



Exploration & Production

GENERAL SPECIFICATION

SUBSEA SYSTEMS

GS SPS 022

Environmental testing of subsea electronics
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Rev.	Date	Notes



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1. Scope

The purpose of the tests specified in this document are to ensure a minimum level of reliability of electrical and electronic subsea equipment. Section 5 of the specification also applies to such equipment installed on the platform but associated with the subsea installation.

Subsea equipment, once installed, will most likely be operating in a very benign environment. However, in some installations involving rotating machinery and/or large choke valves the equipment may be exposed to long term vibration and switching transients from high voltage equipment. During transportation and installation handling it will be exposed to both shocks and vibrations.

This specification shall apply for the following equipment:

- Modules or subassemblies containing electrical and/or electronic equipment, which are intended for permanent subsea installation
- Modules or subassemblies containing electrical and/or electronic equipment, which are part of tools for maintenance of subsea installations
- Other equipment listed in the Contract to comply with this specification
- Modules or subassemblies containing electrical and/or electronic equipment which are intended for interface to the subsea installation, but which are installed on the platform shall conform to section 5.

This specification shall also apply to electronic equipment intended for down hole installation, unless such equipment is covered by other, more stringent specifications.

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.

Standards

Reference	Title
MIL STD 2164 IEC 801-4	Electromagnetic compatibility for industrial process measurement and control equipment

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
Not applicable	

3. Qualification testing

The qualification tests shall ensure:

- That the equipment is robust and suitable for the environment to which it will be exposed during transportation, handling, installation and operation.
- That the exposure to the ESS test procedure (section 4.2) will not cause any damage to or degradation of the equipment.

With regards to shock and vibration, the qualification tests shall be applied as follows:

- Printed circuit boards and sub-assemblies shall be qualified to Q1
- Electronic modules comprising one or more circuit boards assembled in a rack type frame shall be qualified to Q2 or Q3.

Design and operating temperatures shall be as follows:

- The high design temperature shall be minimum 70°C.
- The low design temperature limit shall be -10°C or lower.
- The normal operating temperature shall lie in the interval 0 to 40°C. This shall be demonstrated by calculations and tests at thermal conditions similar to the conditions the equipment will be exposed to when installed subsea at the design water temperature. The worst-case load conditions and thermal conditions shall be the basis for these calculations and tests.

- The temperatures defined above refer to the mean temperature of the ambient atmosphere within the enclosure in which the electronic or electrical system is operating.

3.1 Definition of Qualification test Q1

3.1.1 Shock tests

The Equipment Under Test (EUT) shall be mounted on the test fixture as it will be mounted in normal service. If, in normal service, shock absorbers or vibration dampers are part of the mounting, these shall be part of the mounting also in these shock tests.

Four shocks shall be applied in each of six directions along three mutually perpendicular axes. The axes shall be selected to maximise the probability of detecting faults in the design. For printed circuit boards one of the axes shall be perpendicular to the plane of the board.

The shock level shall be: 30 g, 11 ms half sine.

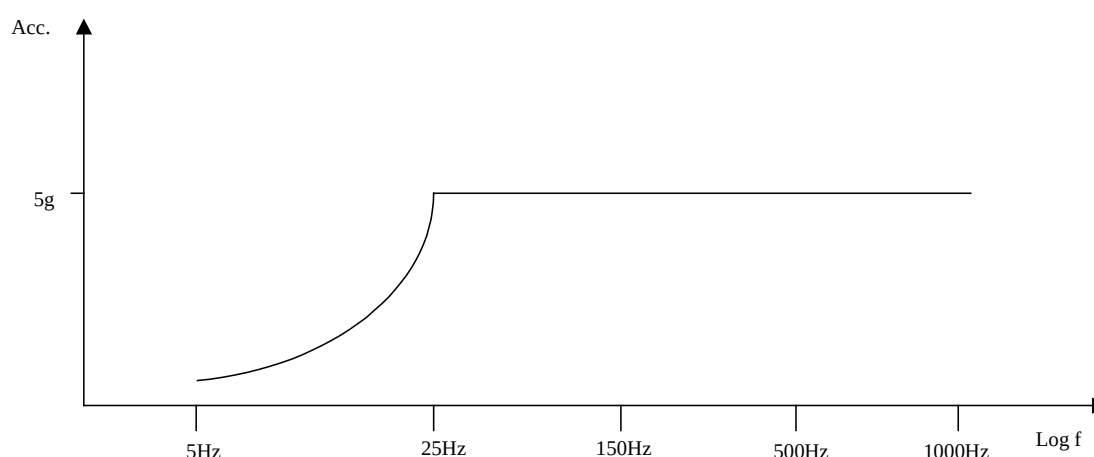
After the shock tests, no significant damage or distortion shall have occurred, and the EUT shall pass a 100% functional test.

