



Exploration & Production

GENERAL SPECIFICATION

ELECTRICAL

GS EP ELE 114

HV Synchronous Motors

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1. Scope

The purpose of this specification is to set out the general requirements for the design, manufacture and performance of HV synchronous motors either fed by a grid (fixed speed motors) or fed by a Variable Speed Drive (variable speed motors), to be installed in Company sites located either onshore or offshore.

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.

The following order of precedence applies specifically to electrical equipment:

- Applicable laws and regulations of the country in which the system will be operated. In cases where no "local" regulations exist, the French laws and regulations shall be used
- Company Particular Specifications and data sheet (if any)
- Company General Specifications
- Applicable International Electro-technical Commission (IEC) Standards
- Applicable CENELEC Standards
- Applicable recognised standards and codes (e.g. UTE-NFC, BSI, VDE, etc.) where IEC publications have not yet been issued.

Any conflict or inconsistency between the above set of documents (standards, specification, codes and local regulation or laws) shall be raised to Company attention for resolution.

Standards

Reference	Title
IEC 60034 (Parts 1; 5; 6; 9; 14)	Rotating Electrical Machines - (Parts 1; 5; 6; 9; 14)
IEC 60072	Dimensions and output ratings for rotating electrical machines
IEC 60085	Thermal evaluation and classification of electrical insulation
IEC 60146-1-2	Semiconductor convertors - General requirements and line commutated convertors. Part 1-2: Application guide
IEC 60529	Classification of Degree of Protection Provided by Enclosures
IEC 61000-2-4	Electromagnetic compatibility (EMC) - Part 2-4: Environment - Compatibility levels in industrial plants for low-frequency conducted disturbances
IEC 61800-4	Adjustable speed electrical power drive systems
IEC 62262	Degrees of protection provided by enclosures for electrical equipment against external mechanical impacts (IK code)
IEC 62402	Obsolescence management - Application guide



Reference	Title
IEEE 43	IEEE recommended practice for testing insulation resistance of rotating machinery (ANSI)
IEEE Std 115	Test procedures for synchronous machines Part I: Acceptance and performance testing Part II: Test procedures and parameter determination for dynamic analysis
IEEE Std 995	Recommended practice for efficiency determination of alternating-current adjustable speed drives Part I: Load commutated inverter synchronous motor drives
ISO 7919-1	Mechanical vibration of non-reciprocating machines. Measurements on rotating shafts and evaluation criteria. Part 1: general guidelines.
ISO 12944-2	Paints and varnishes - Corrosion protection of steel structures by protective paint systems - Part 2: classification of environments
ISO 281	Rolling bearings - Dynamic load ratings and rating life
ISO 2954	Mechanical vibration of rotating and reciprocating machinery - Requirements for instruments for measuring vibration severity
ISO 4628-3	Paints and varnishes - Evaluation of degradation of coatings - Designation of quantity and size of defects, and intensity of uniform changes in appearance - Part 3: Assessment of degree of rusting
ISO 8821	Mechanical vibration - Balancing - Shaft and fitment key convention

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 EP COR 350	External protection of offshore and coastal structures and equipment by painting
GS EP COR 354	External protection of onshore structures and equipment by painting
GS EP ELE 079	Electrical apparatus for potentially explosive gas atmospheres
GS EP ELE 121	HV Variable Speed Drive Systems
GS EP TEC 007	Obsolescence and Lifetime Cycle Management

3. Abbreviations

EMA	Experimental Modal Analysis
FAT	Factory Acceptance Tests
LCI	Load Commutated Inverter
THD	Total Harmonic Distortion
VPI	Vacuum Pressure Impregnated
VSD	Variable Speed Drive

4. Environment conditions

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

- Indoor equipment IP 23
- Outdoor equipment IP 55
- Indoor or outdoor equipment IK 08



5. General

5.1 Materials, workmanship and suitability

All materials and parts included in the construction of the motors shall be new and unused, of current manufacture, of the highest grade, and free from all defects and imperfections likely to affect its performance.

5.2 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.

5.3 Motors for hazardous area

Motors installed in hazardous areas shall be selected as per **GS EP ELE 079** requirements.

Motors and accessories shall bear their own marking, according to the mode of protection used.

5.4 Rating and performance

5.4.1 General

Unless otherwise specified in the data sheet, fixed speed motors shall be suitable for continuous duty type S1 and variable speed motors shall be suitable for duty type S9, at the rated power and specified ambient conditions without any harmful effects.

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

5.4.2 Auxiliary supplies

Unless otherwise specified in the data sheet the voltages provided by Company for auxiliary equipment shall be:

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

The auxiliary loads shall be included into the power balance.

5.4.3 Start-up

Unless otherwise specified, fixed speed motors shall be designed for direct-on-line asynchronous starts, in this case fixed speed motors shall be designed for heavy duty 1000 starts/year for the mechanical system and electrical system.

5.4.4 Sudden short circuit

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

5.4.5 Pulsating stator current

The motors driving equipment which requires a variable torque during each revolution (e.g. reciprocating compressors) shall have sufficient inertia to limit the variations in motor stator current to a value not exceeding 20% of the rated current.

