

**CHAPTER VI GLASS FIBER
REINFORCED POLYESTER
(GRP) PIPES**

VI. Glass Fiber Reinforced Polyester (GRP) Pipes

GRP pipes are manufactured using resin, glass fiber, and silica sand. Orthophthalic polyester resins are traditionally used because their performance for drinking water applications has been proven. The GRP pipe manufacturing process allows for the use of continuous glass fiber reinforcement in the circumferential direction, which is ideal for pressure pipes since the primary stresses are in this direction. The use of continuous reinforcement in this direction results in a higher-performing product at a lower cost. A highly compact structure is thus created, maximizing the contribution of each of the three main raw materials. The combined use of continuous and chopped glass fibers enhances both circumferential and longitudinal strength. A sand reinforcement layer, placed in the middle of the main tube, provides additional rigidity due to its thickness.



Figure IV.1. Manufacturing of GRP Pipes

VI.1. Advantages of GRP Pipes

GRP pipes and fittings offer numerous advantages for hydroelectric installations and penstocks:

1. Corrosion-resistant materials – No need for protection, coating, cathodic treatment, or any other form of prevention.
2. Stable and consistent hydraulic properties over time.
3. Unique and consistent product quality in both extremely hot and cold climatic conditions.

4. Low head losses due to the smooth internal surface.
5. Water hammer pressure surges are twice as low in GRP pipes compared to cast iron or steel pipes under similar conditions.
6. Easy and economical installation and handling, even in difficult terrains, due to their lightweight (25% of the weight of cast iron pipes / 10% of the weight of concrete pipes) and pre-assembled joints.
7. UV-resistant.
8. Precision manufacturing of sleeves with flexible joints, facilitating assembly and eliminating the risk of leakage through infiltration or exfiltration.
9. Low operational costs.
10. No need for corrosion monitoring.
11. Low maintenance costs.
12. Long service life.
13. Experienced on-site installation services.
14. Consistent products worldwide.

VI.2. Applications of GRP Pipes

GRP pipes are manufactured using a special continuous filament winding process, making them highly durable and resistant to rust. They are particularly effective in environments with acidic water, such as wastewater transportation pipelines. These pipes are also lightweight and easy to handle. They must be perfectly manufactured to function correctly. GRP pipes are used in various fields, including:

- Drinking water supply
- Firefighting systems
- Seawater and desalinated water applications
- Power plants
- Industrial and chemical waste management
- Sewer systems and irrigation applications.

VI.3. Specifications for Pipes

VI.3.1. Diameters

GRP pipes are available in nominal diameters ranging from DN 100 to DN 4000 mm. The nominal diameter refers to the internal diameter. Diameters larger than 4000 mm are available upon request.



Figure IV. 2. Mesure de diamètre nominal du tuyau en PRV

GRP pipe systems have a specific initial stiffness, which refers to the pipe's resistance at the time of its manufacture. It is measured in N/m^2 and represents the minimum stiffness a pipe must have (calculated as $E \times I/D^3$).

Table VI.1. Stiffness Classes of GRP Pipes

Stiffness Class (SN)	Stiffness (N/m^2)
2500	2500
5000	5000
10000	10000

VI.3.3. Pressure

GRP pipes are available in the pressure classes listed below:

Table VI.2. Service Pressure and Test Pressure of GRP Pipes

Service Pressure	Test Pressure
(PN)	(bar)
1 (gravity)	1 (gravity)
6	6
10	10
16	16
20	20
25	25
32	32

VI.3.4. Lengths

Pipes are available in standard lengths of 6 and 12 meters, but custom lengths of up to 18 meters can be provided upon request. Pipes with diameters below 300 mm are available in standard lengths of 6 meters.

VI.3.5. Flow Rate

The perfectly smooth internal surface of the pipes allows for an average flow rate of 3.00 m/s. Flow rates of 4.00 m/s can also be achieved if the transported water is clean and free of abrasive materials.

