating temperature, of repetitively supplying 110% of rated load for a period of one hour in each 12-hour period without exceeding the temperature rises specified in the standards.

4.3.4 Momentary excess current

Machines shall be capable, from normal operating temperature, of carrying without damage a stator current of:

- 150% of the rated current for a period of at least 30 seconds
- 110% of the rated current for a period of at least one hour, without dangerous overheating.

4.3.5 Sudden short circuit

Generating units shall be designed to withstand without damage a short circuit of any kind (and at least 300% of the rated alternator current) at the terminals, whilst operating at rated load and 105% of rated voltage, for a period of three seconds.

4.3.6 Form and symmetry of voltages and currents

The generating unit shall be able of operating on an unbalanced system as defined in [IEC 60034-1](#) paragraph 6.2.

Should the limits of deformation and balance occur simultaneously in service at the rated load, this shall not lead to any deleterious temperature in the generator and the excess resulting temperature rise or temperature related to be limits specified in this standard should be not more than approximately 10K.

4.3.7 Telephone Harmonic factor

Irregularities of waveform (THF) shall be as per [IEC 60034-1](#) prescription paragraph 8.1.

The MANUFACTURER shall specify the maximum acceptable harmonic rejection from consumers for generators to operate in satisfactory conditions.

4.3.8 Excitation system

The machines, including excitation systems, shall be designed for a rated power factor of 0.8 lagging (overexcited) at rated output, expressed in kilo-volt-amperes, and with the generator voltage between 90% and 110% of the rated value. Each excitation system shall be rated for at least 110% of the excitation current required during full load operation at rated voltage and rated power factor.

The steady state voltage variations at all loads when operating isolated from the electrical network shall be limited to $\pm 2.5\%$ of the rated voltage.

The voltage variation after instantaneous application of 100% load shall not exceed -15%, and recovery to 97% of rated voltage shall occur within 1.5 seconds.

Should the automatic control fail, the AVR shall revert to manual voltage control without change to the excitation.

The MANUFACTURER shall design impedance and time constants of generator and shall adjust the parameters of the AVR (gain and time constants) in order to obtain minimum voltage recovery time, minimum voltage dip, according to the network configuration stated in the single line diagrams/data sheets.

The MANUFACTURER shall provide details of the voltage response of the generators to the sudden application of large loads (i.e. half rated output and rated output), for COMPANY approval.

4.3.9 Speed regulation

The generating unit shall have a high accuracy governor providing close control over the speed. The speed shall be adjustable over the range 95% to 105% of the rated speed during normal operation.

The steady state speed variations, at all loads when operating isolated from the electrical network shall be limited to $\pm 0.5\%$ of the rated speed.

The governor shall be equipped with adjustable droop characteristic, from zero to at least 10%.

4.3.10 Parallel operation

Where more than one generator is specified the units shall be suitable for parallel operation with each other and or network. The specified generating units shall operate with the other units under load conditions up to their maximum output whereby the power factor shall be maintained approximately at the same value between each generator by means of automatic reactive load sharing.

The generators shall normally share the reactive load without hunting, in accordance with their rating under all conditions.

The engine shall normally share the active load without hunting, in accordance with their rating under all conditions.

The ceiling voltage and response to system faults shall be such that a rapid field forcing is obtained, with benefit to the stability between generators. Sufficient current shall be available to energise backup protective devices in the event of short circuits.

The excitation system shall withstand the following duty cycle, repeated every five minutes:

- Continuous rated current
- Ceiling voltage for 20 seconds
- Continuous rated current.

The excitation system shall allow 100% voltage to be maintained at 90% speed.

The output voltage of the generating unit shall be adjustable between 90% and 110% of the rated value during normal operation.

4.3.11 Earth faults

In case of high voltage generator, the MANUFACTURER shall provide COMPANY with the external earth fault withstand capability curve: $i_0 = f(t)$.

Unless otherwise specified in the Project particular specification, the minimum requirement current shall be 30A for three seconds, without exceeding the specified temperature rise limits.

