



Technical Guide

GRP Pipe Specification – Drinking Water FW

The minimum technical requirements for the design, fabrication and testing of glass fibre reinforced plastic (GRP) pipe and fittings intended to be used for water supply (drinking or raw).

Scope

This specification defines the minimum technical requirements for the design, fabrication and testing of glass fibre reinforced plastic (GRP) pipe and fittings intended to be used for water supply (drinking or raw) with or without pressure.

General

Unless stated otherwise in this specification, the design, fabrication and testing of GRP products shall be in accordance with the applicable up to date standards listed under Section 4 of this specification.

All products shall be designed to achieve a minimum service life of 50 years under all applicable loads, environmental, installation and operating conditions. The maximum permissible initial deflection of the buried pipes shall be 3% and the maximum permissible long term deflection shall be 5%.

Internal and external surfaces of GRP products shall be free from irregularities which detrimentally affect the serviceability of the pipe.

For all parts coming in contact with drinking water, manufacturer shall provide certificates from an independent laboratory warranting that the material used will not affect the water quality.

Definition

Pipe: GRP pipe shall be a corrosion-resistant laminate. GRP pipe is a flexible conduit and shall be designed to transfer imposed loads to the surrounding embedment medium. Each pipe application shall be a custom

engineered design for which pipes are manufactured to satisfy the individual project requirements.

Joint: The pipes shall be connected with GRP sleeve couplings that utilize elastomeric sealing rings to maintain joint water-tightness. Joints may be flexible or rigid.

Fitting: All GRP fittings such as bends, tees and reducers shall be equal or superior in performance to pipe of the same classification. Where standard fittings do not provide a solution that is fit for purpose “custom special design” may be proposed by the manufacturer.

Accessories: All the accessories including gaskets, bolts, nuts, seal lubricants and adhesives shall be non-toxic and suitable for drinking water service.

TABLE 1 Codes and Standards

AWWA M 45	Fibreglass Pipe Design
AWWA C 950	Fibreglass Pressure Pipe
BS 4504	Circular Flanges For Pipes, Valves and Fittings (PN Designated)
BS 5480	Glass Reinforced Plastics (GRP) Pipes, Joints and Fittings for Use for Water Supply or Sewerage
ISO 7685	Plastics Piping Systems-Glass-Reinforced Thermosetting Plastics (GRP) Pipes Determination of Initial Specific Ring Stiffness
ISO 8513	Plastics Piping Systems-Glass-Reinforced Thermosetting Plastics (GRP) Pipes Determination of Longitudinal Tensile Properties
ISO 8521	Plastics Piping Systems-Glass-Reinforced Thermosetting Plastics (GRP) Pipes Determination of the Apparent Initial Circumferential Tensile Strength
ISO 10468	Glass-Reinforced Thermosetting Plastics (GRP) Pipes – Determination of the Long-Term Specific Ring Creep Stiffness under Wet Conditions and Calculation of the Wet Creep Factor

ISO 10471	Glass-Reinforced Thermosetting Plastics (GRP) Pipes -Determination of the Long-Term Ultimate Bending Strain and the Long-Term Ultimate Relative Ring Deflection under Wet Conditions
ISO 10639	Plastics Piping Systems for Water Supply, With or Without Pressure-Glass-Reinforced Thermosetting Plastics (GRP) Based On Unsaturated Polyester (UP) Resin
EN 681-1	Elastomeric Seals-Materials Requirements for Pipe Joint Seals Used In Water and Drainage Applications
EN 1225	Plastics Piping Systems-Glass-Reinforced Thermosetting Plastics (GRP) Pipes- Determination of the Creep Factor under Wet Conditions and Calculation of the Long-Term Specific Ring Stiffness
EN 1227	Plastics Piping Systems-Glass-Reinforced Thermosetting Plastics (GRP) Pipes Determination of the Long-Term Ultimate Relative Ring Deflection under Wet Conditions
EN 1228	Plastics Piping Systems Glass Reinforced Thermosetting Plastics (GRP) Pipes - Determination of Initial Specific Ring Stiffness
EN 1393	Glass Fibre Reinforced Thermosetting Plastics (GRP) Pipes-Determination of Initial Longitudinal Properties
EN 1394	Plastics Piping Systems-Glass-Reinforced Thermosetting Plastics (GRP) Pipes Determination of the Apparent Initial Circumferential Tensile Strength
EN 1447	Plastics Piping Systems-Glass-Reinforced Thermosetting Plastics (GRP) Pipes- Determination of Long-Term Resistance to Internal Pressure
EN 1796	Plastics Piping Systems for Water Supply with or Without Pressure-Glass-Reinforced Thermosetting Plastics (GRP) Based On Unsaturated Polyester Resin (UP)
ASTM D 2992	Obtaining Hydrostatic or Pressure Design Basis for "Fibreglass" (Glass-Fibre-Reinforced Thermosetting-Resin) Pipe and Fittings
ASTM D 3517	"Fibreglass" (Glass-Fibre-Reinforced Thermosetting - Resin) Pipe
ASTM D 3567	Determining Dimensions of "Fibreglass" (Glass-Fibre-Reinforced Thermosetting-Resin) Pipe and Fittings
ASTM D 4161	"Fibreglass" (Glass-Fibre-Reinforced Thermosetting - Resin) Pipe Joints Using Flexible Elastomeric Seals

