HELLENIC GAS TRANSMISSION SYSTEM OPERATOR

357-359, MESSOGION AVE.,
15231 ATHENS, GREECE
Tel.: 210 6501258
Fax : 210 6501551

TECHNICAL JOB SPECIFICATION
500/9
REVISION 0
DATE 29/06/2011

LNG PLANT

FIBERGLASS REINFORCED PLASTIC PIPES & COMPONENTS

QUALITY ASSURANCE PAGE

CHANGES LOG

REVISIONS LOG

0	**29-06-2011**	**FIRST ISSUE**	**PQ DPT**	**V.G.**
Rev. No	Rev. Date	REASON FOR CHANGE	Made By	Approved By

CONTENTS

REFERENCE DOCUMENTS

- ELOT EN ISO 14692-1
  [Petroleum and natural gas industries — Glass-reinforced plastics (GRP) piping — Part 1: Vocabulary, symbols, applications and materials]
- ELOT EN ISO 14692-2
  [Petroleum and natural gas industries — Glass-reinforced plastics (GRP) piping — Part 2: Qualification and manufacture]
- ELOT EN ISO 14692-3
  [Petroleum and natural gas industries — Glass-reinforced plastics (GRP) piping — Part 3: System design]
- ELOT EN ISO 14692-4
  [Petroleum and natural gas industries — Glass-reinforced plastics (GRP) piping — Part 4: Fabrication, installation and operation]
- ASTM D 696
  [Test Method for Coefficient of Linear Thermal Expansion of Plastics Between -30°C and 30°C]
- ASTM D 1598
  [Standard Test Method for Time-to-Failure of Plastic Pipe Under Constant Internal Pressure]
- ASTM D 2105
  [Standard Test Method for Longitudinal Tensile Properties of "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe and Tube]
- ASTM D 2412
  [Standard Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel- Plate Loading]
- ASTM D 2925
  [Chemical Resistance of Thermosetting Resins used in Glass Fiber Reinforced Structures]
- ASTM D 2992
  [Standard Practice for Obtaining Hydrostatic or Pressure Design Basis for "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe and Fittings]
- ASTM D 4255
  [Standard Guide for Testing In-plane Shear Properties of Composite Laminates]

1.0 SCOPE

This specification provides the minimum requirements for design, fabrication and qualification of fiberglass reinforced plastic (FRP/GRP) piping systems and components for above ground seawater service.

2.0 GENERAL REQUIREMENTS

2.1 DESIGN CONDITIONS

Specific Design Conditions are as mentioned in the relevant Material Requisition. Design conditions as discussed in this Specification are defined as follows:

2.1.1 PRESSURE

a. Operating pressure: the normal operating pressure range anticipated on a continuous basis over the long term.

b. Design pressure: the pressure to be used for selection and qualification of the pipe and components. Design pressure is higher than the operating pressure to include surge pressure or other common events anticipated routinely over the life of the system, and provide additional strength capability to accommodate system stresses.

c. Hydrotest pressure: the pressure used for static hydrotest of the system after installation. Hydrotest pressure shall not exceed 150% of the Design Pressure.

2.1.2 TEMPERATURE

a. Operating temperature: the normal temperature range anticipated on a continuous basis over the long term.

b. Design temperature: the maximum temperature that the piping system could experience infrequently and for short durations, under any combination of conditions. Design temperature pressure is used primarily for resin selection.

c. Ambient temperature: the range of climatic conditions under which the system is expected to operate.

d. Installation temperature: the range of ambient temperatures anticipated during the piping system installation period.

2.2 SEA WATER SERVICE CONSIDERATIONS

Selection of materials, manufacturing methods and design features must consider the seawater service requirements. Chemical, temperature, abrasion and fire resistances shall govern these requirements. Design conditions shall satisfy all the requirements described in **ELOT EN ISO 14692-3**.

The Manufacturer shall provide documentation which supports the selected resin system for each Service Class, and provides the information necessary to calculate reduced properties for use in the design.

3.0 FABRICATION

3.1 MATERIALS

Resin Systems

Manufacture of pipe and fittings shall be limited to thermosetting vinyl ester and epoxy resin systems with a documented history of successful performance in similar services.

