



Exploration & Production

GENERAL SPECIFICATION

CORROSION

GS EP COR 226

**Materials for thermal insulation of pipeline, piping
and subsea components**

03	01/2012	General review, modification of acceptance test criteria for aging and field joint adhesion, test temperature amendment
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1. Scope

This GS covers:

- Integral External Insulation (IEI) where the insulation is bonded to the outer surface of a structure or to a corrosion protective layer on the outer surface of a structure
- Insulation Modules (IM) which consists of a discrete pre-formed component attached onto the structure to be installed.

Pipe in pipe, active systems and internal insulation systems are not covered by this document.

This GS has been developed on the basis of known materials (elastomers, PU, PP, epoxy, in solid, blown foam, syntactic and composite syntactic foam). It can be used for qualification of other materials. In that case, additional (or different) requirements and/or data might be needed, based on Company approval.

Materials concerned by this GS are typically used for the insulation of the following:

- Pipe lines
- Steel flowlines and risers, including riser tower
- Subsea components such as wellheads, christmas trees, manifold and jumpers.

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
ASTM D 3045	Standard Practice for Heat Aging of Plastics without Load
ASTM G 8	Test method for cathodic disbonding of pipe line coating
ISO 62	Test method for water absorption of plastics
ISO 178	Plastics-Determination of flexural properties of rigid plastics
ISO 527	Plastics-Determination of tensile properties
ISO 844	Rigid cellular plastics-determination of compression properties
ISO 868	Test method for hardness measurements of plastics
ISO 1183	Plastics-Test method for determining the density and relative density of non-cellular plastics
ISO 4892 (Parts 1; 2)	Plastics-Methods of exposure to laboratory light sources - (Parts 1; 2)
ISO 8302	Thermal insulation-Determination of steady state thermal resistance and related properties-Guarded hot plate apparatus
ISO 11357-4	Test method for determination of specific heat capacity by differential scanning calorimetry



Reference	Title
ISO 11359-2	Plastics-Thermo-mechanical analysis (TMA) - Part 2: Determination of coefficient of linear thermal expansion and glass transition temperature
NF ISO 2578	Plastics. Determination of time-temperature limits after prolonged exposure to heat

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 221	Three layer polypropylene external coating for pipelines
GS EP SPS 008	Thermal insulation of subsea stations
GS EP SPS 009	Corrosion protection of subsea stations



3. Definitions

3.1 Company

TOTAL SA or its subsidiary or agent acting on its behalf shall be referred to herein as the "Company".

3.2 Raw materials and raw materials producer

Materials used to produce thermal insulation coating systems (for instance, polypropylene pellets for multilayers PP coatings) shall be referred to herein as "Raw Materials". Producers of such materials shall be referred to as "Raw Materials Producer".

3.3 Manufacturer

"Manufacturer" shall be referred to herein as the Company manufacturing EIE or IM and applying it to the structure to be thermally insulated.

3.4 Inspector

The Company's representatives or members from Company elected Inspection Agencies for the time being or from time to time duly appointed in writing by the Company to act as its representatives for the purpose of the contract shall be referred to herein as the "Inspector".

4. Raw materials requirements

The Company shall have access to all raw materials tests results and manufacturing procedures.

4.1 Marking and identification

The Manufacturer shall ensure that raw materials are traceable and suitably marked for easy identification.

4.2 Storage and handling

Raw materials shall be stored and handled according to raw materials supplier recommendation. Materials Safety Data Sheets shall be made available to Manufacturer and their instructions strictly enforced.

4.3 Raw material specifications

During qualification, Manufacturer shall obtain from raw material supplier a conformity certificate (for each individual materials) with the following information:

- Product name and producer
- Manufacturing plant
- Properties to be checked with every batches and corresponding conformity ranges
- Date of issue
- Signature of authorized personnel (with name and function).



For each batch of raw materials used by the Manufacturer, content of certificate of analysis (obtained with every batches and deliveries) shall be verified against content of conformity certificate. Conformity certificate shall be submitted to Company for approval during qualification process.

5. Materials requirements

The Manufacturer shall document the properties of chapter 5 listed below, for all individual materials.

In case of multi layers systems, each layer can be documented independently with regard to the relevant properties of this chapter. ***For multi layer systems, the maximum temperature may be considered individually for each layer and might be different from maximum operating temperature, provided a detailed thermal profile within the insulation coating has been performed by the Manufacturer and submitted prior to qualification to Company for approval.***

If the above is not applicable or not done, maximum operating temperature shall apply to all layers. Previous tests available at higher temperature might be submitted to the Company for approval.

All wet insulation systems shall comply with the relevant requirements of **GS EP SPS 008** and **GS EP SPS 009**.

5.1 General information

Full and detailed description of insulating system (use of corrosion protection layer, external mechanical protection layer, adhesives layers, etc.) shall be given.

