FUTURE PIPE INDUSTRIES B.V.

Glassfiber Reinforced Pipe Systems

Fibermar© Pipe Systems

For Marine Applications

System Specification

Rep418/Rev00/0800

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1. General:

This specification covers design conditions, material requirements, methods of manufacturing, test methods, dimensions, identification and inspection of Fibermar epoxy pipes and fittings.
Fibermar epoxy pipe systems for marine applications are manufactured by filament winding continuous glassfibres impregnated in an aromatic or cyclo aliphatic amine cured epoxy system. Fibermar products can be used for the transportation of water or chemical products at a maximum operating of 16 bar and a maximum continuous operating temperature of 110ºC.

2. Design:

2.1.Design pressure:
The design pressure should be the most severe internal operating pressure that the system will be subjected to under all modes of operation, including start-ups, shut downs, etc, throughout the entire life time of the system.
The reinforced thermosetting resin pipe system should be designed such, that the possibility to subject the system to pressure surge or water hammer is excluded. Quick opening and closing of valves should be avoided.

2.2.Design temperature:
The design temperature should be the most severe temperature that the system will be subjected to under all modes of operation, throughout the entire lifetime of the system. The hot design temperature should be the highest temperature that the piping system will be subjected to; the cold design temperature should be the lowest temperature that the piping will be subjected to under all modes of operation. The installation temperature will be the expected ambient temperature at the location during the time of the year in which the piping will actually be installed.

2.3.Hydrostatic design stress:
The design of Fibermar epoxy pipe systems is based on external pressure according a generally accepted and widely used calculation method (Roark/Young) to determine the maximum allowable external pressure. The safety factor used on external pressure is 3 and a service factor of 1.
The hydrostatic design stress (H.D.S) is the estimated maximum tensile stress in the pipe wall in circumferental direction due to internal hydrostatic pressure that can be applied continuously with a high degree or certainty that failure will not occur. The H.D.S. is obtained by multiplying the hydrostatic design basis (H.D.B.) by the service (design) factor. The H.D.B. is the extrapolated value of the long-term hydrostatic strength (LTHS) to 50 years and is determined in accordance with ASTM D 2992.
Future Pipe Industries B.V. implies a long-term safety factor of 2 and a safety factor on short-term hydrostatic failure of 4 which is determined in accordance with ASTM D 1599. By using a winding angle of 63º for our marine system the H.D.B. is 100 N/mm^2. For further information we refer to our engineering guide.

2.4.Mechanical design:
All conventional methods of calculating the stress in the pipe wall, resulting from internal- and external loads are applicable to the Fibermar pipe system.
The continuum theory forms the base for the determination of the allowable equivalent stress, derived from the stresses perpendicular and parallel to the reinforcement, as well as the interlaminar shear stress. Summation of the stresses, resulting from internal pressure, bending, thermal expansion, support spacing, etc, should not exceed Future Pipe Industries' recommended stress values.
Future Pipe Industries has set the maximum service (design) factor for combined stress situations on a value of 0.67.

3. Basic materials:

3.1.General:
All structural materials shall be new, fresh and free from all detrimental defects and imperfections and only be used for production after having been controlled and approved by Future Pipe Industries Quality Department. Testing and controlling will be done according to the relevant methods. The basic materials used for pipes and fittings will meet the performance requirements of this specification.

3.2.Resin:
The resin to be used will be epoxy resin Epikote 828 or equivalent. The resin-curing agent mixture will have sufficient chemical and mechanical resistance to meet the imposed requirements. The resin will be stored in adequate tanks for a period of at maximum 6 months, on suppliers prescribed conditions.

3.3.Curing agent:
The curing agent will be an aromatic or cyclo-aliphatic amine type. The choice of the curing agent type depends on the application of the reinforced thermosetting resin system and/or the fabrication method. The curing agent will be stored in adequate tanks for a period of at maximum 6 months, on suppliers prescribed conditions.

3.4.Reinforcement:
As reinforcement of the thermosetting resin, two types of glass with a low alkali content will be used. The glass reinforcement materials will be stored dry and protected against dust or other negative influences.