5.4.6 Form and symmetry of voltages and currents

The motors shall be able to operate on an unbalanced system as defined in [IEC 60034-1](#) paragraph 7.2.

For fixed speed motors, the performance of the equipment shall not be affected by Harmonic voltage THD up to 10% and each Individual Harmonic Distortion within the limits of class 3, tables 3 and 4 of [IEC 61000-2-4](#).

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 motor and the excess resulting temperature rise or temperature related to be limits specified in this standard shall be not more than approximately 10K.

5.4.7 Harmonics

For fixed speed motors, when tested in open circuit and at rated speed and voltage, the voltage THD shall not exceed 3% and individual harmonics voltage shall not exceed 2%. The Manufacturer shall specify the maximum acceptable harmonic rejection from consumers to motor to operate in satisfactory conditions.

For variable speed motors, the Manufacturer shall liaise with the VSD Supplier to take into account the effects of harmonics and inter harmonics of the VSD on the motor design.

For variable speed motors, when used with a Load Commutated Inverter (LCI), the losses shall be determined using the [IEEE Std 115](#) test procedure amended by [IEEE Std 995](#) for harmonic losses and auxiliary losses.

5.4.8 Windings insulation level (Stator and Rotor)

For fixed speed motors fed via vacuum circuit breaker, the Contractor shall indicate to the Manufacturer the maximum dV/dt expected on the motor terminals in order to assess the motor insulation levels.

Variable speed motors shall comply with the minimum motor insulation levels as per [IEC 61800-4](#) requirements. The Manufacturer shall liaise with the VSD Supplier to take into account the expected voltage stress on the motor winding insulation system as a result of transient peak voltage values, peak rise time and repetition rate.

5.4.9 Excitation system

For fixed speed motors, the excitation system shall be designed for a rated power factor of 0.8 leading (overexcited) at rated output, expressed in kilo-volt-amperes, and with the motor voltage between 90% and 110% of the rated value.

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.

Excitation system shall have a thermal protection of the rotor based on excitation current measurement.

Fixed speed motors shall be supplied with a separate panel which contains the excitation system, regulation equipment, local control switches and/or pushbuttons, etc. Excitation system shall be equipped with an automatic power factor controller capable of maintaining the power factor within a margin of $\pm 2.5\%$.

For variable speed motors, the following shall apply:

- The excitation panel shall be included within the VSD panel
- The excitation system shall be controlled by the VSD
- The excitation current shall be cancelled as soon as a trip is triggered by the VSD.

5.4.10 Earth faults

The Manufacturer shall provide Company with the external earth fault withstand capability curve: $i_0 = f(t)$.

For fixed speed motors, unless otherwise specified in the data sheet, the minimum requirement current shall be 30A for three seconds, without exceeding the specified temperature rise limits.

For variable speed motors, the Manufacturer shall liaise with the VSD Supplier to define the earth fault current and the associated time.

5.4.11 Mechanical

5.4.11.1 Transient air-gap torque

The Manufacturer shall state the maximum transient air-gap torque during 2 or 3 phase short-circuit faults.

For fixed speed motors, the Manufacturer shall state the maximum transient air-gap torque during asynchronous start and reconnection after power interruption.

5.4.11.2 Critical speeds

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

The driven equipment Manufacturer shall perform a torsional analysis of the complete system. The motor 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 motor air-gap torque and dynamic torque characteristics during system fault conditions.

In addition for variable speed motors, the motor Manufacturer shall liaise with the VSD Supplier and driven equipment Supplier to take into account, as part of the torsional analysis, the torque pulsations produced as a result of VSD voltage and current harmonics.

5.4.11.3 Vibration

The maximum relative shaft displacement and the maximum combined mechanical and electrical run-out shall not exceed the values indicated by Table 2 vibration grade B of [IEC 60034-14](#). The maximum relative shaft displacement shall include the run-out.

The maximum bearing housing vibration magnitude in displacement, velocity and acceleration shall not exceed the values indicated by Table 1 vibration grade B of [IEC 60034-14](#). With a free-suspension mounting condition, the test bench rigidity shall correspond to the rigidity of the machine mounted "in situ".

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

The 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.

For variable speed motors, the Manufacturer shall carry out an EMA (Experimental Modal Analysis) to identify potential resonances in the stator structure, especially in the winding heads.

6. Construction requirements

6.1 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.

Motors shall have jacking bolts or facilities to raise the machine with the aid of a mechanical jacking device to facilitate alignment of the motor with the driven equipment.

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

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

6.2 Machine cooling

Unless otherwise specified in the data sheet, cooling method shall be as per [IEC 60034-6](#) and as following:

- IC 0A1 for IP 23
- IC 4A1A1, IC 5A1A1, IC 6A1A1, IC 6A1A6 or IC 8A1W7 for IP 54 or IP 55.

Cooling system assemblies shall be designed such that the natural frequency of vibration is neither excited by the motor running frequency nor its harmonics.

Number of cooling pumps and fans shall be designed with n+1 redundancy.



6.2.1 Air-to-water cooled machines

Each cooler shall be provided with a water leakage detector of piezzo type. The water box/header construction shall be such that leaking tubes can be readily plugged and that all tubes are accessible for cleaning.

