TOTAL EXPLORATION PRODUCTION

GENERAL SPECIFICATION

PIPING - VESSELS - WELDING

SP - TCS - 148

GLASS - REINFORCED PLASTIC

PIPING MATERIALS

(Tubes and accessories)

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CONTENTS

1 - SCOPE

This document applies to the supply of piping materials (tubes and accessories) intended for the fabrication of networks carrying liquid products such as water, crude oil, chemicals or drippings at a temperature of less than 110°C, the diameters of which being from 1" to a maximum of 20".

The VENDOR must provide a complete and homogeneous assembly that can be connected by flanges to steel piping.

2 - DEFINITION OF CONTRACTING PARTIES

OWNER	The legal Owner of what is built.
COMPANY	The party which signs the contracts and orders on behalf of the Owner.
TOTAL	TOTAL acts as the COMPANY representative and performs the role of MANAGER.
ENGINEERING COMPANY	This term designates the engineering companies which work under the supervision of TOTAL and assume the function of ENGINEER. In all cases, a contract exists between the COMPANY and the ENGINEERING COMPANY specifying the missions entrusted to the latter.
CONTRACTOR	The Company responsible for construction and installation on the final or prefabrication site.
VENDOR	VENDOR of equipment and material, whether separately identifiable or in bulk.
INSPECTION AGENCY	Service agency as opposed to the Vendor who delivers a piece of equipment under the order and on behalf of the ENGINEERING COMPANY.

3 - REFERENCE DOCUMENTS

The latest revisions of the following codes and standards shall apply to the supply of glass reinforced piping materials within the scope of the present specification :

- API 15 LR API specification for low pressure fiberglass line pipe.
- ASTM D 543 Test for resistance of plastics to chemical reagents.

- ASTM D 570 Test for water absorption of plastics.
- ASTM D 648 Test for deflection temperature of plastics under flexural load.
- ASTM D 1599 Test for short-time rupture strength of plastic pipe, tubing and fittings.
- ASTM D 1652 Test for epoxy content of epoxy resins.
- ASTM D 2105 Test for longitudinal tensile properties of reinforced thermosetting plastic pipe and tube.
- ASTM D 2122 Determining dimensions of thermoplastic pipe and fittings.
- ASTM D 2143 Test for cyclic pressure - strength of reinforced, thermosetting plastic pipe.
- ASTM D 2310 Classification for machine made reinforced thermosetting resin pipe.
- ASTM D 2343 Test for tensile properties of glass fiber strands, yarns and rovings used in reinforced plastics.
- ASTM D 2393 Test for viscosity of epoxy resins and related components.
- ASTM D 2412 Test for external loading properties of plastic pipe by parallel - plate loading.
- ASTM D 2471 Test for gel time and peak exothermic temperature of reacting thermosetting resins.
- ASTM D 2563 Recommended practice for classifying visual defects in glass reinforced plastic laminate parts.
- ASTM D 2583 Test for indentation hardness of rigid plastics by means of a Barcol impressor.
- ASTM D 2584 Test for ignition loss of cured reinforced resins.
- ASTM D 2992 Obtaining hydrostatic design basis for reinforced thermosetting resin pipe and fittings.
- ASTM D 2996 Specification for filament wound reinforced thermosetting resin pipe.
- ASTM G 23 Recommended practice for operating light and water exposure apparatus (carbon arc type) for exposure of non-metallic materials (replaces E.42-69).
- ANSI B 31-3 Chemical plant and petroleum refinery piping.
- ANSI B 16-5 Steel pipe flanges and flanged fittings.
- TOTAL Specification SP-LOG-881 : Sea-packing
- TOTAL Specification SP-LOG-883 : Shipping markings

If there is a disagreement between this specification and one of these codes or standards, the VENDOR must so inform TOTAL who will decide ; it is understood that in this case, the more stringent requirement shall be assumed to apply in the absence of formal approval by TOTAL.

4 - DESIGN

4.1 - Drawings

Dimensioned assembly drawings and/or isometric drawings are prepared by the ENGINEERING COMPANY.

The VENDOR is required to check these drawings and to propose any appropriate changes or suggestions before fabrication.

The VENDOR and the ENGINEERING COMPANY shall adopt a detailed final version of these drawings.