Reinforcements

Structural reinforcements shall be E-glass fiber, including continuous roving for filament winding. Surfaces exposed to the service fluid shall be reinforced with C-glass or synthetic surfacing veils.

Additives

Resin shall be modified with additives for opacity or color, UV protection, fire resistance, reduction of smoke generation, abrasion resistance, static grounding etc.

Corrosion Liner Selection

Surfacing veil type, corrosion liner thickness, resin etc. shall be as required to meet the corrosion resistance and other service requirements of the piping system.

3.2 MANUFACTURING METHODS

FRP/GRP pipe and fittings covered by this specification shall be manufactured in general accordance with the following process and qualified per the requirements of Section 4 of this specification.

3.2.1 FILAMENT WINDING

The two acceptable methods are reciprocal and continuous. It is a precision winding technique. By this method a large number of resin impregnated glass roving are wound on a rotating steel mandrel, with a helix angle precisely adjusted under a uniform tension such as to assure that all fibers contribute equally to the strength of the pipe.

3.2.2 PIPE WALL CONSTRUCTION

The wall of FRP/GRP pipes is made up of three layers totally sticking, every one possessing different properties according to its function such, as inner layer (including barrier layer), a structural layer and an outer layer.

Inner layer shall provide the hydraulic characteristics, abrasion resistance, chemical and hydrolytic resistance. The barrier layer shall improve the resistance of the inner layer containing aggregates to penetration of water by mechanical, physical or chemical action.

Structural layer shall provide most of the load bearing capabilities in both the circumferential and longitudinal direction.

Outer layer shall provide a protective system against degradation, abrasion or attack by UV radiation. Additionally the inner and outer layers containing glass reinforcement shall also contribute to the structural properties of the pipe.

3.2.3 FITTINGS (BENDS, TEES, etc.)

Fittings are manufactured either by the open molding process or, by mitering the pipe and welding the segments into a single fitting (hand lay-up and spray-up) or they are manufactured by the filament wound.

Bends, reducers, tees and other fittings may be compression molded, fabricated from sections of pipe, or manufactured by the filament wound or hand lay up process, using the same resin and corrosion liner, equal to or better than that of the pipe.

3.2.3.1 Bends

Bends with diameter through 450 mm shall be smooth turn, one piece with long radius.

Bends with diameter greater than 450 mm may be mitered and assembled with laminated butt and strap joints.

Joining overlays shall be at least 20% thicker than butt joints used to join plain end straight pipe and shall fully compensate for stress intensification effects.

3.2.3.2 Tees

Equal size and reducing tees may be molded in one piece or fabricated from sections of pipe. Additional reinforcing shall be provided to fully compensate for the stress intensification effects. Tees fabricated from pipe sections in all pressurized pipe shall include an internal sealing overlay in addition to the external reinforcing overlay.

3.2.3.3 Flanges and nozzles

Flanges may be joined to the pipe with an adhesive joint or hand lay up contract molded in one piece that includes a flange neck for attachment of the pipe with a laminated butt and strap joint. Flanges shall be flat-faced, or flat-faced with a confined O-ring gasket groove. Flat faced flanges shall not be mated to raised face flanges, ring gaskets or other configurations which could cause bending in the fiberglass flange as bolts are tightened.

3.3 TOLERANGES

Diameter tolerances shall comply to **ELOT EN ISO 14692-2.**

3.4 JOINT TYPES

The pipe and fittings covered by this specification shall be assembled using one of the following joining systems, which can withstand internal pressure and longitudinal forces (restrained joints).

Double O-ring bell and spigot with locking key joint (Rubber seal lock joint, RSLJ) or a separate coupling with O-ring or specialized gaskets.

Laminated Butt and Strap Joint.

Any other joint type proposed shall be approved by the Owner.

The manufacturer shall ensure that the materials of construction of ancillaries such as O-rings, lubricants, gaskets, mastic and locking strips are suitable for the intended service conditions.

3.5 PIPE LENGTH

The pipe length shall be about 12 m.