- Liner reinforcement:
  C-glass or polyester non-woven is used as reinforcing material for the chemically resistant inner layer (liner). This type of reinforcement will appear in the form of a fleece, having a surface weight of 25-50 gr/m^2 and is provided with a special finish to assure a good adhesion with the matrix.

- Structural reinforcement:
  E-glass is used as reinforcing material for the structural wall. This type of glass will appear in the form of continuous roving or woven cloth. Rovings are used in the filament winding process for the production of pipes. Woven glass fabrics are used for the production of fittings and as local reinforcement for all products. The reinforcing material is provided with a special finish to assure a good adhesion with the matrix.

3.7.Adhesive:
For all adhesive bonded joints a two component epoxy resin mixture is used. The adhesive is available in two variants. The first can be used for all applications except for conductive pipe systems. The second variant can be used for conductive pipe systems. The adhesive is delivered as a kit, containing pre-measured quantities of resin and curing agent and written instructions covering preparation of surfaces, mixing, joining, safety, potlife and curing. The adhesive has to be used before the latest work up date, indicated on the packing.

3.8. O-ring seal:
For the rubber seal joint standardly a nitrile butadiene rubber (NBR) will be supplied for the sealing of the joint. Depending on the type of fluid that will be transported another type of rubber can be advised.

4. Fabrication:

4.1.Pipes:
Pipes are manufactured by the filament winding process. In this process the continuous fibrous glass strand rovings are wound onto the outside of a mandrel in a predetermined pattern under controlled tension. The rovings are saturated with the resin/curing agent mixture and helical wound under a calculated winding angle. The inside diameter (ID) of the finished pipe is fixed by the mandrel outside diameter. The outside diameter (OD) of the finished pipe is fixed by the number of helical wound layers.

4.2.Fittings:
Fittings in the diameter range up to 400 mm are filament wound or manufactured from pipe parts and are manufactured using pre-impregnated woven glass fabric, which is applied onto the outside of a mandrel in a pre-determined pattern under controlled tension.
The inside diameter (ID) is fixed by the outside diameter of the mandrel. The outside diameter (OD) of the fittings is determined by the amount of material that is wound on the mandrel.
Fittings in the diameter range over 400 mm are filament wound or manufactured from pipe parts, which are first fitted together and then wrapped with pre-impregnated glass fabrics. Pipe parts used for the production of fittings meet the pipe requirements.

4.3.Liner:
Where a liner is applicable the liner will consist of thermosetting resin, reinforced with C-glass with a low alkali content or linear polyester non-woven. The resin content will be at least 70% by weight and the nominal thickness of the liner is 0.5 mm. The resin used for the liner will be exempted of pigments.

4.4.Reinforced wall:
The reinforced wall consists of thermosetting resin, reinforced with continuous fibrous glass strand rovings of E-glass, with a low alkali content. For fittings woven glass fabrics made of E-glass are used. The thickness of the reinforced wall depends on the required external pressure and/or internal pressure. The resin used for the reinforced wall will be exempted of pigments. The winding angle of the continuous glass strand rovings of Fibermar pipe systems will be 63º or 55º.

4.5.Topcoat:
The resin used for the topcoat will be a pure thermosetting resin and will be the same as used for the reinforced wall to assure a good adhesion between these two layers. The resin will be exempted of pigments. The thickness of the topcoat will be at least 0.3 mm.

If low flame spread is required the topcoat will consist of a fire retardant barrier. The materials used for this barrier are the same as for the reinforced wall only a fire retardant filler is added to the resin. The barrier can be applied during the filament winding process or on site.

5. Marking:

All pipes and fittings shall be marked with manufacturers trade name, the nominal diameter, class and identification code. This identification code corresponds with production data. The marking shall remain legible under normal handling and installation practices.

Fibermar EMT/CMT series.
EMT stands for epoxy marine tensile resistant (non-conductive).
CMT stands for a conductive marine tensile resistant.

-	Tradename	-	Fibermar
-	Series identification or class	-	Example: EMT 20 / PN10 20 stands for maximum external pressure of 20 metres water column. PN10 stands for a maximum nominal pressure of 10 bar.
-	Identification code	-	EMT. (number)
-	Nominal diameter	-	50-900 mm
-	Fire performance level	-	FR for low flame spread characteristics according to IMO A653(16).