4.3.12 Mechanical

4.3.12.1 Critical speeds

Machines with a rigid, subcritical rotor bearing system shall have the first critical speed not lower than 125% of the rated speed. For machines with a flexible, overcritical rotor bearing system, the first critical speed shall not be above 80% of rated speed and the second not lower than 125% of rated speed.



The prime mover MANUFACTURER shall perform a torsional analysis of the complete system. The generator MANUFACTURER shall provide all required data in a timely fashion to allow this work to proceed including dimensional data to prepare the torsional model as well as generator air gap torque and dynamic torque characteristics during system fault conditions.

4.3.12.2 Vibration

Maximum vibration level of the bearing housing on load or offload shall be 2.5 mm/s rms. The vibrations measured on the shaft shall be 50 microns peak to peak plus 10 microns maximum runout if runout demonstrated.

When freely suspended, the bearing vibration shall not exceed 1.8 mm/s rms in any direction. When rigidly mounted, the bearing vibration of machines shall not exceed 2.8 mm/s rms in any direction.

Vibration of the generator frame, including terminal boxes, shall not cause any damage to the machine and shall be limited to 4.5 mm/s.

These maximum allowable vibration levels shall apply for testing the machine alone in the factory and testing the machine mounted "in situ". These levels shall apply to all operating temperatures between ambient and maximum operating temperature, and all operating conditions between no-load and maximum capability, and all levels of bearing oil viscosity between the minimum and maximum specified for the bearings.

5. Construction requirements

5.1 General

Products that are highly toxic to the environment or that are considered potentially carcinogenic (e.g. asbestos) shall not be used. The use of hygroscopic materials shall be avoided. Materials shall be selected to prevent contact corrosion.

Generators shall have jacking bolts or facilities to raise the machine with the aid of a mechanical jacking device to facilitate alignment of the generator with the prime mover.

Safety during operation and maintenance shall be carefully considered during design of the generators and auxiliaries.

5.1.1 Stator frame

The stator frame shall be of heavy duty cast or fabricated steel construction. The generator frame and bearing supports shall have sufficient strength and rigidity to avoid distortion or increased vibration as a result of external mechanical forces such as tightening of fixing bolts.

5.1.2 Magnetic circuit

The magnetic circuit shall consist of low-loss laminations securely held in position.

5.1.3 Windings

5.1.3.1 Insulation

HV generator insulation shall be class "F", provided by vacuum pressure Impregnation process.

LV generator insulation shall be insulation "H" or "F", according to the MANUFACTURER standard.



Temperature rise class Temperature rise shall be class "B" when insulation class is "F" and "F" when insulation class is "H".

5.1.3.2 Exciter

All windings of the main exciter and pilot exciter shall be of high quality enameled wire with suitable earth and interface insulation.

Impregnation process shall be as for the stator windings.

When a permanent magnet exciter is used, it shall have its magnets energised so as to avoid any subsequent intervention after an adverse electromagnetic field environment, consecutive to transient phenomena such as heavy short-circuits.

5.1.3.3 Stator

Windings shall be vacuum pressure impregnated and of high quality enamelled wire or preformed copper bar conductors.

They shall be adequately supported and braced to withstand vibration and the dynamic stresses of external short circuits. The stator windings shall be star connected.

The stator winding shall be fitted with 2 PT 100 resistance temperature detectors in the hottest part of each phase winding. RTD's shall be either three or four wire types.

5.1.3.4 Rotor

The field windings shall be made of copper. The field coils shall withstand all normal transient conditions (electromechanical and electrodynamical stress) occurring during a balanced or unbalanced short circuit.

5.1.4 Anti-condensation heaters

Suitably rated anti-condensation heaters shall be provided to avoid deterioration of the machine due to condensation. Heaters shall be suitable for 230 VAC supply single phase.

5.2 Terminal boxes

The machines shall be provided with separate mechanical device between power and control/command circuits.

Power terminal box shall be sized according to connection constraints (cable's type Cu or Al, section, bending radius, lug's size, etc.).

