

GENERAL SPECIFICATION

ELECTRICAL

GS EP ELE 121

HV Variable Speed Drive Systems

02	10/2012	Update for long cable applications and as marked
01	01/2012	Update of reference standards & obsolescence
00	10/2009	First issue
Rev.	Date	Purpose of the revision

Owning entity: DEV/TEC

Managing entity: DEV/TEC/ELE

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1. Scope

This specification defines the minimum requirements for design, manufacture, inspection and testing of HV variable speed drive systems. It is to be read in conjunction with the corresponding Project specification and/or data sheets.

The Supplier shall clearly identify in his technical offer any deviation to these specifications.

2. Reference documents

The reference documents listed below form an integral part of this General Specification.

Design and engineering shall conform as a minimum requirement to the current edition of the following in order of preference:

- 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.

External Documents

Unless otherwise stipulated, the applicable version of these documents, including relevant appendices and supplements, is the latest revision published at the effective date of this document.

Reference	Title
IEC 60034-1	Rotating electrical machines - Part 1: Rating and performance
IEC 60071 (All parts)	Insulation co-ordination - All parts
IEC 60076 (Parts 3; 6)	Power transformers - Parts 3; 6
IEC 60146-1-2	Semiconductor convertors - General requirements and line commutated convertors. Part 1-2: Application guide
IEC 60204-1	Safety of machinery - Electrical equipment of machines - Part 1: General requirements
IEC 60529	Classification of degrees of protection provided by enclosures
IEC 60871-1	Shunt capacitors for a.c. power systems having a rated voltage above 1000 V - Part 1: General
IEC 61000	Electromagnetic compatibility (EMC)
IEC 61071	Capacitors for power electronics

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Reference	Title
IEC 61378 (Parts 1; 3)	Converter transformers - Parts 1; 3
IEC 61800 (Parts 3; 4; 5-1)	Adjustable speed electrical power drive systems - Parts 3; 4; 5-1
IEC 62271-200	High-voltage switchgear and controlgear - Part 200: AC metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV
IEEE Std 519	Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems
ISO 12944-2	Paints and varnishes. Corrosion protection of steel structures by protective paint systems - Part 2: classification of environments

Total General Specifications

Unless otherwise stipulated, the applicable version of these documents, including relevant appendices and supplements, is the latest revision published in the applicable yearly collection.

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 011	Electrical requirements for packaged units
GS EP ELE 079	Electrical apparatus for potentially explosive gas atmospheres
GS EP ELE 111	Induction motors
GS EP ELE 114	HV Synchronous Motors
GS EP ELE 141	Power transformers
GS EP ELE 221	Electrical Control System (ECS)
GS EP INS 135	Cyber Security requirements for design and supply of ICSS and Package Systems
GS EP PVV 145	Flanges
GS EP SAF 221	Safety rules for buildings
GS EP TEC 007	Obsolescence and Lifetime Cycle Management

3. Abbreviations
VSDS Variable Speed Drive Systems

VSI Voltage Source Inverter

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LCI	Load Commutated Inverter
ESD	Emergency Shutdown
MTTF	Mean Time To Failure
VPI	Vacuum Pressure Impregnated
ECS	Electrical Control System
ICSS	Integrated Control and Safety System
SSTI	Sub Synchronous Torsional Interaction

Note: Variable Speed Drive Systems consists of power equipment (possible harmonic filters, input transformer, converter section, possible output transformer or filter, motor), control, protection and auxiliaries.

4. Design Requirements

4.1 General

VSDS shall be suitable for continuous full load service and for the operational duty of the driven equipment within the rated conditions and specified ambient conditions without exceeding the temperature rises specified in the standards and without deleterious effects of any kind.

The VSDS shall be capable of withstanding the thermal and dynamic stresses and transient mechanical torques such as those resulting from a short circuit. Any damage resulting from such a short circuit or internal fault shall be confined to the component concerned to avoid damage to other parts of the VSDS. The motor/driven equipment shall be able to withstand the transient torques developed during short circuit conditions (this shall be jointly managed with Supplier of motor driven equipment).

The Supplier shall provide, at the bid stage, the heat generated by all indoor equipment across the full operating range of the VSDS.