Machines shall be provided with local temperature indicators for water inlets and outlets and also cooling air temperature detectors to measure the temperature of the primary air after the heat exchangers.

Primary coolant shall always be air.

Secondary coolant shall be treated water and may be either sea water or fresh water, depending on local availability.

Where seawater is circulated within the heat exchanger then double tube design shall be used. In case of fresh water, single tube design shall be used.

Tubes/header/waterbox shall be made of Cupro-Nickel for both sea or fresh water coolant provided that maximum flow speed (including turbulence effects) is lower than 2.5 m/s and the water circulation is permanent.

Tubes/header/waterbox shall be made of stainless steel 316L for fresh water coolant whenever maximum flow speed (including turbulence effects) is more than 2.5 m/s or the water circulation is not permanent (ex motor not permanently in operation).

For sea water application where maximum flow speed (including turbulence effects) is more than 2.5 m/s, tube/header/waterbox material selection shall be made on a case by case basis, depending on temperature ranges and after evaluation of crevice corrosion risks.

Tubes/header/waterbox may be made of carbon steel for onshore installation without any environmental corrosion risk (H_2S) and where fresh water is available.

Whatever the coolant and operation configuration, the tube/header/waterbox material choice shall be subject to written Company approval after a complete corrosion study carried out by Contractor.

For motor above 15 MW, dual coolers (complete with separate water boxes, valves and dedicated leakage detector) shall be fitted, each capable of meeting at least 60% of cooling requirements of full rated output of motor.

Unless otherwise specified in the data sheet, the "remote" heat exchanger, required for cooling the treated water in a closed circuit, is provided by the Company.

6.2.2 Air-to-air cooled machines

Cooling air for air-to-air machines shall be obtained from a dedicated air intake system via filtration. The motor Manufacturer shall liaise with the driven Manufacturer to ensure all requirements are satisfied and all ducts, fans, etc. are provided.

6.3 Stator frame

6.3.1 Frame

The stator frame shall be of heavy duty cast or fabricated steel construction. The motor 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.



Boroscopic inspection point(s) shall be provided to facilitate the inspection of the winding overhang.

6.3.2 Magnetic circuit

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

6.3.3 Windings

6.3.3.1 Impregnation (Stator and Rotor)

Windings shall be provided with Vacuum Pressure Impregnated (VPI) process.

For low voltage exciter and rotor fed with a voltage below 380V, dip impregnated is acceptable.

6.3.3.2 Insulation class and temperature rise

The insulation of the rotor, stator and exciter windings shall be class "F" and the temperature rise shall be class "B" at rated current.

6.3.3.3 Exciter

Windings of the main exciter and pilot exciter shall be of high quality enamelled wire with suitable earth and inter-phase insulation level which shall be in accordance with [IEC 60146-1-2](#).

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.

6.3.3.4 Stator

The stator windings shall consist of identical coils made of enamelled wire or preformed copper bar conductors covered with mica materials or equivalent.

Windings shall be adequately supported, braced, and blocked to withstand without damage the dynamic stresses occurring during short-circuit and to limit winding vibration through the motor speed operating range in order to avoid subsequent cracking of the winding insulation.

For variable speed motors, the stator structure shall be decoupled from the motor frame in order to avoid stator vibration transmission to the motor frame.

The stator windings shall be externally star connected.

Unless otherwise specified in the data sheet, each 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.

6.3.3.5 Rotor

The field windings shall be made of copper protected from corrosion with either resin or varnish.

The field coils shall withstand all normal transient conditions (electromechanical and electro-dynamical stress) occurring during a balanced or unbalanced short circuit.

6.3.4 Anti-condensation heater

Anti-condensation heater shall be designed to avoid deterioration of the motor due to condensation.



Unless otherwise specified in the data sheet, heaters shall be of a fully insulated design and suitable for 230 VAC supply.

6.4 Terminals and terminal boxes

The motors shall be provided with separate terminal boxes between power and control circuits.

All electrical connections shall be brought to terminals.

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

The powered terminal box shall be accommodated to put all required current transformers for control, measurement and protection.

For motors rated 1MW and above, the star point shall be brought out of the enclosure in a dedicated terminal box. For motor rated 2MW and above, this terminal box shall be sized to accommodate installation of differential protection CTs. Differential protection do not apply for motors fed by a LCI.

For motors rated 5MW and above, Rogowski coils shall be installed in the power terminal box to allow partial discharge measurements on-Site and monitor any evolution/trend compare to FAT records. For fixed speed motors, use of partial discharge capacitive sensors is subject to Company approval. Clamping devices to withstand short circuit currents shall be provided within the main terminal box for cable connections, to separate and support the conductors.

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.

6.5 General requirements related to EEx"p" design

An automatic leakage compensation unit shall be supplied by the motor Manufacturer and shall ensure the necessary purging cycle prior to the motor start and maintain the minimum required pressurisation during motor operation.

No external power supply shall be required. All the controls shall be performed from the Instrument Air supplied by others. The motor pressurisation system shall be equipped at the air inlet with a filter (40µm or lower) and its by-pass.

All hardware shall be preferably mounted on the motor pressure control cabinet.