The star point terminal box shall accommodate the required current transformers for control, measurement and protection.

Clamping devices to withstand short circuit currents shall be provided within the main terminal box for cable connections, to separate and support the conductors.

The main connecting boxes shall be located as specified in the data sheets.

In auxiliary cable connecting boxes, unused wires of multicore cables shall be brought to terminals.

Cable gland plates or cable transits shall be provided, and shall be non-magnetic for single core cable connections.

Cable glands shall be bronze marine for offshore and brass for onshore applications.

5.3 Rotor

5.3.1 Shafts

Rotor shafts shall be one piece, heat-treated forged steel construction.

Welding on finished shafts and rotors is prohibited. Shafts and/or spiders subject to welding shall be stress relieved after welding.

The rotor shall withstand without any mechanical damage or permanent distortion:

- The maximum torque variations under operating conditions: short-circuit, emergency shutdown, etc.
- The maximum overspeed, which may be reached after a full load rejection or a manual governing action.

5.3.2 Balancing

Rotor balancing shall be conducted at rated speed, and shall be followed by an overspeed test at 1.2 times rated speed for at least two minutes.

Impedance of the rotor shall be measured before and after the test to detect loose connections.

Balancing shall be conducted with a half depth key.

Rotors shall be equipped with provisions, which allow addition of balancing weights by use of bolts in specially threaded holes directly in the rotor body.

Balancing weights shall be of lead or similar ductile material.

Fans shall be separately and individually balanced prior to mounting on the rotor shaft. They shall be of non-corroding material or shall be effectively treated with a corrosion resistant coating (after balancing of the rotor assembly).

5.4 Excitation system

The excitation system shall be brushless, consisting of a three-phase inverted synchronous generator, rotating rectifier assembly, permanent magnet pilot exciter or shunt excitation system and voltage regulator for each machine.

The current rating of the semi-conductors utilised in the rotating rectifier shall not be less than 200% of the maximum current flowing through the elements at maximum continuous excitation current. If parallel connection of semi-conductors is used, the above current rating shall be not less than 220% for the parallel group.

The repetitive reverse blocking voltage rating of the semi-conductors shall be not less than 200% of the maximum peak voltage generated by the main exciter.

Exciter field voltage and current transmitters (4-20 mA output) shall be provided for remote indication

A device shall be provided to detect the failure of any diode in the rectifier bridge assembly.

The Automatic Voltage Regulator (AVR) controlling the dc voltage applied to the main exciter field winding shall be of the continuous, quick acting electronic type. The parameters shall be readily adjustable. Manual control shall be achieved by the use of a separate, independent module controlling the field current, with local control switches or pushbuttons for increasing or decreasing the excitation.

The AVR control circuits shall be modularised and mounted in racks within the excitation control cubicle. Fault indicators (e.g. LEDs or a digital display) shall be provided to allow rapid fault finding.

The excitation system shall be completely self-contained and shall not depend on any auxiliary supply for correct functioning.

The Automatic Voltage Regulator (AVR) shall be fully electronic and continuous acting. The reference voltage value shall be adjustable only locally.

The AVR electronic control unit shall include a reactive current measuring and balancing system.

5.5 Maintenance access

The generator and exciter enclosures shall be fitted with suitable inspection plates and access covers which shall be designed for quick and simple removal. Access to the rotating excitation rectifier equipment shall be adequately sized to permit easy maintenance.

Ease of rotor withdrawal to facilitate rapid inspection and repair in service shall be considered as a highly desirable feature.

5.6 Earthing

The generator unit shall be equipped with two earth connection facilities located at readily accessible locations on opposite sides of the complete skid. In the case of a remotely located terminal box, an earth connection shall be provided within each box.

Unless otherwise specified, the shaft shall be electrically connected to the earth terminal, when all bearings and the rotor winding of a machine are insulated

5.7 Instrumentation

As a minimum, the following instrumentation shall be provided and installed in the control panel:

- Generator voltage, with selector switch
- Generator frequency
- Stator current with selector switch
- Generator power
- Generator power factor
- Individual alarm and fault indicators for each protective function.