4.2 Environmental Conditions

The VSDS converter will be installed within a separate non-hazardous, pressurised, air conditioned, clean and dry building or container with an average ambient air temperature of 25°C but it shall be able to operate as long as room temperature does not exceed 40°C.

VSDS and all associated equipment shall be suitable for the specified place of installation with typical dusty and corrosive atmosphere.

4.3 Power Supply Conditions

Equipment shall be suitable for continuous operation with voltage and frequency variations as defined in [GS EP ELE 011](#).

Voltages for auxiliary equipment shall be compliant to [GS EP ELE 011](#).

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4.4 Operational Safety, Availability, Reliability, Maintainability

Safe conditions shall be ensured under all operating conditions, including those associated with start-up and shut-down of plant and equipment and throughout the intervening shut-down periods.

For all operational and maintenance purposes, modules which need to be changed or maintained shall be removable and replaceable without dismantling other components.

The design of the VSDS shall ensure periods of continuous operation of at least 5 years.

The VSDS including all individual components forming part of the system shall have an availability of at least 0.997 and a minimum MTTF of 5 years.

The VSDS shall be designed for 20 years operation under the specified operating conditions and adapted inspection, maintenance and repair program.

All hardware and software that may be developed by the Supplier, further to the VSDS delivery, shall ensure full ascending compatibility to allow for easy replacement of equipment that would become obsolete.

The Supplier shall guarantee hardware and software support during the expected lifetime of the VSDS.

The VSDS converter cubicle shall have a front door emergency stop button which shall be guarded with plastic cover to protect them from accidentals shutdown.

4.5 Degree of Protection

Minimum degree of protection of equipment, as defined in [IEC 60529](#), shall be:

- Outdoor equipment: IP55
- Indoor equipment: IP21.

4.6 Internal Arc Classification

The cabinet shall be Internal Arc Classified (IAC) type AFLR (or AFL depending of the room layout) for internal arc up to the supply system rated short-circuit current with duration of 500 ms. AFLR and AFL definition is as per [IEC 62271-200](#).

The cabinet shall be type-tested under conditions of arcing due to internal fault in accordance with [IEC 62271-200](#) or [IEC 61800-5-1](#). For [IEC 61800-5-1](#) the test condition chosen for the breakdown of components shall induce an internal arc fault.

Type test certificate shall be provided.

4.7 Mode of Operation

The VSDS shall have the capability to deliver sequential starting and load operating point duties without restriction. Where the VSDS, motor and driven equipment form one contract, the mode of operation will be specified in the project specification and will include start, run-up and stop requirements.

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4.8 Emergency Shutdown

For process ESD purpose, VSDS shall be fitted with a stop function category 0 as per [IEC 60204-1](#).

4.9 Acceptable Technologies

4.9.1 Motor

Motor type shall be:

- Induction motor for ratings lower than 15 MW
- Synchronous motor for ratings above and including 15 MW
- Defined case by case when specific design conditions have to be considered, in which case prior approval from the Contractor and the Company on the design is required.

4.9.2 Converter

Converters shall be:

- Based on VSI technology for ratings up to 20 MW, or based on LCI technology
- Designed such that the current in the motor stator winding (s) does not exceed 2000 A
- For LCI, the topology of the converter shall minimize inter harmonics, especially regarding the $6*(F_m - F_n)$ component frequency which shall be cancelled.

Note: F_m means Motor frequency in Hertz and F_n means Network frequency in Hertz.

Converters rectifier topology shall be:

- 12-pulse maximum for LCI
- Governed by [IEEE Std 519](#) harmonics requirements at network line side with the lowest possible design complexity (12 pulse as a minimum for VSI).

In case of Active Front End rectifier topology, a sine filter shall be installed on the rectifier side. If the Active Front End rectifier is used in a transformer less configuration, a study made by the VSDS's Supplier shall verify that this configuration does not modify the network fault current in case of earth fault. Mitigation measures (e.g. filter) shall be implemented by VSDS's Supplier if the earth fault current is modified.

4.10 VSDS Rating

VSDS shall comply with the driven equipment characteristics as described in the datasheets.

The Supplier of the VSDS shall obtain from the driven equipment Supplier all relevant data including the exact torque speed characteristic of the driven equipment and shall design the VSDS accordingly.