Any pressure decrease under a pre-set threshold (1mbar for example) shall initiate immediate equipment shut down and shall be signaled remotely to the Process Control System.

6.6 Rotor

6.6.1 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, pulsating torque, etc.
- The maximum overspeed.

6.6.2 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 half coupling.

Rotor 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 not be of lead or similar ductile material.

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

6.7 Rotating exciter

The rotating exciter shall be of brushless type.

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.

The rotating exciter diodes shall be of hermetically sealed silicon type protected against abnormal transient conditions by surge protector.

When a 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.

Both the Permanent Magnet Motor and the rotating brushless exciter shall be mounted outboard of the bearing.

Excitation protection system shall be able to detect the failure of any diode in the rotating rectifier bridge assembly.

When applicable for fixed speed motors, the voltage transformer for the AVR power supply and motor voltage sensing shall be located within the motor switchboard or dedicated cubicle.

6.8 Maintenance access

The motors shall be fitted with suitable inspection plates and access covers which shall be designed for quick and simple removal.

Access shall be provided to measure air gap at Drive End and No Drive End.

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.

6.9 Motor earthing

The motors shall be equipped with two external earth lugs located at readily accessible locations and at least 15 mm diameter located 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 in the data sheet, the shaft shall be electrically connected to the earth terminal, when all bearings and the rotor winding of a machine are insulated.

The motors shall be fitted with bonding straps across joints within or between the main enclosure, terminal box, the bedplate and the heat exchanger.

6.10 Bearings

Unless otherwise specified in data sheet, both bearings (drive and non drive end) shall be fully insulated from the motor frame to prevent the flow of shaft currents.

It shall allow correct bearing insulation resistance measurement during operation without bridging the insulation.

Piping and instrument connections shall not bridge the insulation.

This bearing shall be adequately labelled to indicate the presence of insulation.

Shaft earthing shall be made at drive end bearing side by the use of slip ring or brush.

At Non Drive End side, a slip ring or brush shall be used for the Rotor Earth Fault protection (64R).

Sleeve bearings shall be of the self aligning type.

The bearing design shall be such that the replacement of liners will be possible without the removal of the rotor, the lower half of the end bell or plate, the coupling or the exciter.

Each bearing shall include as a minimum:

- Dual or two resistance temperature detectors (located in the area of minimum oil thickness), giving bearing white metal temperature. RTD shall be PT100, three or four wire types
- Local oil flowmeter or oil level gauge
- X-Y vibration probes (if specified in Project particular specification)
- Accelerometer.

6.11 Lubrication

Lubrication system shall be common for the motor and its driven equipment, in accordance with mechanical specification.

The Manufacturer shall liaise with the driven equipment Supplier to obtain information on low-speed requirements to adapt his bearing lubrication system (i.e. Jacking oil requirement).



6.12 Motor protection

Refer to Appendix 1 and Appendix 2.

For the stator differential protection, one set of CT's shall be located within the motor terminal box and one set in the incomer cubicle of the switchboard, in any case the motor Manufacturer shall provide the current transformers.

Other protection devices as recommended by the Manufacturer shall be submitted to Company approval.

All the recommended settings shall be provided by the Manufacturer prior to FAT.

6.13 Labels and rating plates

The motor shall be fitted with a rating plate as defined in the [IEC 60034](#). Also, labels shall be provided for all auxiliary terminal boxes.

Terminal boxes 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 rating plate to be mounted on the main equipment.

6.14 Noise levels

Motor noise levels shall comply with [IEC 60034-9](#). For motor rated above 5500 kW, noise level shall be submitted to Company for approval.

6.15 Special tools

A complete set of any special tools required for operation, maintenance and testing shall be provided.

The Supplier shall provide a list of special tools, individually priced, with his quotation.

7. Inspection and testing

7.1 Qualification tests

The Supplier shall supply type test certificates carried out on similar equipment in accordance with the [IEC](#) publications along with this proposal.

- Short-circuit current test at a voltage 0.5 times the rated voltage
- Hot spot temperature test
- Short circuit test for reactance and time constant determination at reduced voltage
- Noise level
- Occasional excess current test.

7.2 Test during production

For variable speed motors, an impact test using modal hammer shall be done to identify the potential resonances frequencies in the stator structure.

7.3 Factory Acceptance Tests (FAT)

FAT's shall be carried out in the presence of Company at the Manufacturer's works and shall comprise routine tests in accordance with the relevant standards and other additional tests when specified in the data sheet.

Unless otherwise specified in the data sheet, these tests shall be carried out individually on each machine.

When tests are required for just one machine, the Company select which machine will be tested.

7.3.1 Tests shall be carried out prior shipping any motors. Routine tests

A test certificate shall be supplied for each machine.