For each individual material (i.e.: each layer for multi layers system): the following information shall be furnished: Chemical nature of material

- Fillers content (by weight and volume) and type
- Recommended maximum operating temperature in wet and dry environment
- Recommended maximum operating water depth.

5.2 Thermo-mechanical properties

For each individual material (i.e. each layer for multi layers system) the following information is required:

- Differential Scanning Calorimeter (DSC) spectra up to a temperature of T_g (glass transition) + 50°C for thermosets and T_f (melting point) + 20°C for thermoplastics. First and second heating and cooling shall be documented. Heating rate: 20°C/min, cooling rate: 10°C/min
- Dynamic Mechanical Thermal Analysis (DMTA) spectra at a frequency of one Hertz and up to a temperature of T_g + 50°C for thermosets and T_f + 10°C for thermoplastics. Elastic modulus, loss modulus and loss angle (Tan Delta) shall be reported. Heating rate: 20°C/min.

5.3 Insulation properties

For the individual materials concerned (i.e.: for each relevant layer of multi-layer system):

- Density at 23°C and atmospheric pressure ([ISO 1183](#))
- Density at 23°C after application of a hydrostatic pressure equivalent to the maximum water depth at maximum temperature (for at least 48 hrs) ([ISO 1183](#))
- Thermal conductivity at 23°C and maximum temperature at atmospheric pressure ([ISO 8302](#))
- Specific heat capacity at 23°C and maximum temperature at atmospheric pressure ([ISO 11357-4](#))
- Thermal expansion coefficient over the full temperature range (-20°C to maximum temperature) ([ISO 11359-2](#)).

In case density after application of a pressure equivalent to the maximum water depth at maximum temperature has increased by at least 10% of original value, then a measurement of thermal conductivity and specific heat capacity at 23°C shall be done after such treatment.

In case water absorption at saturation as per 5.8 is equal or higher than 5% by weight, and unless it is proven that materials cannot be water saturated after 20 years in operation, then a measurement of thermal conductivity and specific heat capacity shall be done at 23°C with water saturated samples.

Tests results shall comply with project requirements for thermal insulation properties.

5.4 Mechanical properties

For the individual materials concerned (i.e.: for each relevant layer of multi-layer system):

- Tensile strain and stress at break at 23°C and maximum temperature ([ISO 527](#))
- Flexural modulus at 23°C and maximum temperature ([ISO 178](#))
- Hardness at 23°C ([ISO 868](#))
- Compression strength and modulus at 23°C and maximum temperature ([ISO 844](#))
- For IM only: Hydrostatic strength at 23°C and maximum temperature (test method to be submitted to Company for approval).

The results shall be compatible with water depth, operating temperature and laying constraints of the project.

5.5 Corrosion protection

- For IEI: Cathodic disbondment test for 28 days at 23°C ± 2°C and maximum operating temperature (whether there is a corrosion protection primer or not) ([ASTM G 8](#)).
- For IM: Cathodic disbondment test at 23°C ± 2°C and maximum operating temperature for 28 days for corrosion protection primer shall be documented ([ASTM G 8](#)).

Disbonded radius after test shall be less or equal to 5 mm at room temperature and 10 mm at maximum operating temperature.

5.6 Ageing properties

5.6.1 UV resistance (for top coats only)

The requirements to the top coat shall be as follows:

- UV resistance: according to [ISO 4892-1](#) and [ISO 4892-2](#)
- Artificial weathering: Table 1-Method A of [ISO 4892-2](#)
- Black panel temperature (BST): $65 \pm 3^{\circ}\text{C}$
- Relative humidity: 65%
- Cycle: 18 min humid-102 min dry
- Total radiant energy: 5 GJ/m²
- Continuous exposure.

After UV ageing, measurement of mechanical properties as per 5.4 at 23°C only shall be done. Aged samples shall be suited in size for mechanical properties testing with no further preparation (machining and the likes prohibited).

5.6.2 Thermal ageing

The hydro-thermal ageing resistance shall be demonstrated as follows:

- An Arrhenius type approach as per [ISO 2578](#) and [ASTM D 3045](#), demonstrating the fitness-for-purpose of the insulation materials for 20 years at maximum temperature or alternatively, if this approach is shown to be impractical:

Ageing in water and dry heat ageing at maximum actual temperature as described in chapter 5 (or maximum operating temperature) and maximum actual temperature as described in chapter 5 (or maximum operating temperature) +20°C for 1000, 2000 and 3000 hours. After ageing, measurement of mechanical properties as per 5.4 at 23°C only. Aged samples shall be suited in size for mechanical properties testing with no further preparation (machining and the likes prohibited). Unless otherwise specified and when water is fresh water: In both ageing cases, attention shall be given to oxygen content, which should be as close as possible to actual content in service.