3.1.2 Vibration tests

The EUT shall be mounted on the test fixture as it will be mounted in normal service. If, in normal service, shock absorbers or vibration dampers are part of the mounting, these shall be substituted by stiff structural members in this vibration test.

The following excitation shall be applied to three mutually perpendicular axes. The axes shall be selected to maximise the probability of detecting faults in the design. For printed circuit boards one of the axes shall be perpendicular to the plane of the board. The excitation level shall be:

- 5 Hz to 25 Hz ± 2 mm displacement
- 25 Hz to 1000 Hz 5 g acceleration
- Sweep rate maximum one octave per minute



Note: The excitation is specified with constant amplitude (± 2 mm) in the region below 25 Hz as otherwise the displacement amplitude would be prohibitively large for 5 g acceleration at these low frequencies. The maximum sweep rate is specified as one minute per octave; i.e. one

minute minimum between each doubling of the frequency. The sweep rate must be low enough to allow any resonance to build up amplitude.

A double sweep from 5 Hz to 1000 Hz and back to 5 Hz shall be performed. No resonance with mechanical amplification factor greater than 10 shall be observed in the range 5 Hz to 500 Hz for the EUT to pass the test.

For each of the three axes, all resonance with mechanical amplification factor greater than 5 in the range 5 Hz to 500 Hz during the above double sweeps shall be recorded. The EUT shall pass a 2-hour endurance test at each of these recorded frequencies/axes at the above excitation level.

As an alternative to the 2-hour endurance test at each resonance frequency/axis, the EUT can be qualified by subjecting it to a 2-hour endurance test with the random vibration as defined in section 4.2. This endurance test shall be performed in the axis where the largest amplification factor was recorded. If the EUT is a printed circuit board, the endurance test shall be performed in the axis perpendicular to the plane of the board.

If it can be documented that the EUT in its final use will not be exposed to significant vibration in the frequency range above 150 Hz. COMPANY may approve a reduction in the frequency range in which the above resonance search is performed, from 5-500 Hz to 5-150 Hz. If the frequency range is reduced to 5-150 Hz, additional tests must be defined to prove that the EUT is capable of withstanding the vibrational loads it will be exposed to during the ESS test as defined in section 4. Such additional tests must be approved by COMPANY. (These tests will normally be performed by monitoring the acceleration of individual components during a trial ESS test and ensuring that the components are not exposed to too high loads).

After the vibration testing, no significant damage or distortion shall have occurred, and the EUT shall pass a 100% functional test.

3.1.3 Temperature tests

With electrical power applied, and under full load, the EUT shall be temperature soaked for 48 hours at the high design temperature. During this soak, periodic functional tests shall be made and no defects detected.

The same procedure is repeated for the low design temperature.

During the above temperature tests, reduced accuracy of measurement functions may be tolerated. However, such functions should perform as specified at the normal operating temperature as defined in above.

3.2 Definition of Qualification test Q2

3.2.1 Shock tests

During these shock tests the EUT shall be mounted on the test fixture as it will be mounted in normal service. If, in normal service, shock absorbers or vibration dampers are part of the mounting, these shall be part of the mounting also in these shock tests.

Four shocks shall be applied in each of six directions along three mutually perpendicular axes. The axes shall be selected to maximise the probability of detecting faults in the design. For equipment containing printed circuit boards one of the axes shall be perpendicular to the planes of the majority of the boards. The shock level shall be: 10 g, 11 ms half sine.

After the shock tests, no significant damage or distortion shall have occurred, and the object shall pass a 100% functional test.

