AMIANTIT

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Flowtite Pipe Systems

For Hydropower and Penstock Applications

AMIANTIT PIPE SYSTEMS

Production process

The basic raw materials used in FLOWTITE pipe manufacturing are resin, fibreglass and silica sand. Usually, orthophtalic polyester resins are used since they give good performance for potable water applications.

FLOWTITE pipes are manufactured using the continuous advancing mandrel process which represents the state of the art in GRP pipe production. This process allows the use of continuous glass fibre reinforcements in the circumferential direction. For a pressure pipe, the principle stress is in the circumferential direction. Incorporating continuous reinforcements in this direction therefore yields a higher performing product at a lower cost. A very compressed laminate is created that maximizes the contribution from the three basic raw materials. Both continuous glass fibre rovings and choppable roving are incorporated for high hoop strength and axial reinforcement. A sand fortifier placed near the neutral axis in the core is used to provide increased stiffness by adding extra thickness.

Product Advantages

FLOWTITE products and accessories offer many advantages for the use in hydropower and penstock applications:

- Corrosion resistant material - No need for linings, coatings, cathotic protection or other forms of corrosion prevention
- Hydraulic characteristics essentially constant over time
- Unique and constant product features in extremely hot and cold climate
- Low headloss due to smooth inner surface
- Pressure of water hammer approx. 50% less, compared to Steel or DIP at similar conditions
- Economic and easy installation and handling also in difficult terrain due to low weight (approx. 25% of DIP / 10% of Concrete) and pre-assembled gasketed couplings
- UV resistance
- Precisely manufactured couplings with flexible gaskets enable easy installation and avoid infiltration and exfiltration
- Low operating costs
- No corrosion surveys required
- Low maintenance costs
- Long service life
- Experienced field service in place
- Consistent product available all over the world

Product Range

Pipe programme

The FLOWTITE GRP product programme offers an extensive range of pipe diameters and is completed by an outstanding range of fittings and accessories.

Our range of standard diameters in mm:

100 · 150 · 200 · 250 · 300 · 350 · 400 · 450 · 500
600 · 700 · 800 · 900 · 1000 · 1200 · 1400
1600 · 1800 · 2000 · 2400 · 2600 · 2800 · 3000

Other diameters up to 4000mm are available on request.

All pipes are available in standard stiffness classes SN 2500 Pa, SN 5000 Pa and SN 10000 Pa. Additional, custom designed stiffness classes are available on request.

Dependant on diameters, the FLOWTITE GRP pipes are available in nominal pressure classes between 1 bar and 32 bar. We feel committed to high quality standards and therefore ensure that all pipes with a pressure greater than PN1 are 100% pressure tested for twice their nominal pressure.

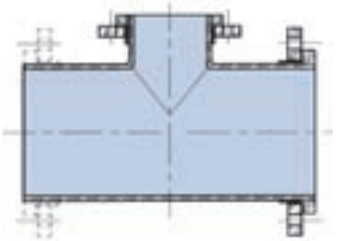
Standard Pressure Class PN in bar
1 (gravity)
6
10
16
20
25
32

Our pipes are supplied in standard length up to 12 metres. Other, customized lengths are also available on request.

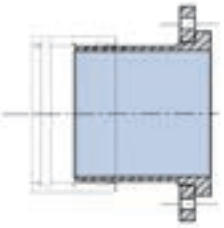
Fittings and accessoires

In addition to the pipe programme, a wide range of GRP fittings and accessories are offered. This includes bends, tees, branches, flanges, reducers saddles, manholes or pre-assembled, custom designed spools. The high flexibility of the materials used allows the individual and tailor-made manufacturing of fittings based on customers requirements.

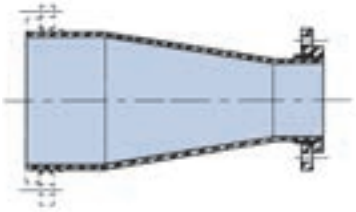
Bends 5-90°



Tee 90°

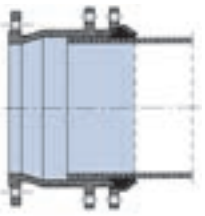


Loose / fixed flanges



Reducer

Branch 60°



Connections to other materials

Product specifications

FLOWTITE GRP pipe systems provide solutions for applications that place high requirements in terms of corrosion and high pressure resistance. Our GRP pipes are characterized by the immense strength of the glass fibre and the high level of resistance against corrosion by the resin. This combination of mechanical and chemical properties makes them an ideal choice for hydropower and penstock applications.