- Physical inspection for compliance with specification and standards
- Dimensional checks
- Insulation resistance test on all windings, heaters, RTDs, etc.
- Power, frequency and voltage withstand test
- Cold winding resistance measurement of stator, rotor and exciter
- Measurements and calculations of all stator impedances saturated and non saturated reactances (X_d , X_q , X_o , $X'd$, etc.)
- No-load saturation test
- Phase sequence
- Dielectric tests
- Polarization Index as per [IEEE 43](#)
- Partial Discharge measurement
- Overspeed test
- Bearings vibrations tests and shaft displacement tests (unfiltered) from 0 to 120% of the rated speed and determination of critical speed.
- Bearing temperature rise at no load, full speed
- Sleeve bearing inspection plus insulation measurement if any
- Running tests on all auxiliary devices, sensors, anti-condensation heater, etc.
- Rotor balancing test (during manufacture)
- Calculation of efficiency at 50%, 75% and 100% load, at rated power factor
- Open-circuit voltage harmonics measurement (THD and individual harmonics).



7.3.2 Full load tests

When full load tests are required in the data sheet, the following tests shall be carried out:

- Measurements of efficiency at 50%, 75% and 100% load, at rated power factor
- Motor heat run test
 - Measurements:
 - . Winding insulation resistance after heat run
 - . Temperature rise
 - . Vibrations
 - . Bearing temperature rise
- Full load wave analysis
- Voltage and current phases balance.

7.4 Test reports

A pro-forma of test reports shall be presented to the Company for approval prior 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.

8. Design Life & Obsolescence

Facilities are typically designed with an expected design life in the order of 25 years.

The motor design shall therefore take into account the requirement that the equipment will most probably require to be upgraded during the design life of the facilities in particular for all the electronic based components (excitation system, electronic protection relays, purging system relays, etc.). These requirements shall be incorporated from Basic Engineering stage.

The design will include provisions to allow an upgrade of the motor to be performed with minimal disturbance.

All hardware and software that may be developed by the Supplier further to the motor delivery, shall ensure full ascending compatibility to allow for easy replacement of equipment that became obsolete with limited reconfiguration.

At the Bid stage, the motor Supplier shall detail his lifecycle management strategy focusing on product obsolescence, support options and further migration alternatives. The lifecycle/obsolescence management plan and associated cost shall be part of the Bid process evaluation.



The motor Supplier shall complete an inventory of all provided equipment (hardware and software) matching to different lifecycles phases, including all Sub-Vendors equipment (e.g. AVR, protection relays).

Motor **Supplier** shall guarantee that:

- Machine components (including software and hardware) shall remain in the “active products” range (i.e. supporting developments and releases) over a period of at least 15 years after the SAT
- An announcement to Customer is provided 5 years prior the end of the commercial phase
- Motor components (including software and hardware) shall be fully supported and available over a period of at least 25 years after the SAT
- Maintenance services including availability of engineering services shall be available to support the motor during the plant life time.

Obsolescence and life time cycle management shall be in accordance with **GS EP TEC 007**.

9. Documentation to be provided

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

- Motor quality plan
- General arrangement of motor
- Motor rotor detail drawings
- Arrangement details of auxiliary equipment
- Detail drawings of all terminal boxes
- Rating plate and nameplate drawings
- Short circuit current versus time
- Data sheet showing full machine characteristics: short circuit ratio, saturated and non saturated reactances (X_d , X'_d , X''_d , X_2 , X_0 , etc.), time constants (T'_{do} , T'_d , T''_d , etc.), etc.
- Motor capability charts and P-Q diagram
- Preliminary protection setting recommendation
- Transient torque analysis
- Torque-speed curve (variable speed motors only)
- Stator Experimental Modal Analysis
- Operation and maintenance manuals and technical details
- Spare part list for commissioning and two year operation
- Obsolescence management dossier.



10. Other references

Following documents are applicable:

- Standards: IEC 60034-5, IEC 60072, IEC 60085, IEC 62262, IEC 62402, ISO 281, ISO 2954, ISO 4628-3, ISO 7919-1, ISO 8821, ISO 12944-2.
- Total General Specifications: GS EP COR 350, GS EP COR 354, GS EP ELE 121.



Appendix 1 Fixed speed motors protections

Protection ANSI	Code	Action
Bearing overtemperature	26	Alarm (1 st) and Motor trip (2 nd)
Bearing vibration	39	Alarm (1 st) and Motor trip (2 nd)
Stator winding overtemperature	26	Alarm (1 st) and Motor trip (2 nd)
Coolant overtemperature or failure	26	Alarm
Stator Instantaneous phase overcurrent	50	Motor Trip
3 phases stator overcurrent	51	Motor Trip
Stator thermal overload	49	Motor Trip
Neutral voltage displacement	59N/64S	Motor Trip
Phase unbalance	46	Motor Trip
Stator under/over frequency	81	Load shedding or Motor Trip
Stator under/over voltage	27-59	Motor Trip
Stator differential overcurrent	87 M	Motor Trip
Excitation stator winding overtemperature	26	Alarm (1 st) and Motor trip (2 nd)
Rotor Instantaneous phase overcurrent	50	Motor Trip
3 phases rotor overcurrent	51	Motor Trip
Rotor thermal overload	49	Motor Trip
Rotor earth fault	64R	Motor Trip
Field failure or loss of synchronism	40	Motor Trip
Rotating rectifier diode failure	94	Motor Trip