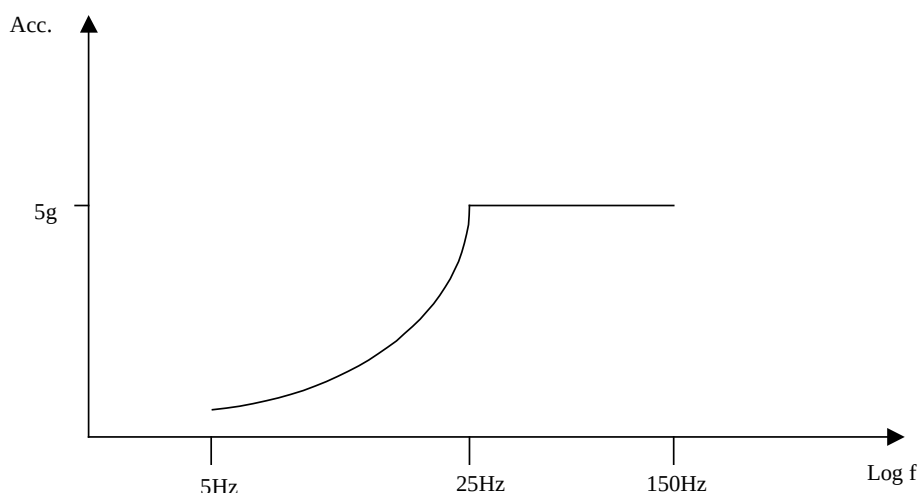
3.2.2 Vibration tests

The EUT shall be mounted on the test fixture as it will be mounted in normal service.

If, in normal service, shock absorbers or vibration dampers are part of the mounting, these shall be substituted by stiff structural members in this vibration test.

The following excitation shall be applied to three mutually perpendicular axes. The axes shall be selected to maximise the probability of detecting faults in the design. For equipment containing printed circuit boards one of the axes shall be perpendicular to the planes of the majority of the boards. The excitation level shall be:

- 5 Hz to 25 Hz ± 2 mm displacement
- 25 Hz to 150 Hz 5 g acceleration
- Sweep rate maximum one octave per minute



Note: Some vibration test equipment rigs have problems with large displacement amplitudes. Therefore the excitation is specified with constant amplitude (± 2 mm) in the region below 25 Hz as otherwise the displacement amplitude would be prohibitively large for 5 g acceleration at these low frequencies. The maximum sweep rate is specified as one minute per octave; i.e. one minute minimum between each doubling of the frequency. The sweep rate must be low enough to allow any resonances to build up amplitude.

A double sweep from 5 Hz to 150 Hz and back to 5 Hz shall be performed. No resonance with mechanical amplification factor greater than 10 shall be observed in the range 5 Hz to 150 Hz for the EUT to pass the test.

For each of the three axes, any resonance with mechanical amplification factor greater than 5 in the range 5 Hz to 150 Hz during the above double sweep shall be recorded. The EUT shall pass a 2-hour endurance test at each of these recorded frequencies/axes at the above excitation level. No damage shall be caused by these endurance tests.

The EUT shall pass a 100% functional test after the above tests; the double sweep as well as the endurance tests, if applicable.

3.2.3 Temperature tests

As for section 3.1.3.

3.3 Definition of Qualification test Q3

3.3.1 Shock tests

As in section 3.2.1.

3.3.2 Vibration tests

The EUT shall be mounted on the test fixture as it will be mounted in normal service. If, in normal service, shock absorbers or vibration dampers are part of the mounting, these shall be substituted by stiff structural members in this vibration test.

The EUT shall then be exposed to a prolonged endurance test with the random vibration as specified in section 4.2 applied for 2 hours.

3.3.3 Temperature tests

As in section 3.1.3.

4. Environmental Stress Screening (ESS)

4.1 General

The purpose of this test is to disclose potential failures due to flaws in the assembly of components. The test shall be applied to all delivered items as part of, or in conjunction with the Final Acceptance Test (FAT).

This test procedure is based on [MIL STD 2164](#) (EC) with simplifications. Reference in square brackets refer to sections in the above MIL STD. The references are included for information.

The entire test (vibration, thermal cycling and burn-in) must be made with the EUT powered and with full and continuous monitoring of all functions. To obtain such monitoring, special test equipment shall be made for connection to I/O circuits, etc. If the EUT is programmable (e.g. subsea electronic module) special test software within the EUT shall be made to ensure efficient and continuous monitoring of all parts of the EUT, ensuring a maximised probability of detection of intermittent faults even if the faults occur relatively infrequent and are of very short duration.

The test apparatus must ensure that the EUT under no circumstances will be exposed to excessive humidity due to rapid changes of temperature.

The temperature cycling is performed by varying the temperature of the atmosphere in the test chamber. Circulation must be provided to ensure a uniform temperature in the atmosphere. Heat radiation on to the EUT must be avoided.

The ESS vibration shall be limited to a total of 10 minutes at the level specified in 4.2 so as not to over-stress the EUT. For diagnostic purposes during testing and fault-finding, the vibration level may be reduced if longer exposure times are required (Appendix B, section 20.2.4).

During the ESS vibration exposure the EUT shall be mounted on the test fixture as it will be mounted in normal service. If, in normal service, shock absorbers or vibration dampers are part of the mounting, these shall be substituted by stiff structural members during the ESS vibration testing.