Technical Requirements

Raw Material

Resin: The resin shall be unsaturated thermosetting polyester which is cured by heat and chemical additives. The resin used shall have a heat distortion temperature of at least 70°C.

Glass fibre: All fibre reinforcement shall be E type glass and shall have a surface treatment compatible with the resin.

Aggregate: Aggregates are inert granular material of a size range between 0.05 mm and 1 mm such as graded silica

sand. They shall be incorporated where they are a designed part of the composite structure. The purity of silica sand shall be minimum 97%.

Filler: Fillers are inert fine materials with a particle size below 0.05 mm.

Pigments: The use of pigments/colorants is not permitted in pipe production.

Pipes

5.2.1. Manufacturing Process

All GRP pipes shall be manufactured by continuous filament winding process for $DN \geq 300$ mm. For smaller diameters, helical filament winding process shall be used. Filament winding process (both the continuous and helical) is used to manufacture pipes by feeding raw materials onto the outside of a mandrel.

5.2.1. Wall Construction

The pipe shall be a composite laminate consisting of a corrosion resistance internal liner, a structural layer and an external layer.

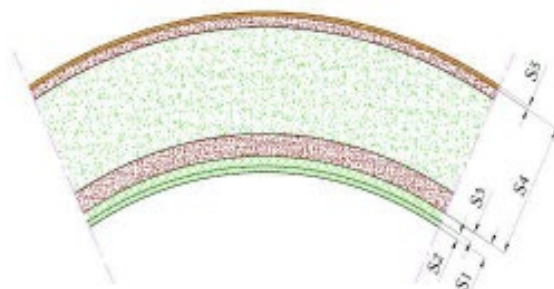


FIG. 1 S1: Internal liner, S2: Surface layer, S3: Barrier layer, S4: Structural layer, S5: External layer

Internal liner: The internal liner shall be a thermosetting resin rich layer forming the interior layer of the pipe to give high corrosion resistance. The thickness of this layer shall be determined by the pipe manufacturer but shall not be less than 1 mm. The liner shall consist of two layers, a surface layer and a barrier layer. The surface layer shall be resin rich and reinforced with ECR glass or suitable synthetic type surface tissue. The barrier layer shall have resin with or without reinforcement and with or without aggregate.

Structural layer: The structural layer shall consist of glass reinforcement and a thermosetting resin, with or without aggregates. The composition of structural layer depends on pipe pressure and stiffness class.

External layer: The exterior resin rich layer of the pipe shall have a minimum thickness of 0.2 mm reinforced with ECR glass or suitable synthetic type surface tissue. 5.2.2.

5.2.2. Wall Thickness

The average wall thickness of the pipe shall not be less than the nominal wall thickness declared by the manufacturer, and the minimum wall thickness at any point shall not be less than 87.5% of the nominal wall thickness.

5.2.3. Dimensions

Diameter: Pipes shall be designated by nominal size (DN). Outside diameter of the pipes shall be in accordance with ISO 10639 Table 5 for DN > 600 mm, and Table 6 for DN ≤ 600 mm. Inside diameter of the pipes shall be declared by the manufacturer.

Length: The nominal pipe length shall be 6 or 12 meters. The tolerance on the laying length shall be ± 60 mm. Of the total quantity of the pipes supplied of each diameter, the manufacturer may supply up to 10% in lengths shorter than the nominal length with a minimum pipe length of 1,5 meter unless a higher percentage of such pipes has been agreed between the manufacturer and the purchaser.

5.2.4. Pressure Class

The pressure class shall be higher than the working pressure of the pipe. The nominal pressure (PN) shall conform to ISO 10639 Table 2. Other nominal pressure values can be acceptable with agreement between the purchaser and the manufacturer.