The test results after wet and dry ageing are reported in a table and compared to the original values before ageing. To demonstrate that the materials are fit-for-purpose, the following minimum criteria shall apply:

- No loss of properties of more than 50% of original values
- Stabilization of the loss of properties between 2000 and 3000 hours exposure times for both ageing conditions.

5.6.3 Syntactic materials

Syntactic materials are either polypropylene (PP), epoxy (EP) or polyurethane (PUR) matrix filled with glass micropheres. The tests performed for the selection of the grade of microsphere vs. the pressure and temperature rating of the project shall be such that no risk of collapse of the said microspheres in the syntactic material is expected for the 20 years lifetime of the project.

For syntactic PP multi layers systems, the first three layers of the insulation coating (epoxy primer/adhesive/first PP layer) shall fully comply with **GS EP COR 221**.

Acceptance criteria for the survival rate of glass microspheres before and after application to the equipment shall be submitted to CPY for approval.

This survival rate shall be monitored during production.

5.6.4 Polyurethane (PUR) materials

It is well known that PUR are sensitive to hydrolysis (chemical degradation with water and temperature). In case PUR is used, it shall be clearly demonstrated that hydrolysis is not critical for the given water depth and operating temperature. It is taken as basis of design that cracking or damage of the insulation coating will lead to hot water ageing. Ageing test in water should be carried out in accordance with the guidelines of **NF ISO 2578** and **ASTM D 3045** or alternatively as per 5.6.2.

Unless otherwise agreed, upper temperature limit for solid PUR is set to 80°C. In all cases and whatever the temperature, testing shall be conducted as mentioned in this paragraph.

5.7 Adhesion properties

Insulation systems range from multi-layers materials physically bonded to the substrate to adjusted modules of single material. Adhesion shall be checked between each layer of the insulation system and between the steel and the primer.

Adhesion shall be measured at 23°C and maximum temperature.

Particular attention shall be given to substrate-primer adhesion, with absolutely no bare substrate accepted after peeling (i.e. primer shall not peel off the steel).

It might not always be easy to perform such tests on insulation layers. Therefore, Manufacturer should provide the Company with its own testing procedure for approval.

Effect of ageing on adhesion properties shall also be assessed. For this, chapter 5.6 can be used as guidelines.

All adhesion tests results shall be in line with all laying and installation constraints of the equipment. Adhesive values and test procedure shall be approved at PQT (Production Qualification Test) stage by Company.

5.8 Water absorption

Water is fresh water.

For the individual layers concerned (i.e.: for each relevant layer of multi-layer system):

Water uptake should be reported as weight increase (compared to initial sample before test) with time and reported on a graph. Surface to volume ratio of the test sample should be selected as to obtain enough sensitivity in the measurement related to the time interval chosen in between measurements. Test samples shall be such that length and width are much higher than thickness.

Temperature of the test is 23°C and maximum operating temperature. Referenced standard is **ISO 62**.

The duration of the test shall be such that saturation is reached (no further evolution of weight with time) and the value at saturation shall be reported. If the value is higher than 5% by weight



and is proven to be reachable within 20 years time frame (for either temperature), then tests as per chapter 5.3 and 5.4 shall be performed (at 23°C only).

Results shall comply with the requirements of the project with regards to thermal insulation properties, water depth and design temperature.

6. Field joint

The field joints shall be designed to be compatible with the main insulation system. Insulation properties and calculations shall include field joints whenever relevant. Adhesion between field joint and parent coating shall be checked at room temperature, maximum actual temperature as described in chapter 5 (or maximum operating temperature) and after ageing as per chapter 5.6 of this specification. As a minimum, adhesion failure shall be cohesive within the insulation layers and not adhesive at interfaces.

Adhesion test procedure and values shall be approved at PQT stage by Company.

Mechanical properties shall be such that no buckling of the insulation material on the pipe and/or the field joints appears during installation.

Simulated service tests are to be performed with the selected field joint whenever applicable. Quality control of final product.

The Inspector shall have free access to all departments of the plants where both IM and IEI are manufactured and applied. An office and all necessary means to the perfect completion of his work shall be made available for him.

The Company shall have access to all tests results and manufacturing procedures for both IM and IEI.

The Manufacturer's quality plan shall specify inspection points, inspection methods and acceptance criteria. It shall be submitted to the Company during qualification for approval. Results of all inspections shall be recorded and made available to the Company upon request.

7. Design

The design of moulds, cut backs, and all operations related to casting, designs etc., shall be submitted to CY for approval before PQT and fully endorsed by raw material suppliers in writing.

Of special interest here (but not limited to) is the geometrical design of the mould to avoid any stress concentration, quantity of materials poured in one operation (to limit exothermic reactions and internal stresses build up) and heating up of adjacent materials together with surface preparation.

Raw material supplier shall be present at PQT and at start of production, and give full support and training to operators.