5.8 Control and protection panels

Each generating unit shall be provided with the following panels:

- One local (skid mounted) panel housing "local mechanical gauges"
- One control panel installed either in the switchroom containing the associated switchboard or locally on the skid in the "local mechanical gauges" panel. The panel shall house the electronic governor, excitation/voltage regulation equipment, any associated synchronising equipment/facilities and the instrumentation listed in 5.7.

- Where applicable, the control panel shall be fitted with hardware such that it can be interfaced with the Electrical Control System (ECS). All input and output signals of the control panel shall be available at suitable terminals for connection by others
- The Emergency diesel generator control system shall have the necessary interfaces with the DCS, ECS, LV and HV switchgear system, as specified in the particular project. The SUPPLIER shall take care of these requirements, coordinate with all the MANUFACTURER/VENDORS and shall provide all the required interfaces for successful integration without any time and cost implication to the COMPANY.

When installed outdoor, the control panel shall comprise an outer double door with windows to allow the meters selector, switch positions, etc. to be seen. The panel shall be of metal construction, vertical, free-standing with front access only via hinged lockable doors.

The degree of protection shall be IP 55 for an outdoor panel and IP 23 if the control panel is located indoors with IP 20 rating when the door is open.

The panels will be floor mounted and cable access will be from below. They shall be naturally ventilated.

Internal wiring shall be by stranded conductors, with 1,000 V flame retardant PVC insulation. Conductors shall have a minimum cross-sectional area of 1 sq mm (2.5 sq mm for power wiring). Wiring shall be securely and neatly held in position, either loomed or run in trunking. Each wire shall be identified by numbered ferrules.

Wiring for external connections shall be brought to terminals, which shall be arranged for easy access for cable connections, testing, inspection and fault finding. No more than two wires shall be terminated to each terminal. Terminals shall be clamp type mounted on DIN rails. 20% spare terminals shall be provided.

All metallic non-current carrying parts of the switch gear including hinged doors shall be bonded together and connected to the earth busbar

Sensitive speed control equipment and wiring shall be carefully shielded.

Unless otherwise specified, control voltage shall be 48 V dc and shall not be supplied by the starting batteries but by an independent battery system with a back-up from the 48 V dc battery charger dedicated to the electrical switchgear.

Unless otherwise specified in the particular project specification, a control panel shall typically house the following (for each engine-generator set):

- AC generator control devices, automatic and manual synchronisation equipment, alarm, VDU display and other devices as required.

Control devices shall include but not be limited to:

- Manual synchroscope
- Automatic synchroniser
- Incoming and running voltage meters
- Incoming and running frequency meters
- AVR raise/lower switches
- Manual/Off/Auto synchronising selector switch
- Circuit breaker status indication lamps



- Circuit breaker control switch
- Control selector switches.

5.9 Generator protection

The following electrical protection relays shall be provided (by others and fitted in the generator switchboard cubicle) as a minimum:

- Stator 3 phase overcurrent (50/51)
- Reverse power (32)
- Zero sequence overcurrent (51 n)
- Stator overfrequency and underfrequency (81), trip
- Stator overvoltage and undervoltage (27, 59), trip
- When specified in the project particular, stator differential overcurrent (87G) trip.

Also a stator winding over temperature relay (49) shall be provided by the generating unit MANUFACTURER and installed in the control panel.

In addition, other protection devices as recommended by the MANUFACTURER shall be incorporated or deleted after COMPANY approval.

5.10 Engine starting (essential and emergency generating unit only)

5.10.1 General

The generating unit shall be suitable for rapid starting and loading to full capacity within 15 seconds. In case of start failure an annunciation shall be provided on remote control panel.

Power for successive cranking cycles shall alternate between two independent systems with chargers.

Each system shall provide energy for six (6) consecutive starting attempts each for five seconds cranking followed by ten seconds rest.

Depending on installation conditions, starters shall be of electrical, pneumatic or hydraulic type.