4.2 ESS Test Sequence

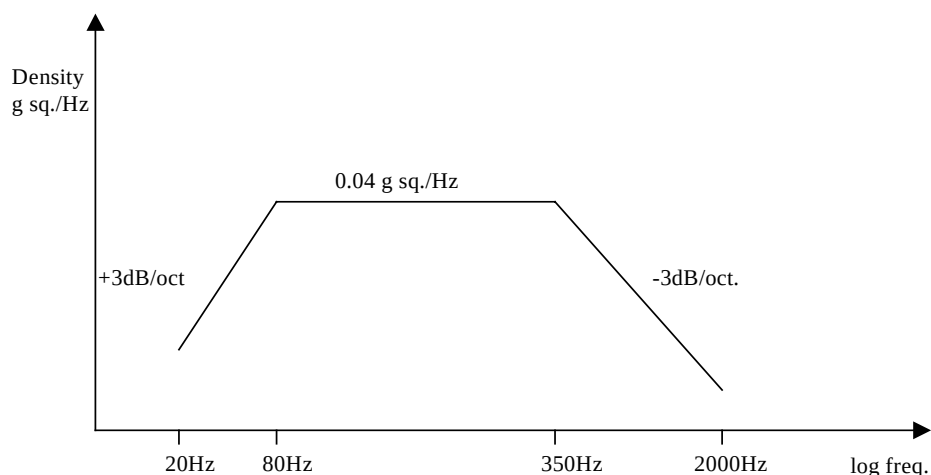
The following test sequence shall be applied:

Random vibration along the axis perpendicular to the planes of the majority of the printed circuit boards shall be applied. If errors are detected, the excitation should be halted immediately and the fault located. If the application of vibration is required to locate the fault, this should be done at reduced amplitude (Appendix B, section 20.2.4).

The random vibration shall be applied for a total of 10 minutes, preferably divided in two times 5 minutes before and after the thermal cycling.

The random vibration spectrum shall have the following characteristics:

- 20-80 Hz at 3 dB per octave rise
- 80-350 Hz at 0.04 g squared/Hz
- 350-2000 Hz at 3 dB per octave roll off
- Composite excitation level shall be 6 g rms



Note: The random vibration is specified as spectral energy density over a frequency range. The integral of the density profile is a measure of the total energy (or load on the equipment). The integral of the above curve is approximately 6 g rms.

The above spectrum may be modified by introduction of notches if resonances of the EUT results in intolerable vibrational loads on individual components. The composite excitation level shall still be 6 g rms. Modification of the above spectrum shall be approved by COMPANY.

10 thermal cycles shall be applied. The temperature limits in for the temperature cycling shall be the maximum and minimum design temperatures as defined in section 3. If faults are detected during thermal cycling, these shall be repaired according to approved methods, and the sequence started over. See also (Appendix B, section 20.2.3). After 10 cycles of no failures, the test has been passed. One thermal cycle shall be performed as follows:

- Increase to high design temperature at minimum 5°C per minute
- Keep at this temperature for a minimum of 30 minutes

- Decrease to low design temperature at minimum 5°C per minute
- Keep at this temperature for a minimum of 30 minutes.

The test shall be ended with a 48 hour burn in at the high design temperature under full load conditions.

The tested item shall undergo a 100% functional test after the burn in.

5. Electrical noise compatibility

The equipment shall conform to the applicable CE norms regarding Electromagnetic Compatibility for the environment in which the equipment is to be used. The tests outlined below shall be considered as a minimum requirement.

These tests are intended to demonstrate the immunity of the electronic equipment when subjected to types of transient interference such as that originating from switching transient and electrostatic discharge.

The basis for the tests is the International Standard [IEC 801-4](#): Electromagnetic compatibility for industrial process measurement and control equipment. Part 4: Electrical fast transient/burst requirements.

The tests shall be done as qualification tests on one sample of the various types of equipment after the design has been finalised.

The tests shall be applied to the following equipment ports:

- Power supply connections of equipment installed on the platform and connected to the subsea equipment (e.g. surface modems, power feed equipment)
- I/O circuits in the above equipment
- Power supply connections of the subsea equipment
- Communication ports of the subsea equipment
- Other ports of the subsea equipment intended for connection of field installed equipment.

The test severity shall be as defined in the [IEC 801-4](#) Clause 5:

- Platform equipment:
 - Level 4, i.e. 4 kV on power supply circuits and 2 kV on other circuits.
- Subsea equipment:
 - Level 3, i.e. 2 kV on power supply circuits connected to the main umbilical voltage and 1 kV on other circuits.

If it can be documented that high voltage transients will not likely occur in the operating environment, COMPANY may approve testing at lower levels of severity.