3.6 HANDLING AND SHIPPING

FRP components shall be handled and protected by qualified personnel according to industry standards and manufacturing requirements to avoid mechanical damage from impact, sharp edges and scratching.

No chains, wire ropes or clamps shall be directly attached to the FRP/GRP piping components for the purpose of lifting or moving.

Fitting shall be transported either packed in a container or strapped into pallets.

Pipe with bell ends may be stored with the bell ends in alternate directions to avoid contact and possible damage to the ends. Spacer stripping shall be clear of the bell ends. End protection shall protect both inside and outside of the pipe ends, and shall remain in place during storage.

Ancillary materials such as rubber O-rings, flange gaskets, locking strips, reinforcements and lubricants shall be packed and stored in accordance with the Manufacturer's recommendations.

4.0 QUALIFICATION OF FRP PIPE AND COMPONENTS

4.1 GENERAL

The purpose of qualification of pipe, fittings and joints is to assure pressure containment integrity by establishing a pressure rating which meets or exceeds the Design Pressure. In addition, qualification provides a basis for determining allowable axial stress, to be used in the piping system design. The extent to which qualification testing is required shall follow the rationalization given in **ELOT EN ISO 14692-2** and is summarized in table 1.

4.2 TESTING CONDITIONS

Components including flanges, joints, tees and bends, may be tested as assemblies. Where assemblies of manufactured components are tested, the integrity of joints and fittings, as well as component bodies are verified. The pressure at failure shall be used to qualify alt components in the assembly. All pipes between adjacent fittings or end closures shall have a length of at least 3 times the diameter of the pipe.

All qualification tests shall be made on assemblies with free ends such that the full pressure induced axial load is borne by the component or assembly being tested.

4.3 QUALIFICATION BY LONG TERM HYDROSTATIC TESTING

This procedure is suitable for qualifying pipe, adhesive joints, restrained gasketed joints, and machine fabricated fittings such as filament wound flanges, bends and tees. When testing spooled assemblies to qualify joints and fittings, the HDS and pressure rating shall be based on the pipe wall thickness of where the failure occurred.

Components	Product Type	Qualification tests	Purpose
Plain pipe	Family representative[a]	**Full regression test** at 65°C, or design temperature if higher (ASTM D2992:1996-Procedure B)	Qualified pressure Qualified stress Gradient
Pipe plus joint, fittings and fabrication processes	Family representative[a]	**Full regression test** at 65°C, or design temperature if higher (ASTM D2992:1996-Procedure B) **Or Default gradient**	Qualified pressure Baseline gradient for determining survival test pressure
	Product sector representative	Two 1000-h survival tests at 65°C, or design temperature if higher (ASTM D1598)	Qualified pressure
	Component variant	Two 1000-h survival tests at 65°C, or design temperature if higher (ASTM D1598) Or **Scaling method** Or **Design method** (in exceptional cases)	Qualified pressure
[a] Only one size of component diameter is required to be tested			

Table 1. Full qualification procedure for pipes (plus joints) and fittings.

4.3.1 The hydrostatic design basis (HDB) shall be determined in accordance with procedure B of **ASTM D 2992**.

4.3.2 The HDB is the hoop stress at failure, extrapolated from the test data to 50 years, and must be divided by a design factor (N) to obtain the hydrostatic design stress (HDS).

The HDS is the design hoop stress that can be applied in the bi-axial pressure condition continuously with a high degree of certainty that failure of the pipe or component will not occur within intended service life.

$$HDS = \frac{HDB}{N} \qquad \text{Equation 1}$$

Where:

HDS = hydrostatic design stress
HDB = hydrostatic design basis
N = 3.0 for static HDB (Procedure B)

4.3.3 The pressure rating of the pipe or component is determined from the HDS using the following relationship:

$$P = \frac{(HDS)t}{R} \qquad \text{Equation 2}$$

Where:

P = pressure rating
HDS = hydrostatic design stress
t = structural wall thickness of the pipe
R = radius of pipe

4.3.4 The pressure rating of the pipe or assembly of components must meet or exceed the required Design Pressure for the specific Service Class.

5.0 PIPING SYSTEM DESIGN

The design of FRP piping systems shall provide for the most severe coincident condition of temperature, pressure and other loads.