Appendix 2 Variable speed motors protections

Protection ANSI	Code	Action
Bearing overtemperature	26	Alarm (1 st) and Motor trip (2 nd)
Bearing vibration	39	Alarm (1 st) and Motor trip (2 nd)
Stator winding overtemperature	26	Alarm (1 st) and Motor trip (2 nd)
Coolant overtemperature or failure	26	Alarm
Stator Instantaneous phase overcurrent	50	Motor Trip
3 phases stator overcurrent	51	Motor Trip
Stator thermal overload	49	Motor Trip
Neutral voltage displacement	59N/64S	Motor Trip
Stator over frequency	81	Motor Trip
Stator over voltage	59	Motor Trip
Stator differential overcurrent (1)	87 M	Motor Trip
Excitation stator winding overtemperature	26	Alarm (1 st) and Motor trip (2 nd)
Rotor Instantaneous phase overcurrent	50	Motor Trip
3 phases rotor overcurrent	51	Motor Trip
Rotor thermal overload	49	Motor Trip
Rotor earth fault	64R	Motor Trip
Field failure or loss of synchronism	40	Motor Trip
Rotating rectifier diode failure	94	Motor Trip

(1) Except for motor fed by a LCI.



Appendix 3 Data Sheet HV Synchronous Motor



TOTAL

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DATA SHEET	N° []
Project:	[]
DS EP ELE 114	HV Synchronous Motor
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Rev. Date	[]	[]	[]	[]	[]	[]
Written	[]	[]	[]	[]	[]	[]
Verified	[]	[]	[]	[]	[]	[]
Approved	[]	[]	[]	[]	[]	[]

Appel d'offres/Call for tender ☐		Commande/Order ☐	
1	Repère Tag number	2	Nombre de moteurs Number of motors
3	[]	3	[]
4		4	
5	CONDITIONS D'INSTALLATION SITE ENVIRONMENTAL CONDITIONS		
6		6	
7		7	
8	Lieu d'installation Site	8	On-shore ☐ Off-shore ☐
9	[]	9	[]
10		10	
11	Température Ambient temperature	11	Moyenne annuelle Yearly average
12	[]	12	°C
13		13	Maximum
14	Altitude (si > 1000 m) Altitude (if > 1000 m above sea level)	14	[]
15	[]	15	°C
16		16	Minimum
17	Atmosphère corrosive Corrosive atmosphere	17	[]
18		18	°C
19	Embruns salins Sea spray	19	[]
20		20	Hygrométrie Humidity
21	Localisation (IEC 60079-10) Location	21	[]
22		22	%
23		23	
24		24	
25		25	
26		26	
27		27	
28		28	
29		29	
30		30	
31		31	
32		32	
33		33	
34		34	
35		35	
36		36	
37		37	
38		38	
39		39	
40		40	
41		41	
42		42	
43		43	
44		44	
45		45	
46		46	
47		47	
48		48	
49		49	
50		50	
51		51	
52		52	
53		53	
54		54	
55		55	
56		56	



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Appel d'offres/Call for tender ☐		Commande/Order ☐	
1			
2	Mode de protection		
3	Type of protection		
4	Ex "px" ☐ Ex "d" ☐		
5	Indice de protection IP		
6	Degree of protection IP		
7	IP 55 ☐	Autre	W ☐ S ☐
8	Enroulements stator		
9	Stator windings		
10	Nombre de bornes sorties		
11	Number of power terminals		
12	Enroulements rotor		
13	Rotor windings		
14	Classe d'isolation		
15	Insulation class		
16	Classe d'échauffement		
17	Temperature rise class		
18	Type de charge entraînée (Ventilateur, Pompe Compresseur)		
19	Driven load (Fan, Pump, Compressor)		
20	MOTEUR A FREQUENCE VARIABLE		
21	VARIABLE SPEED MOTOR		
22	Plage de vitesse		
	de	Rpm	A
	from		to
			Rpm