4.2 - Supports

As a general rule, overhead piping must be able to move freely ; on the other hand, underground piping must be anchored.

4.2.1 - Overhead piping

The supporting of the piping must be determined by the ENGINEERING COMPANY on the basis of information furnished by the VENDOR ; this information must include standard drawings of supports, together with the general rules applicable to materials of the supply. In particular, the piping shall not be designed to support the weights of the equipment to which it is connected (valves, etc must be self-supported).

Miter elbows shall be anchored on each side.

The supports shall be made of steel and are not included in the supply.

4.2.2 - Underground piping

The anchoring stresses must be determined according to the type of pipe. The dimensions of the corresponding blocks shall be specified.

The locations of the anchor blocks shall be determined by the ENGINEERING COMPANY. Anchor blocks shall be provided at each elbow, tee and reducer.

5 - FABRICATION

5.1 - Structure of the tube

5.1.1 - Inside layer (gel coat or liner)

This inside layer shall have a resin content of at least 70%. The gel coat may be reinforced by C glass cloth or woven polyester.

It shall be at least 0.5 mm thick. The resin used shall be free of pigment or other additives.

5.1.2 - Layers providing mechanical strength

These layers shall be of glass-reinforced thermosetting resin. Generally, the same resin shall be used as for the gel coat. If not, the resins must be compatible and provide a bond as good as identical resins. The resin used must be pigment-free.

5.1.3 - Outside layer

This generally consists of the same resin used as for the layer providing mechanical strength (layer made of pure resin, called "gel coat").

However, subject to TOTAL prior approval, the VENDOR may use a "gel coat" containing the following additives :

- pigments (for protection against U.V.),
- graphite (to decrease the surface resistivity),
- antimony oxyde or alumina (to enhance the self extinguishing properties).

5.2 - Raw materials

5.2.1 - Resins

The only acceptable synthetic thermosetting resins are epoxy resins and vinylester resins.

Isophthalic or orthophthalic polyester resins shall not be used.

However, in the case of fluids having a high content of especially corrosive chemicals (acids or bases), reference shall be made to the VENDOR's recommendations for the selection of the appropriate resin, which may then be a polyester of the isophthalic, orthophthalic or bisphenol type.

5.2.2 - Glass fibers

Two types of glass, having different chemical compositions, are used to reinforce thermosetting resins (they are known as "C" glass, and "E" glass) :

- Inside layer :
  . "C" glass is used in the form of light-weight fabrics (30 to 50 g/m2) to reinforce the gel coat.

- Layers providing mechanical strength :
  . "E" glass is a reinforcing glass for the layers of composite materials providing mechanical strength. It is used in various forms : rovings, mats, fabrics, chopped fibers.

5.3 - Fabrication processes for tubes and accessories

5.3.1 - Tube fabrication processes

The tubes covered by this specification shall be made by filament winding of "rovings" of resin-impregnated glass. They must comply with the standard ASTM D 2996. These tubes must also belong to one of the following classes, described in ASTM D 2310 :

- Type 1, Grade 1 (epoxy), Class F (reinforced epoxy liner)

  or

- Type 1, Grade 2 (vinylester), Class E (reinforced vinylester liner)

The usual winding angle is 54° ± 2° ; other angles may be used with justification (calculation note). Asymmetrical winding angles may be considered if they combine transversely and longitudinally oriented fibers (two different angles close to 90° and 0°). The ends of the tubes must be removed if, because of the fabrication process, they have glass fibers wound at a different angle from those of the central portion of the tube.

5.3.2 - Fabrication processes for accessories

The accessories covered by this specification are 45° elbows, 90° elbows, tees, reductions, couplings, collars for loose flanges, and fixed flanges.

The same materials as for the tubes shall be used for accessories.

The following fabrication processes may be used for these accessories :

- filament winding
- injection
- contact moulding
- press moulding

Preference shall be given to accessories produced by filament winding, since they have greater mechanical strength.

Accessories shall have at least the same chemical and mechanical properties (with respect to bursting, internal pressure, crushing, external pressure, load along a generating line and axial tension stresses) as the tubes on which they are intended to be fitted.