VSDS shall meet the torque requirements at any line voltage between 90% and 110% of nominal.

Supplier shall state within the offer the maximum cable length allowed from transformer to converter and from converter to motor without converter's output filter.

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As a general principle to be validated by the VSDS Supplier, earth fault current shall be limited to less than 10 A.

4.11 Rating of Converter Electronic Components

The ratings of the power semi-conductors including diodes, transistors and thyristors, shall be based on data given by the Supplier within his catalogue or in official data sheets. Voltage/Current margin and junction temperature on power semi-conductors shall be clearly indicated within the offer.

Sub components of identical power cells shall be from the same supplier with identical technical performances.

LCI shall use identical semi-conductors components for rectifier and inverter bridges.

Current rating of the converter semi-conductor component shall not be less than 120% of the maximum current flowing through the elements at full load throughout the whole operation speed range. Parallel-connected semi-conductors shall have current ratings not less than 140%.

All the converter components shall be suitable for permanent operation of the converter at 110% of the rated output power. Supplier shall provide all data allowing the over-sizing of the converter elements to be verified.

Power semi-conductors of the rectifier and inverter shall be designed to withstand the current of a short circuit on the DC side.

4.12 Converter Output Voltage Stress

In case of use of VSI, converter output voltage dV/dt shall be minimized to less than 1 kV/ μ sec.

4.13 Electromagnetic Compatibility

The VSDS shall meet EMC requirements of [IEC 61000](#).

4.14 Harmonics and Inter Harmonics at the Line Side

The VSDS shall meet the immunity levels of [IEC 61800-3](#).

The emission levels of harmonics shall meet the requirements of [IEEE Std 519](#).

Calculations at the Point of Coupling (PC) of the VSDS to demonstrate compliance with above including size and effect of harmonics and inter harmonics shall be provided by the Supplier. Such calculation shall cater for the specified short-circuit impedance and harmonic contribution from other drives. The details of the electrical network are provided by the Contractor.

Where [IEEE Std 519](#) levels requirements cannot be met, the Supplier shall propose corrective options, e.g. filters, and include such options in the quotation, taking into account any interaction with other system components. The design of filters shall consider the existing background harmonics of the network.

VSDS's Supplier shall make available harmonics rejection information to Contractor for an overall harmonic study of the electrical network by Contractor. If there are already existing harmonic filters connected to the electrical network, Contractor shall ensure that existing

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harmonic filters will not be overloaded by the VSDS, otherwise mitigations measures shall be implemented.

In case of use of large VSDS (>15 MW) with an islanded power plant, Sub Synchronous Torsional Interaction (SSTI) study of the power plant shall be done by a third party in cooperation with the VSDS's supplier under the supervision of the Contractor.

4.15 Pulsating Torques

Supplier shall advise special precautions to be followed to avoid unacceptable pulsating torques at the driven equipment. This advice shall be based on the expected driven equipment characteristics and Supplier's experience. The Supplier shall liaise with the driven equipment Supplier to ensure that the level of pulsation is acceptable.

Supplier pulsating torques calculation capability shall be demonstrated within the offer.

Supplier shall provide a detailed study to demonstrate effects of harmonics and inter harmonics on pulsating torque.

4.16 VSDS Efficiency

VSDS efficiency guarantees shall be provided within the offer for driven equipment guaranteed operating point(s).

4.17 Transformer

Transformer shall be designed, manufactured and tested in accordance with [IEC 61378-1](#) and [IEC 61378-3](#).

Transformer shall be compliant to [GS EP ELE 141](#).

In offshore application water forced cooling is accepted and all related auxiliaries shall be redundant.

Transformer shall be oil immersed type.

Converter transformer shall be suitable for operation with the non-sinusoidal current wave shapes and DC components under normal and abnormal conditions of the VSDS without exceeding its temperature or other limits under the operating conditions defined within this specification.

Maximum transformer induction shall be 1.6 Tesla.

Transformer temperature rise shall be limited to 60°K for the windings and to 55°K for the top oil with an ambient temperature below 40°C.

Transformer shall have reduced losses. No-load losses and copper losses shall be clearly indicated within the offer. Losses shall include harmonics losses.

Rated lightning impulse withstand voltage shall be in accordance with [IEC 60076-3](#) table 2 taking into account the highest value.