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Appel d'offres/Call for tender ☐		Commande/Order ☐	
1			
2			
3	Niveau de bruit maximum admissible CEI 60034-9 dB		
4	Maximum permissible noise level		
5			
6	Mode de refroidissement (CEI 60034-6)	Auto ventilé ☐	Moto ventilé ☐ IC
7	Cooling system (IEC 60034-6)	Self ventilated	Moto ventilated
8			
9	Par réfrigérant ☐	Air/air ☐	Air/eau ☐
10	By cooler	CACA	CACW
11	Echangeur double tube ☐		
12	Double tube exchanger		
13	Eau de mer ☐	Eau douce ☐	Eau circuit fermé ☐
14	Sea water	Soft water	Closed circuit water
15	Eau circuit ouvert ☐		
16	Open circuit water		
17			
18	Type d'additif à l'eau de refroidissement	Pourcentage d'additif dans l'eau %	
19	Type of additive in cooling water		
20	Additive percentage in cooling water		
21	Temp entrée de l'eau °C	Temp de sortie de l'eau °C	Matériau Tube, boîte à eau
22	Inlet Water Temperature	Outlet Water Temperature	Tube/Water Box Material
23			
24	Pression à l'entrée bars	Pertes de charges maximum bars	
25	Inlet pressure	Maximum Differential Pressure	
26			
27	Paliers ☐	Roulements ☐	Roulements précontraints ☐
28	Bearings	Roller bearings	Pre loaded roller bearings
29	Coussinets ☐		
30	Sleeve bearings		
31	Ratin oscillant ☐		
32	Tilting pad		
33			
34	Classe de vibrations selon ISO 10816-1: 2,5 ☐ mm/s rms		
35	Vibration class according to ISO 10816-1		
36	Autre mm/s rms		
37	Other		
38			
39	Type d'accouplement		
40	Coupling type		
41			
42	EXCITATION DU MOTEUR A FREQUENCE FIXE		
43	FIXED SPEED MOTOR EXCITATION		
44			
45	Système d'excitation ☐	Local ☐	Indépendant ☐
46	Excitation type	Local	Separate
47			
48	ACCESSOIRES		
49	ACCESSORIES		
50			
51	Capteur de vibration X-Y palier ☐	Nombre	Type
52	X-Y bearing vibration detector	Number	
53			
54	Purges eau de condensation ☐	Capteur de mesures des décharges partielles ☐	
55	Condensed water drain	Partial discharge monitoring sensor	
56			
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Appel d'offres/Call for tender ☐		Commande/Order ☐	
1			
2	Boîtes à bornes	Position	Avec PE
3	Main terminal box	Location	With cable glands
4			
5	TC protection différentielle dans boîte à bornes	6 TC	3 TC
6	Current transformers installed in the terminal box		
7			
8	Câble de puissance	Type	Triolaire
9	Power cable		Three cores cable
10			
11	Section	mm ²	Aluminium
12	Cross section		Aluminium
13			Nombre par phase
14	Diamètre sur isolant	mm	Diamètre extérieur
15	Diameter on		Outer sheath diameter
16			
17	Boîtes à bornes auxiliaires	Nombre	Mode de protection
18	Auxiliary junction boxes	Number	Protection of enclosure
19			
20	Avec P.E	Nature	Type
21	With cable glands		
22			
23	Peinture	Standard fournisseur à soumettre avec l'offre pour approbation	Spécif Client N° GS COR 350
24	Painting	Manufacturer's standard to be submitted with the bid for approval	Customer specif N° GS COR 350
25			
26	Sources auxiliaires disponibles	48V DC	24V DC
27	Available auxiliary supplies		
28			
29	ESSAIS		
30	TESTS		
31			
32	Réception usine	Présence d'un représentant du client	Réception sur site
33	Factory's acceptance tests	With client's inspector	Site acceptance tests
34			
35	Essais de routine	Sur l'ensemble des moteurs	Sur un des moteurs au choix du client
36	Routine tests	On each motor	On one motor selected by CLIENT
37			
38	Essais complets	Sur l'ensemble des moteurs	Sur un des moteurs au choix du client
39	Full tests	On each motor	On one motor selected by CLIENT
40			
41	Mesure des impédances synchrones	Test anti condensation	Mesures des décharges partielles
42	Motor synchronous impedance	Anti-condensation heater	Partial discharge measurement
43			
44	Essai de survitesse	Vibrations paliers à vide	Déplacements d'arbre et run-out
45	Overspeed test	Bearings vibrations at no-load	Run-out and shaft displacement
46			
47	Essais spéciaux		
48	Special tests		
49			
50			
51	CONDITIONS PARTICULIERES		
52	SPECIAL REQUIREMENTS		
53			
54	Compatibilité électromagnétique selon CEI 61000	Installations électriques à bord des navires CEI 60092	
55	Electromagnetic compatibility as per IEC 61000	Electrical installations in ships IEC 60092	
56			
57	Installation électrique à bord des navires selon CEI 60092-301		
58	Electrical installations in ship as per IEC 60092-301		
59			
60	Attestation d'examen de type	Par un organisme agréé	Autre
61	Type examination certificate	By notified body	Other
62			

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Appel d'offres/Call for tender ☐		Commande/Order ☐	
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64			
Constructeur / Manufacturer Type du moteur / Motor type Mode de protection / Type of protection Puissance nominale / Rated output Tension nominale / Rated voltage Intensité nominale / Rated intensity Cos phi / Power factor Vitesse nominale / Rated speed Fréquence / Frequency Rotor / Rotor type Classe d'échauffement / Temperature rise class Classe d'isolation / Insulated class Type de VSD / VSD Type VSI ☐ LCI ☐ Temps au CC/Short-circuit withstanding 300 % during Moment d'inertie / Moment of inertia Constante d'inertie / Inertia constant H = Rendement en % à cos phi=1 / Efficiency at power factor=1 4/4: 3/4: 1/2: Rendement en % à cos phi0.8 / Efficiency at power factor 0.8 4/4: 3/4: 1/2: Couple maximum en cas de court-circuit biphasé / Maximum torque on 2 phases short circuit Couple maximum en cas de court-circuit triphasé / Maximum torque on 3 phases short circuit Imprégnation de l'excitatrice: / Exciter impregnation: Vide / Vacuum Résine imprégnée / Impregnated Resin Tension d'alimentation de l'excitatrice / Exciter voltage Tension d'isolement phase / terre du stator / Phase to Ground stator voltage insulation level Tension d'isolement phase / terre de l'excitatrice / Phase to Ground exciter voltage insulation level Carcasse / Frame fonte / cast iron acier soudé / steel autre / other Réactances / Impedances Synchrone longitudinale / Direct-axis synchronous saturée / saturated non-saturée / unsaturated Xd Xdu p.u. p.u. Transitoire longitudinale / Direct-axis transient saturée / saturated non-saturée / unsaturated X'd X'du p.u. p.u. Subtransitoire longitudinale saturée / Direct-axis subtransient saturated X''ds p.u. Capacité phase terre / Phase to earth capacitance Synchrone transversale / Quadrature-axis synchronous saturée / saturated non-saturée / unsaturated Xq Xqu p.u. p.u. Subtransitoire transversale saturée / Quadrature-axis subtransient saturated X''q p.u. Reactance de Potier / Potier reactance Xpot p.u. Reactance inverse / Negative sequence (Unsat./Sat.) X2 p.u.			