6. Product Data:

Tabel 1. Fibermar Pipe System with nominal pressure of 10 or 16 bar

ID	EMT / CMT 20	EMT / CMT 30	EMT / CMT 40	EMT / CMT 50
25 40 50 65 80 100 125 150 200 250 300 350 400 450 500 550 600	**See pressure class 16 bar**			
700	15.8	18.0	19.8	21.4
750	16.9	19.3	21.2	22.8
800	17.9	20.5	22.5	24.3
900	20.1	22.9	25.2	27.2

P = Pipes
- Pipe PL\PL Lamination joint or mechanical coupler
- Pipe CB\CS Adhesive joint
- Pipe LB\LS Rubber seal joint

F = Fitting
- Coupler
- Adapter
- Elbow 22,5º, 45º or 90º, R=1,5*D
- Elbow 22,5º, 45º or 90º, R=1*D
- Equal and unequal tee
- Lateral 45º
- Eccentric en concentric reducer
- Flange
- Blindflange
- Heavy duty flange
- Stub end flange
- Equal and unequal crosses
- Fixation and wear saddle
- Saddle with nipple
- Grounding saddle
- Reducing saddle

M = Mitred
- Elbow 0-90º, R=1,5*D
- Elbow 0-90º, R=1*D
- Equal and unequal tee
- Eccentric en concentric reducer
- Flange

Tabel 2. Reinforced wall thickness pipe (mm) - PN 10 bar system

ID	EMT / CMT 20	EMT / CMT 30	EMT / CMT 40	EMT / CMT 50
25 40 50 65 80 100 125 150 200 250 300 350 400 450 500 550 600	**See pressure class 16 bar**			
700	15.8	18.0	19.8	21.4
750	16.9	19.3	21.2	22.8
800	17.9	20.5	22.5	24.3
900	20.1	22.9	25.2	27.2

Tabel 3. Reinforced wall thickness pipe (mm) - PN 16 bar system

ID	EMT / CMT 20	EMT / CMT 30	EMT / CMT 40	EMT / CMT 50
25				1,8
40				1,8
50				1,8
65				2,0
80				2,4
100				3,0
125				3,7
150				4,5
200	4,3	5,0	5,5	5,9
250	5,4	6,2	6,8	7,4
300	6,5	7,4	8,2	8,8
350	7,5	8,7	9,5	10,3
400	8,6	9,9	10,9	11,8
450	9,7	11,1	12,3	13,2
500	10,7	12,3	13,6	14,7
550	11,9	13,6	14,2	16,2
600	12,9	14,8	16,3	17,6

Tabel 4. Reinforced wall thickness Tee, Y en reducer (mm)

ID	PN10 bar system	PN16 bar system
25		2,4
40		2,4
50		2,4
65		3,2
80		3,2
100		3,3
125		4,1
150		5,0
200	4,1	6,6
250	5,1	8,3
300	6,1	9,9
350	7,1	11,6
400	8,2	13,2

Tabel 5. Reinforced wall thickness Elbow and coupler (mm)

ID	PN10 bar system	PN16 bar system
25		1,6
40		1,6
50		1,6
65		2,4
80		2,4
100		2,6
125		3,2
150		3,8
200	3,3	5,1
250	4,1	6,4
300	4,9	7,7
350	5,7	9,0
400	6,5	10,3

7. Performance requirements:

7.1.Joint strength:
The applicable joint shall show no leakage or other evidence of failure when tested in accordance with the Wavistrong Test Specification 01/01.

7.2.Impact resistance:
Pipe and fittings shall show no porosity when tested in accordance with Wavistrong Test Specification 01/05 and ASTM D 2444.

7.3.Boil resistance
Samples made from pipe or fitting laminates shall show no evidence of delamination or other impairment when tested in accordance with Wavistrong Test Specification 01/06 and ASTM D 570.

7.4.Beam strength:
The axial modulus of elasticity of pipes, when tested in accordance with Wavistrong Test Specification 01/07 D 2925 will have a minimum value of 11500 N/mm^2.