VI.3.6. Joints

Sections of GRP pipes are typically joined using GRP couplings. Pipes and fittings are available separately or with the coupling already attached to one end. The couplings are equipped with a special rubber seal (called the REKA system) that fits into a groove at each end of the fitting. The depth of the fitting is indicated on each end of the pipe.

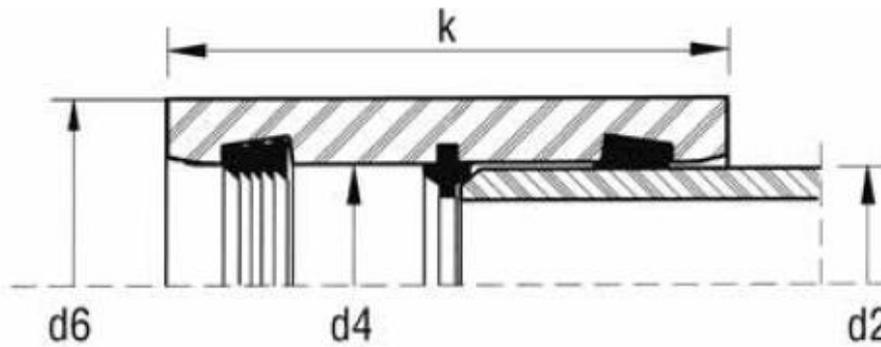


Figure IV.3. Depth of GRP Coupling

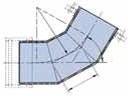
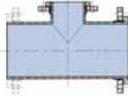
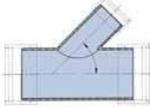
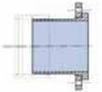
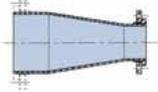
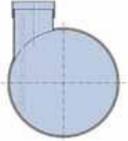
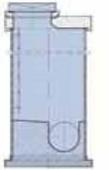
Among other possible jointing systems are rolled and flanged fittings. There are also fittings with biaxial socketing systems, such as locked and glued joints, for use in other applications, including those with biaxial thrust.

VI.4. GRP Fittings

All pipeline systems require fittings. A wide range of GRP fittings is available for water supply and sewer systems, including elbows, tees, reducers, flanges, reducing cones, branch saddles, and inspection chambers.

Molded GRP fittings typically cover a range from DN 100 to DN 800. Segmented and rolled fittings are primarily used from DN 900 up to the maximum production size. Special pipes and fittings with locked joints are available for underground pressure networks with axial thrust. This solution often replaces the installation of concrete thrust blocks, making your system more efficient and cost-effective.

Table VI.3.. GRP Fittings

Type of Fitting	Designation
	Elbow 15-90°
	90° Tee
	60° Branch Saddle
	Joint with Collar
	Reducing Cone
	Adapter Fitting: GRP - Vitriified Clay Adapter Fitting: GRP – PVC
	Tangent Inspection Tee
	Standard Inspection Chamber

VI.5. Commissioning

Before commissioning the drinking water supply network (AEP), pressure tests and disinfection of the pipeline sections must be carried out. The testing of water pipelines involves pressurizing the water inside the pipeline to verify its leak-tightness and mechanical strength. These tests are conducted as the construction progresses. The hydraulic pressure test of the pipelines is the final step before the acceptance of the drinking water network. Unless otherwise specified, the testing of pipeline sections is generally carried out after partial backfilling of the trench.

VI.5.1. Test Preparation

Test preparation involves removing all foreign objects from the pipelines before pressurization. The testing equipment is installed at the lowest point of the pipeline to facilitate the expulsion of air during filling. The use of appropriate pressurization equipment is necessary to maintain the required pressures during the tests. The lengths of the sections to be tested depend on the pipeline diameter and site conditions. Before filling the pipeline, it is important to ensure that all shut-off valves and air venting systems are open. The water used for testing should preferably be potable water, and its temperature should not exceed 45°C.

The lengths of the sections to be tested depend on the pipeline diameter and site conditions. For large pipelines, the test is conducted on sections not exceeding 500 meters in length. The optimal length for testing should preferably be between 300 and 500 meters.