5.4 - Various types of connections

Connections shall be made by cemented joints of the bell and spigot type, or by flanges. Mechanical joints are only allowed on crude oil gathering lines. Butt-cemented joints are not authorized, except in the case of networks having a pressure less than or equal to 5 bars conveying especially corrosive chemical fluids (case of use of polyester resins, § 5.2.1).

The VENDOR shall guarantee the same service pressure for the connections as for the tubes.

The dimensions of the connections are determined by the VENDOR.

The validity of the connections is proven by the tests called for in § 6.

5.4.1 - Cemented joints

The VENDOR must give a detailed description of the bonding method he recommends (for both shop and site fabrication).

He must supply all materials and equipment necessary, together with the following information concerning the adhesive :

- the curing time as a function of temperature
- long-term variations in hardness after curing at various temperatures
- the time at which the piping system may be put into service

There must be not gel-coat on the surface of the female part to be cemented.

Fittings fabricated by filament winding shall have female sockets at all ends ("bell" ends), except as otherwise indicated.

Fittings fabricated with glass strips may have only male ends ("spigots").

The VENDOR shall indicate the dimensions of the male and female parts, together with the fabrication tolerances. He shall also indicate the shear stress on the glued surface at the service pressure, acting with full end thrust under pressure.

Socket connection parts must be delivered in a machined condition by the VENDOR.

There are three types of bell and spigot connection, classified in decreasing order of preference :

- cone to cone
- male cylinder to female cone
- cylinder to cylinder

Preference shall be given to cone-to-cone connections ; cylinder-to-cylinder connections are not allowed.

5.4.2 - Fixed-flange connections

The fixed flanges are added on and glued to the tube or fitting, with the cemented joint made as per § 5.4.1 above. They may also be fabricated directly on a piping or accessory end.

They may be fabricated by the winding of rovings or fabrics, or by hot pressure moulding with a reinforcement of chopped glass fibers;

The contact face of the flange must be perfectly perpendicular to the centre line of the tube ; it is designed for a gasket extending out to the outside diameter of the flange.

This contact face must be naturally flat and rough-wound or rough-moulded, without retouching. It is forbidden to grind it, even if the glass fibers are intended to be covered with a coat of resin after grinding ; this face must have grooves in relief (at least 2) to hold the gasket in place.

The outside dimensions of the flanges, in particular the bolt-hole circle, and the outside diameter, must be in accordance with the values specified in the standard ANSI B 16-5 for the relevant ratings (generally 150 lbs).

The VENDOR is required to recommend the best type of gasket to be used on the flanges, compatible with the nature of the fluid to be conveyed. He must indicate the approximate duration of the fire resistance of such a flange connection with the corresponding gasket. Neoprene or equivalent gaskets (Shore hardness of A 50 to 60) shall normally by used. Asbestos-elastomer gaskets shall not be used.

5.4.3 - Loose-flange connections

The loose flanges shall be made of steel, in accordance with the standard ANSI B 16-5 for the relevant ratings (generally 150 lbs).

The collar of the flanges shall be attached to the tubes or fittings by means of a cemented joint, in accordance with the principles stated in paragraph 5.4.1. Their outside diameter must be flush with the bolts of the flanges.

The collar contact faces must be flat and perfectly perpendicular to the centre line of the tubes. Fine grooves (similar to those of steel flanges) are required to hold the gaskets.

The VENDOR is required to recommend the best type of gaskets to be used for these loose-flange connections, compatible with the nature of the fluid to be conveyed. He must indicate the approximate duration of the fire resistance of such loose-flange connections with the corresponding gaskets. Neoprene or equivalent gaskets (Shore hardness A 50 to 60) shall normally be used. Asbestos-elastomer gaskets are not permitted.

5.4.4 - Mechanical joints

These type of joints shall be designed to withstand the full end thrust under pressure in the lines ; they may be either screwed or of the socket type with a locking key, and shall be sealed by means of an O-ring ; the material of the O-ring shall be suitable for the nature of fluid to be conveyed (i.e. crude oil).

5.5 - Minimum thickness

The minimum thickness of tubes and accessories shall satisfy the following criteria :

$t \geq 2.5 + \frac{D}{75}$, where t = thickness (in mm)
D = inside diameter of the component (in mm)

6 - TESTS AND EXAMINATIONS

The tubes and accessories must meet the requirements of this specification.