When an electrical start mechanism is provided the automatic battery charger shall be with ammeter and trickle/boost charging facility as per MANUFACTURER/VENDOR's standard.

The battery charger shall be capable of fully charging the discharged battery in eight hours.

5.10.2 Automatic start mode

Automatic starting shall be initiated on normal supply under voltage (with a time delay), followed by tripping of the essential switchboard normal supply circuit breaker(s) and closing of the essential generating unit circuit breaker.

5.10.3 Manual start mode

Manual starting shall be possible locally.

Provisions shall also be made to periodically test the start up and loading of the essential generator. This will necessitate synchronising of the essential generator with the normal generation system at the emergency/essential switchboard.

5.11 Labels

All items of equipment including generators, exciters, rating plate connecting boxes, panels, circuit breakers, switches, devices, relays, controls, indicators, etc. shall be fully and clearly identified in accordance with the drawings using engraved traffolyte labels with black letters on white background. Labels shall be attached to non-removable parts using corrosion proof screws.

The MANUFACTURER shall supply a second plate to be mounted on the main equipment.

6. Inspection and testing

6.1 Qualification tests

The MANUFACTURER shall supply type test certificates carried out on similar equipment in accordance with the IEC publications along with his proposal.

- Short-circuit current test at a voltage 0.5 times the rated voltage
- Overspeed test
- Tests on batteries and chargers (complying with the relevant specification requirements)
- Occasional excess current test.

6.2 Factory acceptance tests (FAT)

These tests will be carried out individually on each machine and will comprise tests in accordance with the relevant standards:

6.2.1 Generator test

- Rotor balancing test (during manufacture)
- Physical inspection for compliance with specification and standards
- Dimensional checks
- Generator full load heat run
- Power frequency voltage withstand test
- Cold winding resistance measurement of stator, rotor and exciter
- No-load saturation test
- Phase sequence
- Dielectric tests
- Vibration test at no load, full speed
- Bearing temperature rise at no load, full speed
- Sleeve bearing inspection plus insulation measurement
- Noise level test
- Tests on all auxiliary devices, sensors, etc.

- Insulation resistance test on all windings, heaters, RTDs, etc.
- Telephone harmonic factor test.

6.2.2 Generator set test

- Tests on all auxiliary devices
- Measurement of voltage recovery time after sudden 70% block load application
- Measurement of voltage recovery time after 100% rejection load application
- The automatic starting sequence and alarm functions shall be verified
- Calculation of efficiency at 50%, 75% and 100% load, at rated power factor
- Winding insulation resistance before and after heat run
- Temperature rise test at full load 4 hr
- Vibration test at full load
- Bearing temperature rise
- Overspeed test (120% - 2 min, during manufacture)
- Full load wave analysis
- Voltage and current phases balance
- Over load test 110% 1 hr.

6.2.3 Tests after erection on site (Commissioning)

- Tests on batteries and chargers (complying with the relevant specification requirements)
- Tests on all auxiliary devices
- Tests of all alarms and trips
- Synchronizing test.

6.3 Test reports

A pro-forma of test reports shall be presented to the Purchaser for approval before placing the order.

The test reports shall detail as a minimum:

- The expected theoretical values
- The tolerances
- The results of the measurements, including if applicable, any intermediate value which has caused a temporary rejection.

The test reports shall be included in the Contractual technical documents, and shall be considered as an integral part of them.

7. Drawings to be supplied

As a minimum, the following drawings and documentation shall be supplied in timely fashion according to the specified schedule:

- General arrangement of generators and exciters
- Arrangement details of auxiliary equipment
- Layout of control and protection panels
- Cable schedules, wiring and termination diagrams
- AC and DC schematic diagrams
- Operation and maintenance manuals and technical details
- Detail drawings of all terminal boxes
- Data sheet showing full machine characteristics: short circuit ratio, reactances (X_d , X'_d , X''_d , X_2 , X_0 , ...), time constants (T'_{do} , T'_d , T''_d , ...), etc.
- Generator capability charts and P-Q diagram
- Preliminary protection setting recommendation
- Spare part list for commissioning and two year operation.