5.2.5. Stiffness

Stiffness shall depend upon the depth of cover above the crown of the buried pipe. The nominal stiffness shall conform to ISO 10639 Table 1. Other nominal stiffness values can be acceptable with agreement between the purchaser and the manufacturer.

5.3. Joints

Pipes and fittings shall have a joint attached to it, capable of withstanding pressure and maintaining this pressure even when the pipes are deflected and subjected to externally applied lateral loading and/or internal hydrostatic pressure or a combination of those loads.

5.3.1. Flexible Joints (Couplings)

Couplings shall be manufactured by a fully automated process in which the pre-impregnated fibres are wound on

to a heated mould. Any type of filler like sand shall not be used in coupling production.

Couplings shall have full face EPDM (Ethylene Propylene Diene Monomer) rubber inside and shall meet the performance requirements of ASTM D 4161.

Couplings shall allow the angular deflections as follows:

TABLE 2 Angular Deflections

Nominal Angular Deflection (degree)	Nominal Pipe Diameter (mm)
3°	DN ≤ 500
2°	500 < DN ≤ 900 mm
1°	1000 < DN ≤ 1800 mm
0,5°	DN > 1800

EPDM rubber used inside the couplings shall have a shore hardness of 60 ±5 and shall be in compliance with EN 681-1 Type WA, WC. The full face EPDM rubber shall be positioned and bonded during the production. The rubber profile shall have one sealing lip at each side which provides leak-tightness in pressure and non-pressure applications. The use of asymmetric type rubber profile is not permitted.

5.3.2. Rigid Joints

Rigid joints such as flanged joints and butt and wrap joints shall be by design equal or superior in performance to pipe of same classification in the both circumferential and longitudinal directions.

Butt and wrap joints shall be done by hand lamination technique in which the glass fibres are impregnated with resin and the impregnated fibres are applied on the pipes. The minimum length and thickness of the laminate shall be calculated by the manufacturer.

Flanges shall be manufactured by hand lamination technique and shall be drilled according to BS 4504 Section 3.1. Flanged pipes shall incorporate an annular gasket at the joints.

5.4. Fitting

Fittings shall be designed to be used with trust blocks. All fittings such as bends, tees, junctions and reducers shall be fabricated from complete pipes or portions of straight pipe complying with this specification. The fitting shall comply with the declared design requirements and be suitably mitered. The miter shall be wrapped externally and if practicable internally with impregnated glass fibre to ensure that the longitudinal and circumferential tensile strength is at least equal by design to that of the pipe with which the fitting is to be used.

Quality Assurance

The manufacturer shall establish and apply an integrated management system according to ISO 9001, ISO 14001 and BS OHSAS 18001 standards.

Quality Control

All necessary equipments are to be operated by skilled and experienced technicians.

Calibration of test equipments shall be performed at least once a year by a certified independent firm. In order to assure traceability of materials and products the manufacturer shall keep the records of all quality control tests performed and shall maintain these records for a minimum period of five years from the date of manufacture. The following tests shall be performed by the manufacturer.

Raw Material Tests

All raw materials used for the production of pipes, joints and fittings shall be subjected to a series of tests to ensure that they are in compliance with the required specifications. All deliveries of resin shall be checked for consistency of viscosity, reactivity and solid content. All deliveries of glass fibre shall be checked for tex number, weight per unit area, moisture content and binder content. All deliveries

of silica sand shall be checked for consistency of density, grading, moisture content and purity. EPDM rubber used for couplings shall be checked for consistency of appearance, weight, hardness and dimension.

If the test results do not conform to the requirements, the lot shall be rejected.

Product Tests

Initial tests shall be carried out during production to monitor the quality of pipes. The manufacturer shall have an accredited laboratory to perform stiffness, hoop tensile and longitudinal tensile tests.

Long term tests (type tests) shall be performed to prove the suitability and performance of the raw materials used and method of construction and the design of GRP products. Long term tests shall be performed whenever a change is made in any of these characteristics.



7.2.1. Initial Tests

The pipes shall meet the minimum requirements specified below:

TABLE 3 Initial Tests

Test	Test Method	Minimum Requirements																																								
Hydrostatic-Pressure Test 100% of pipes	AWWA C 950	Pipes shall not allow any water to pass through the pipe wall and appear on the outside surface.																																								
<table border="1"> <thead> <tr> <th>Pipe PN (bar)</th> <th>Test Pressure for DN ≤ 1400</th> <th>Test Time (min)</th> <th>Test Pressure for ND > 1400 (bar)</th> <th>Test Time (min)</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>2</td> <td>3</td> <td>1,5</td> <td>5</td> </tr> <tr> <td>6</td> <td>12</td> <td>3</td> <td>9</td> <td>5</td> </tr> <tr> <td>10</td> <td>20</td> <td>3</td> <td>15</td> <td>5</td> </tr> <tr> <td>16</td> <td>32</td> <td>3</td> <td>24</td> <td>5</td> </tr> <tr> <td>20</td> <td>40</td> <td>3</td> <td>30</td> <td>5</td> </tr> <tr> <td>25</td> <td>40</td> <td>5</td> <td>38</td> <td>5</td> </tr> <tr> <td>32</td> <td>48</td> <td>5</td> <td>48</td> <td>5</td> </tr> </tbody> </table>			Pipe PN (bar)	Test Pressure for DN ≤ 1400	Test Time (min)	Test Pressure for ND > 1400 (bar)	Test Time (min)	1	2	3	1,5	5	6	12	3	9	5	10	20	3	15	5	16	32	3	24	5	20	40	3	30	5	25	40	5	38	5	32	48	5	48	5
Pipe PN (bar)	Test Pressure for DN ≤ 1400	Test Time (min)	Test Pressure for ND > 1400 (bar)	Test Time (min)																																						
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20	40	3	30	5																																						
25	40	5	38	5																																						
32	48	5	48	5																																						
Stiffness 1 in every 100 pipes manufactured at 3% deflection	ISO 7685	Test results shall be higher than nominal stiffness of the pipe.																																								
Level A 1 in every 100 pipes manufactured	ISO 10639	There shall not be any interior surface cracks or crazes. The test ring shall not have any delamination.																																								
Level B 1 in every 100 pipes manufactured	ISO 10639	There shall not be any structural damage as evidenced by inter-laminar separation, tensile failure of the glass fibre reinforcement, and fracture or buckling of the pipe wall. Cracks at the surface may appear at Level B deflection.																																								
Hoop Tensile Strength 1 in every 100 pipes manufactured	ISO 8521	Average circumferential tensile strength shall be higher than the values given in AWWA C 950 Table 10.																																								
Longitudinal Tensile Strength 1 in every 100 pipes manufactured	ISO 8513	Average longitudinal tensile strength shall be higher than the values given in ISO 10639 Table 14.																																								
Wall thickness 100% of pipes	ASTM D3567	Average wall thickness of the pipe shall not be less than the nominal wall thickness declared by the manufacturer, and the minimum wall thickness at any point shall not be less than 87.5% of the nominal wall thickness.																																								
Dimension Length and Outside Diameter 100% of pipes	ASTM D3567	The tolerance on the laying length shall be ± 60mm. Outside diameter of the pipes shall be in accordance with ISO 10639 Table 5 for DN > 600mm, and Table 6 for DN ≤ 600mm.																																								
Visual Inspection 100% of pipes, couplings and fittings	ISO 10639 BS 5480	All pipes, couplings and fittings shall be free of defects such as delaminations, exposed fibre, cracks, bubbles, air voids, pits, or resin-starved areas that due to their nature, degree of extent detrimentally affects the strength and serviceability of the pipe.																																								

7.2.2. Long Term Tests

The pipes shall meet the minimum requirements specified below:

TABLE 4 Long Term Tests

Test	Test Method	Minimum Requirements
Long term hydrostatic pressure design basis	ASTM D 2992 Method B	Calculated long term failure pressure at 50 years, shall not be less than 1.8 times the nominal pressure (PN), expressed in bars.
Long term specific ring stiffness (creep factor) under wet conditions	ISO 10468	50 years extrapolated stiffness value shall not be lower than 50% of the initial stiffness
Long term ultimate ring bending deflection	ISO 10471	Relative ultimate ring deflection under wet conditions shall be higher than the values given in ISO 10639 Table 12.
Joint water tightness	ASTM D 4161	There should not be any sign of damage, leakage or weeping.

Marking

GRP pipes, couplings and fittings shall be legibly marked at least including the following information.

- Manufacturer's name or trade mark
- Manufacturing date and number
- Nominal diameter in mm
- Nominal pressure in bar
- Nominal stiffness in N/m²
- Pipe length
- Manufacturer's inspection mark
- Bend angle in degree, or nominal diameter of Tee Branch in (mm)

Marking for identification purposes shall be made in such a manner so as not to impair the integrity of the pipe / joint / fitting material.

Storage and Packing For Shipment

Pipes shall be stored on a flat surface and protected against mechanical damage.

Packing, shipment and storage shall be carried out in a manner to ensure the original performance, quality and integrity during arrival at destination or during its storage. GRP pipes shall be packed and shipped as nested in each other.





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