5.1 GENERAL DESIGN CONSIDERATIONS

They shall include properties and allowable stresses, layout considerations, all loads imposed and other considerations such as vibration prevention, etc.

5.2 ABOVE GROUND PIPE ANALYSIS

Analysis shall be made manually for preliminary and by computer for stringent results.

6.0 INSPECTION AND TESTING

It shall comply to all requirements described at **ELOT EN ISO 14692-2**. All quality control tests including hydrostatic leak tests shall be performed, satisfactorily.

7.0 MARKING

Marking of FRP pipes shall be in accordance to **ELOT EN ISO 14692-2.**

8.0 DATA REQUIREMENTS

8.1 PROPOSAL

Vendor shall provide the following information for pipe construction type or design proposal.

8.1.1 GENERAL

- Diameters.
- Minimum Pipe Length.
- Pressure Class.
- Fire resistance, Code / Rating achieved.

8.1.2 FABRICATION METHODS

- Corrosion liner thickness.
- Corrosion liner veil type, construction.
- Corrosion liner resin type.
- Corrosion liner fillers and additives.
- Structural wall construction method.
- Structural wall glass content, laminate sequence.
- Structural wall resin type.
- Structural wall fillers and additives.
- Pipe stiffness.
- Joint type.
- Fitting construction method.
- Methods/materials used to obtain fire resistance rating.

8.1.3 PHYSICAL PROPERTIES

- Hoop tensile and flexural modulus.

- Axial tensile and flexural modulus.
- Ultimate axial strength.
- Pipe stiffness.
- Allowable ring bending strain.
- Allowable axial stress.
- Poison ratios.
- Axial Coefficient of Linear Thermal Expansion.
- Axial Compressive Modulus of Elasticity.
- Hydrostatic Design Stress (HDS) per Section 4 and method used. Submit test data.
- Density.
- In-Plane Shear Modulus of Elasticity.

8.2 FRP PIPE MANUFACTURE'S DOCUMENTATION

Documentation shall include specific information required by the pipe installer to assure that, the pipe is installed in accordance with the design basis.

Documentation shall include, but not necessarily be limited to, the following information:

8.2.1 QUALIFICATION OF PIPE AND COMPONENTS

All data used as the basis for the qualification of the pipe and components shall be included in the Documentation.

Complete description of the construction of each of the components qualified.

Complete description of the qualification processes used.

Listing of all tests performed and used as a basis for the qualification.

A listing of all construction data and test values, including minimum values and tolerances, as required to provide a basis for quality control and verification that production pipe and components satisfy the requirements of the qualification procedure.

8.2.2 CALCULATION PACKAGE

8.2.3 DRAWINGS

8.3 QUALITY CONTROL MANUAL AND QUALITY CONTROL PLAN

Quality Control Manual shall detail the organization of quality control program. Manufacturer shall submit with the proposal a Q.C. Manual showing the standard procedures implemented during the normal course of production.

Quality Control of the manufacturing of pipe, components and spool assemblies is the responsibility of the Manufacturer. QC Plan shall be submitted for approval. QC Plan shall incorporate all requirements of this specification, the Manufacturer's qualification procedure and shop standards. As a minimum the QC Plan shall describe the inspection and testing procedures, frequency and documentation to be used for each verification procedure.

8.4 PRODUCTION QUALITY CONTROL DOCUMENTATION

Raw material (including ancillaries) certificates, shall be available for the raw materials of all components to be supplied. The certificates shall be provided, if requested by the Owner, prior to the start of manufacture.

Production quality control reports, in accordance with the testing requirements of **ELOT EN ISO 14692-2** shall be provided for all supplied components within five working days, or other agreed period, after delivery of the complete order or part thereof.

8.5 INSTALLATION DOCUMENTATION

The manufacturer shall provide the Owner with the following documentation to facilitate the proper assembly and installation of his products:

- instructions for field assembly of all joint types supplied;
- instructions for the installation of the piping system supplied;
- instructions for the installation of the piping system supplied;
- instructions for the field repair of damage to pipe and fittings, if this is permitted in accordance with the requirements of **ELOT EN ISO 14692-2.**