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1 Réactance homopolaire Zero sequence (saturated/unsaturated)	X0	p.u.	Reactance de fuite du stator Armature leakage	X1 or Xl	p.u.
2					
3					
4 Résistances :					
5					
6 Résistance directe Positive sequence resistance	R1 or RA	p.u.	Résistance Negative	R2	p.u.
7					
8					
9 Résistance homopolaire Zero sequence resistance	R0	p.u.			
10					
11 Constantes de temps / Time constants			Transitoire en phase en court-circuit Direct axis transient short circuit	T'd	s
12					
13					
14 Transitoire en phase à vide Direct axis transient open circuit	T'do	s	Transitoire en quadrature à vide Quadrature axis transient open circuit	T'qo	s
15					
16					
17 Subtransitoire en phase à vide Direct axis subtransient open circuit	T''do	s	Subtransitoire en quadrature à vide Quadrature axis sub trans. open circuit	T''qo	s
18					
19					
20 Subtransitoire en phase en court-circuit Direct axis sub transient short circuit	T''d	s	Subtransitoire en quadrature en court-circuit Quadrature axis sub trans. short circuit	T''q	s
21					
22					
23 Rapport de court-circuit Short circuit ratio	SCR		Induit en court-circuit Armature short circuit	Ta	s
24					
25					
26 Courant d'excitation : Field current:	A vide At no load	A	A charge nominale At rated load	A	
27					
28					
29 Caractéristiques du lubrifiant / Lubricant characteristics					
30					
31 Huile Oil			Consommation Flowrate		
32					
33					
34 Graisse Grease			Fréquence de graissage Greasing frequency		
35					
36					
37 Type de paliers : Type of journal bearing:	Côté accouplement Drive end		Côté opposé à l'accouplement Non drive end		
38					
39					
40 Type de roulements : Type of ball bearings:	Côté accouplement Drive end		Côté opposé à l'accouplement Non drive end		
41					
42					
43 Réchauffage : Space heater	Puissance Power	kW			
44					
45					
46 Dimensions du moteur (cm) : Size of the motor (cm):	Longueur Length		Largeur Width		Hauteur Height
47					
48					
49 Masses : Weight:	Totale Total	kg	Rotor		kg
50					
51					
52 Dimensions de l'armoire d'excitation (cm): Size of the excitation cabinet (cm):	Longueur Length		Largeur Width		Hauteur Height
53					
54					
55					
56 Attestation d'examen de type : Type examination certificate	Par le constructeur Manufacturer's certificate		Par un organisme agréé By notified Body		
57					
58					
59 Nom de l'organisme Notified body			Référence du certificat Certificate reference		
60					
61					
62					
63					

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Exploration & Production

General Specification

Date: 01/2012

GS EP ELE 114

Rev: 01

Appendix 3



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DATA SHEET	N°
Project:	
DS EP ELE 114	HV Synchronous Motor
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Appel d'offres/Call for tender	☐	Commande/Order	☐
1	Pour moteur à surpression interne seulement / For pressurised Ex "px" motor only		
2			
3			
4	Pression Pa	Débit Nm ³ /h	Temps balayage min
5	Pressure Pa	Flow rate Nm ³ /h	Flushing time min
6	A débit (Nm ³ /h)		
7	Pressostat ☐	Seuil d'alarme Pa	Seuil déclenchement Pa
8	Pressure switch ☐	Alarm Threshold Pa	Trip Threshold Pa
9	Type		
10	Electrovanne ☐	Tension V	Type
11	Electrovalve ☐	Voltage V	Type
12	Type		
13	Vanne manuelle ☐	Nombre	Type
14	Hand valve ☐	Quantity	Type
15			
16			
17	Pour moteur à fréquence variable seulement / For variable speed motor only		
18			
19	Régime de neutre	Courant permanent de défaut à la terre autorisé A	
20	Neutral earthing	Permanent permissible earth fault current A	
21			
22			
23			
24			
25			
26			
27			
28			
29			
30	Divergences par rapport à la spécification		
31			
32			
33			
34			
35			
36			
37			
38			
39			
40	Deviations from job specification		
41			
42			
43			
44			
45			
46			
47			
48			
49			
50			
51			
52			
53			
54			
55			
56			
57			
58			
Cachet constructeur moteur Motor manufacturer's stamp			
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