It is recommended to install systems for measuring the filling and draining of the pipeline at both ends to perform the test. The required conditions for the test are as follows:

- The water temperature must be below 45°C.
- The duration of the test must be at least one hour, with a maximum of twenty-four (24) hours.
- The test pressure must not exceed 1.5 times the nominal pressure intended for the weakest component of the pipeline.

VI.5.2. Pressurization

Pressurization involves increasing the water pressure inside the pipeline to verify its leak-tightness and mechanical strength. After an initial pressurization of 5 minutes at the test pressure, the air vents located at the opposite end of the test section from the pressure gauge are opened to ensure there are no obstructions to the pressure rise across the entire tested section. The pressure is then restored to the test pressure for the prescribed duration, taking all necessary precautions to avoid water hammer in the pipeline.

VI.5.3. Test Procedures

VI.5.3.1. Test Execution

To execute the test, it is important to monitor the pressure gauges and record the rate of pressure increase during pressurization. After allowing sufficient time for the pipeline to stabilize, the pressure test can be conducted systematically by following these steps:

- Allow the pressure to rise until the specified test pressure is reached at the lowest point of the section.
- Close the valves.
- Maintain the pressure at this level for one hour.
- Disconnect the pressurization equipment.
- Stop any additional water from entering the test section during the following hour.

VI.5.3.2. Interpretation of Results

If a pressure drop is observed during the test duration, the initial test pressure is restored by injecting a measured amount of additional water into the test section. The test is considered satisfactory if the following conditions are met:

- There is no pressure drop (a slight increase may even occur due to temperature changes or material contraction).
- The measured amount of water required to restore the pressure to the test pressure is less than the following maximum allowable value:
 - 3 liters per kilometer of pipeline per 25 mm of internal diameter per 3 bars of test pressure per 24 hours.
- For pipelines not exceeding thirty (30) meters in length and 63 mm in diameter, the pressure loss after the one-hour test period must not exceed 0.5 bars.

At the end of the test, it is important to gradually release the residual pressure, as rapid decompression of all air can cause potentially dangerous pressure surges for the pipeline and the personnel conducting the tests. If the test is not satisfactory, it will be necessary to correct all identified defects and repeat the entire procedure until a satisfactory result is achieved.

VI.5.3.3. Disinfection

Disinfection is carried out in the following cases:

- Before putting the new section into service
- After repair or work on the existing network.

To do this, it is necessary to fill the section and close the valves.

Commonly used products: bleach or HTH,

Contact time: 24 hours

Conduct water quality checks

For disinfection, it is necessary to know the diameter and length of the pipeline. For example: Calculate the volume of water to be disinfected before putting a section of 150 meters in length and 125 mm in diameter into service.

VI.6. Identification, execution plans, and signaling

The identification of pipelines should include:

- The nature, section, and length of the pipe
- The elevation of the pipelines and their elements (valves, air vents, etc.)
- The various symbols identifying all parts and structures composing the network

Pipeline identification involves drawing lines or symbols on the ground to indicate the location of the pipelines. Pipeline identification depends on the material used.

- Metallic pipes-

Non-metallic pipes

- Locating a pipe involves detecting an underground pipe without digging up the earth.

VI.7. Laying pipes

The common steps for pipeline installation are:

- Site preparation: This step involves clearing the site by removing obstacles and leveling the ground.
- Trench marking: The trench is marked using the identification and signaling techniques mentioned earlier to indicate the pipeline location.
- Trench excavation: Trench excavation is done using mechanical shovels or excavators to dig the trench following the marked path.
- Pipeline laying: The pipelines are placed in the trench according to the construction plans and in compliance with the applicable standards and regulations.
- Trench backfilling: The trench is backfilled with sand, sifted soil, and backfill soil to protect the pipelines and stabilize the ground.
- Line testing: Once the pipelines are laid, a series of tests are conducted to ensure proper functioning. These tests include pressure tests and leak tests.
- Site restoration: Finally, after the tests are completed and the pipelines are approved, the site is restored by replacing the excavated soil and reinstating the original surfaces.