The VENDOR is accordingly required to test the raw materials he uses and to check during and at the end of fabrication that his product performs as required.

TOTAL reserves the right to witness any or all these tests, and must therefore be given sufficient advance notice of them ; the written results must be submitted to it as they become available as well as to the ENGINEERING COMPANY and the INSPECTION AGENCY.

All destructive tests on finished products shall be witnessed by the ENGINEERING COMPANY and/or the INSPECTION AGENCY.

6.1 - Tests and examination on acceptance of the raw materials

6.1.1 - Checks of resin quality

At the time of acceptance of a batch of resin, the VENDOR is required to check the quality of the batch by carrying out the following tests :

Tests	Type of resin		ASTM Standard
	Vinylesters	Epoxy	
Reactivity	X		D 2471
Epoxy content		X	D 1652
Viscosity	X	X	D 2393 (1)

(1) This standard applies only to epoxy resins

a) Reactivity

The reactivity of the resin here means the rate and intensity of curing under specified conditions. This test is important, because the resin, most often delivered with its accelerator, may be altered if stored for a too long time, especially if the storage temperature is high.

The VENDOR shall assure that the storage time does not exceed approximately 6 months, and that the temperature of the storage area is less than 20°C.

b) Epoxy content

The measurement of the epoxy content, applied to epoxy resins (which are more stable in storage) serves to determine the proportion of hardener to be used for complete curing of the resin.

Since the epoxy content is the content of "epoxy" reagent groups in a certain quantity of resin (generally 100 g), the measurement is made by chemical means (using the action of hydrobromic acid).

c) Viscosity

The measurement of the viscosity of the resin and, more important still, of the resin plus hardener mixture, gives an idea of the application conditions that will result in proper impregnation of the reinforcing materials.

The frequency of the shop quality checks is variable ; the VENDOR may test each batch or each drum in each batch. A certificate stating the results of these checks shall be submitted to TOTAL and to the ENGINEERING COMPANY and the INSPECTION AGENCY.

6.1.2 - Measurement of the water absorption of resins (on polymeric resin)

This test shall be done according to the ASTM D 570. The water absorption shall be less than or equal to 0.03% in weight for 24 hours.

A test report shall be submitted to TOTAL as well as to the ENGINEERING COMPANY and the INSPECTION AGENCY, upon request.

6.1.3 - Quality control of the glass fiber

The certificates of origin of the glass fibers used in fabrication, identified by batch number, must be presented to TOTAL on request.

These documents must, in particular, state the results of the tensile tests called for in the ASTM D2343.

6.2 - Tests and examination of the finished products

- The tubes and accessories covered by this specification must meet the requirements, especially as regards pressure strength and behaviour in the presence of hydrocarbon fires. Each type of product must accordingly be submitted, for certification, to the tests described in § 6.2.1.

- In addition, it is important to check that suitable fabrication techniques are used for these products ; this entails the production examination described in § 6.2.2.

- Finally, other properties, not related to the pressure behaviour, but of great importance for the design and layout of the network, must be known by the VENDOR, who must communicate them ; these properties are mentioned in § 6.2.3.

6.2.1 - Destructive tests

a) Glass content

This test shall be carried out in accordance with the standard ASTM D 2584 on samples taken at random by TOTAL and/or the INSPECTION AGENCY during the examination of the fabrication.

There shall be one check per type of fabrication product, with at least :

- 1 test of a tube
- 1 test of an elbow
- 1 test of a tee
- 1 test of a flange
- 1 test of a reducer
- 1 test of a mechanical joint (male and female ends)

The results obtained must indicate a glass content of more than 65% in weight in the case of tubes and accessories made by filament winding and more than 50% in weight in other cases (in particular contact moulding). Test reports shall be submitted to TOTAL.

b) Internal pressure tests

Two types of test shall be carried out. These test shall apply to the tubes, to the accessories and to the connections.

- Long-term tests :

. Long-term hydrostatic pressure
Standard ASTM D 2992 - Procedure B

These long-term tests make it possible to extrapolate the allowable stress values to 100,000 hours, and are used to determine or confirm the service pressures, after application of a safety factor of 3.