7.5.Ultimate hoop stress:
The short-time hydraulic failure pressure of pipe and fitting, when tested in accordance with ASTM D 1599, shall not be less than four times the rated pressure.

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7.6.Axial tensile stress:
The axial tensile stress for pipes when tested in accordance with ASTM D 2105, will not be less than 55 N/mm^2.

7.7.Hoop tensile stress:
The hoop tensile strength of pipes, when tested in accordance with ASTM D 2290, will not be less than 260 N/mm^2.

7.8.Hardness:
The indentation hardness of pipes and fittings, when tested in accordance with ASTM D 2583 will be at least 30 Barcol.

7.9.Glass content:
The glass content of the reinforced wall of pipes and fittings, will be determined in accordance with ASTM D 2584. The glass content for pipes will be at least 65% by weight, and the glass content for fittings will be at least 60% by weight.

7.10.Hydrostatic design stress
The hydrostatic design stress for pipes and fittings will be obtained from the extrapolated long term hydrostatic tests in accordance with ASTM D 2992 for a lifetime of 50 years. The minimum service (design) factor for the determination of the hydrostatic design stress will be 0.5. The value of the hydrostatic design stress for Fibermar products is 50 N/mm^2.

8. Inspection:

The quality Department of Future Pipe Industries is responsible for shop surveillance and inspection of:
- Incoming materials, parts and processes
- In-process control
- Control of finished products

A detailed description of the inspection is given in the Wavistrong Inspection Program.

7.1.Raw material control:
All raw material used for the production of pipes and fittings will be subjected to a series of tests in accordance with relevant specifications. The inspection method and frequency of inspection is given in the Wavistrong Inspection Program.

7.2.In-process control:
The in-process control consists of a regular check of the equipment used for the production of pipes and fittings. The method of production is compared with written procedures to manufacture the product, which has to fulfil the performance requirements.

7.3.Control of finished products:

- Visual	Pipes and fittings will be inspected according to WTS 01/14 and ASTM D 2563.
- Dimensional control	Dimensions of pipes and fittings will be inspected in accordance with Wavistrong Test Specification 01/16 and ASTM D 3567.
- Hydrostatic testing	A hydrostatic test will be performed on 5% of produced pipes and fittings at 1.5 times rated pressure in accordance with Wavistrong Test Specification 01/10 times.
- Physical tests	With a minimum frequency of once a week the following physical tests will be performed on material cut-off samples out of fully identified products. - The glass content will be determined in accordance with ASTMD2584. - The relative rate of absorption of water in accordance with Wavistrong Test Specification 01/06 and ASTM D 570. - The indentation hardness in accordance with ASTM D 2583.

9. Performance testing:

A performance test program will be carried out in case a change in design, production method or raw material will occur. The performance test program will be carried out on representative diameters and/or representative products. The performance test program will consist of a numbers of tests related to the change.

10. Conductivity:

The Fibermar CMT series are conductive. A description of the conductivity test is given in the inspection procedure INSP/024. The maximum resistance is 10^6 Ω from inside to inside or inside to outside over the full length of the specimen.

11. Application:

The application for Fibermar pipe systems on ships is various. Intended service can be:

- Ballast systems
- Tank cleaning systems
- Sewerage/Sanitary service
- Fresh water service
- In-tank cargo lines
- Drain systems
- Exhaust piping
- Inert gas effluent
- Sprinkler systems
- Cooling water
- Jet water

For all relevant areas onboard ships reference is made to the IMO resolution A.753(18) “guidelines for the application of plastic pipes on ships” and the rules of the classification society.

11. Fire performance:

Fire tests on Fibermar pipe systems have proven that GRE is a safe material for demanding applications onboard ships. Several test have been done according to the FTP-code “International code for application of Fire Test procedures”.

Fire endurance level 3; Standard Fibermar EMT/CMT components have been fire tested successfully in accordance with resolution A 753 (18) level 3. Test reports are available.

Flame spread; Special Fibermar components with an integral fire retardant barrier have been fire tested successfully in accordance with IMO resolution A.653 (16). These special components meet the requirements for low flame spread in machinery spaces. Test reports are available.