The results of these tests must be communicated to TOTAL before the start of fabrication.

- Short-term tests :

  As a general rule, these tests shall be carried out on the largest diameter of the order, in each type of product and/or accessories, with at least (as applicable) :

  . 1 test of a tube
  . 1 test of an elbow
  . 1 test of a tee
  . 1 test of a reducer
  . 1 test of a flange assembly

  (Each piece shall be tested individually, with the exception of the flange assembly).

  The test of a tube shall be carried out on two half-lengths connected by adhesive (bell and spigot joints) and on a mechanical joint (if applicable).

  The tests shall be made with full end thrust.

  The samples for these tests shall be selected by the INSPECTION AGENCY and shall be taken from production stocks already accepted for the relevant purchase order.

  Two types of short-time tests shall be carried out :

  . Weeping under static pressure (as per standard ASTM D 1599)
  The weeping pressure must be at least six times the design pressure or the "maximum service pressure", whichever is smaller. However, a lower value for this test pressure may be agreed by TOTAL based on long-term tests results on similar pieces (refer to "long-term" tests hereabove) : in this case, the test pressure value shall be equal to the maximum service pressure multiplied by a minimum factor of 3, multiplied itself by the aging factor over 100 000 hours as observed during the long term tests.

  . Short-term cyclic pressure
  (As per standard ASTM D 2143, for 750 cycles)

  (This test shall only be performed on specific request of the purchase order).

c) Test of the water absorption of the resin/glass-fiber laminates

This test must be carried out in accordance with ASTM D 570. The water absorption shall be less than or equal to 1.5% for 24 hours. A test report must be submitted to TOTAL.

d) Test of deflection temperature under constant load

This test must be carried out in accordance with ASTM D 648 ; a test report must be submitted to TOTAL.

e) Corrosion tests (unless specifically requested by TOTAL, these tests shall not be made).

(These tests, to be carried out in accordance with the standard ASTM D 543, will be defined in each case by particular specifications, with indications of the nature and temperature of the substances conveyed).

f) Ageing tests (unless specifically requested by TOTAL, these tests shall not be made).

These are accelerated ageing tests, to be carried out in accordance with the standard ASTM G23.

These tests consist of cycles of exposure to temperature, artificial rainfall, and ultraviolet radiation. They will be defined in each case by particular specifications in which the location and conditions of use of the material, in particular, are taken into account.

6.2.2 - Non-destructive examinations

a) Visual examination

In general, this visual examination shall be carried out to 100% on all parts (tubes and accessories) covered by the order.

The acceptance criterion shall be level 1 of standard ASTM D 2563 for the inside surfaces of the tubes (liner) ; for the other parts of these tubes and accessories, level 2 shall be required, with the following exceptions :

- surface cracks : level 3, without apparent glass fiber
- air bubbles : a maximum of two bubbles of 2.5 mm in diameter per square inch
- "Pimple" : acceptable if less than 2.5 mm in diameter
- "Pit" : level 2, but depth of as much as 8% of thickness, without apparent glass fiber
- scratches : maximum depth 0.2 mm, without apparent glass fiber

The outside surface must be rich in resin. This resin shall be the same as the resin of the tube. The outmost glass fibers must be covered by a coat of resin approximately 0.5 mm thick. The surface must have a glossy appearance and there must be no large variation in colour in a single tube.

The ends of the tubes and accessories shall be prepared as requested by the ENGINEERING COMPANY, among the following possibilities :

- the tubes are left straight, cut off at right angles
- ends with fixed flanges
- ends with collars and loose flanges
- machined made ends at both ends for cemented joints with couplings
- machined bell and spigot ends (one each)
- ends with mechanical joints (male and/or female)

If this point is not specified in the order, the VENDOR shall deliver the tubes and accessories with machined ends ready for connection.

b) Dimensional inspection

Dimensional inspection shall be carried out on 100% of the tubes and accessories.

Since the only acceptable type of fabrication for the tubes is the filament winding process, the inside diameters of the tubes shall have a precise dimension by fabrication. However, TOTAL reserves the right to check this dimension.

Inside diameters and thicknesses shall be checked in accordance with the procedure of the standard ASTM D 2122.

The standard ASTM D 2996 shall be used for checking the thickness of the gel coat.

The tolerance on the inside diameter in :
- 1.0 mm
+ 1.0 mm

The tolerance on the wall thickness is :
- 0.0 %
+ 12.5 %

The VENDOR shall indicate the length of his tubes, together with the tolerances on this length.

At the request of the ENGINEERING COMPANY, the VENDOR may connect two standard lengths at the works to obtain a double length.

c) Barcol hardness test

This test shall be carried out on 100% of the tubes and accessories, at the same time as the visual examination and dimensional inspection.

This hardness test shall be carried out on the external and internal surfaces of the tubes, in accordance with the standard ASTM D 2583 ; the minimum value must be 40 Barcol for epoxy resins and 30 Barcol for vinylester resins.

d) Hydrostatic test

At the works, at the end of fabrication, the tubes and accessories must be tested with water at a pressure equal to 1.5 times the design pressure. This test must be carried out on at least 10% of the tubes and accessories, selected at random by TOTAL or the INSPECTION AGENCY.

6.2.3 - Physical properties of the tubes

The following physical values must be made known to the ENGINEERING COMPANY.

(The VENDOR must indicate them after having made the required measurements) :

a) Coefficient of thermal expansion

These are the coefficients of thermal expansion measured on the tube, lengthwise and transversely.

b) Tensile tests of tubes

This test, in accordance with the standard ASTM D 2105, gives the longitudinal Young's modulus and the tensile strengths of the tubes, including the ends.

c) Diametrical crushing of the tubes

The results of the tests, carried out as per the standard ASTM D 2412, must be given (in particular, the force producing a 5% reduction in diameter).

6.3 - Certification

The tests described in paragraphs 6.1 and 6.2 serve for the approval of the raw materials and of the fabrication process, as well as for the acceptance of the materials ordered.

The tests called for at the start of fabrication must be carried out in the presence of TOTAL or the INSPECTION AGENCY, which may request some of the tests called for on the tubes and accessories be repeated if there is a doubt on the repeatitivity of the results. Should a destructive test have failed, an other two pieces of the same supply shall be tested in the same conditions as previously. If these tests fail again, the complete lot of similar pieces shall be rejected and no other qualification test shall be performed unless the fabrication process has been improved by the VENDOR, and agreement given by TOTAL.

Following these examinations, the INSPECTION AGENCY shall issue a certificate, which must accompany the invoicing for the supply.

6.4 - Identification

All tubes and accessories must be permanently marked by the VENDOR with the following information :

- name of VENDOR and name of product
- class of material according to his standards (if any)
- nominal diameter
- date of fabrication (month, day, year, in clear)

The INSPECTION AGENCY must also affix its mark on the tubes and accessories it has inspected in conformity with this specification and which it has accordingly accepted. an indelible "REJECTED" mark must be applied to defective parts.

7 - RULES FOR HANDLING AND STORAGE

7.1 - Storage at works

When the finished products are taken to the VENDOR's storage yard, the VENDOR must make all arrangements necessary to prevent any damage.

Storage must be on a smooth surface with no roughness.

Storage in several layers is possible ; in this case, wide planks, approximately 2.00 m apart and vertically aligned, must be interposed between the layers. The thickness of planks must be such that the bell ends of the tubes do not touch other tubes or tube ends.

From the end of fabrication, the tubes must be fitted with end protectors for storage, handling and transport.

If the anticipated storage period is relatively long (over three months), storage must be in a sheltered area.

7.2 - Handling

It is strictly forbidden to handle the tubes without end protectors.

The only acceptable handling methods are :

a) by hand : the tubes are handled one by one

b) by crane : wide slings of textile webbing, held spread by a bar, are used ; handling using end hooks is forbidden

It is forbidden to unload a vehicle by rolling the entire load off the side.

7.3 - Packing for shipment

Shipments from the works are made in wooden cases or in special containers.

Each layer of tubes is separated from the next layer by planks not more than 2 m apart. These planks are aligned vertically. The thickness of the planks must be such that the bell ends do not touch other tubes or tube ends.

The packing, the fabrication of the cases, and the marking of the parcels, must comply with the specific requirements of TOTAL specifications SP-LOG-881 and SP-LOG-883 for this type of material.