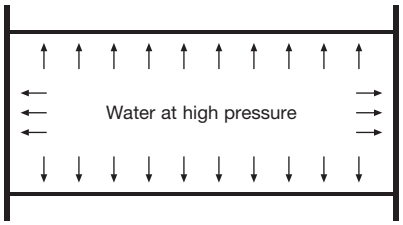
Corrosion resistance	++
UV resistance	+
Thermal expansion	+
Chemical resistance	+
Thermal insulation	+
Ratio kg/m	++
Flow velocity / hydraulic characteristics	++

Consistently high quality standards are an important factor of our FLOWTITE pipe systems. All manufacturing sites are periodically certified by third parties and have official certification such as ISO 9001 and others.

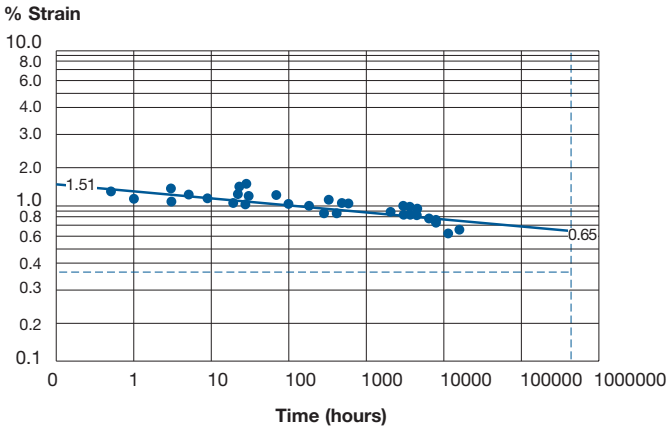
Depending on the country, the pipe systems are approved according to AWWA, CEN, ASTM, DIN, BSI, ISO and many other international or local standards and certifications.

Hydrostatic Design Basis – HDB

An important qualification test for the utilisation of the pipe hydropower applications is the establishment of the Hydrostatic Design Basis – HDB. This test requires hydrostatic pressure testing for failure (leakage) of a defined number of pipe samples at a variety of very high constant pressure levels. These results are evaluated on a log-log basis for pressure (or hoop tensile strain) vs. time to failure and then extrapolated to 50 years. The extrapolated failure pressure (strain) at 50 years – called hydrostatic design basis (strain) or HDB – must be greater than the pressure class (strain at the rated pressure) according to the safety factor. Due to combined loading considerations – defined as the interaction of internal pressure and external soil loads –, the actual long-term factor for safety against pressure failure alone is higher than this safety factor. This qualification test assures the long-term performance of the pipe in pressure service. The fifty-year predicted HDB strain value as published by FLOWTITE is 0.65%.



Externally carry end load (like thrust block)



Effect of long-term pressure in pipe life

Poisson's ratio and thermal coefficient

For FLOWTITE pipes, the ratio for hoop (circumferential) loads and axial response ranges from 0.22 to 0.29. For axial loading and circumferencial response Poisson's ratio will be slightly less. The thermal coefficient of axial expansion and contraction for Flowtite GRP pipes is 24 to 30 x 10^{-6} cm/cm/^{0}C.

Flow coefficient, flow velocities and headloss

Based on tests carried out on FLOWTITE pipe in existing installations, the Colebrook-White coefficient may be taken as 0.029 mm on site. This corresponds to a Hazen-Williams flow coefficient of approximately C=150. The Manning coefficient is n = 0.009. In contrast to other corroding materials, the inner surface roughness of FLOWTITE pipes does not change with time as GRP pipes display no corrosion.

Velocities of up to 4 m/s can be used if the water is clean and contains no abrasive material. A reference list for projects in which velocities higher than 4 m/s were recorded is available

Our local service teams offer support in calculating the headloss thus ensuring that the correct pipe materials and dimensions are chosen. The ideal choice results in huge savings and/or additional money for other investments.

Pipe material	Roughness (mm)	Headloss (m)	Loss in production (kwh)	Difference in kwh
GRP	0.01 (lab)	9.45	389,183	
GRP	0.029 (site)	10.04	411,324	+22,141
Ductile w/cement	0.1 (new, lab measuring)	11.53	468,876	+79,693
Ductile w/cement	1 (site after some time)	18.1	730,139	+340,956

Headloss* – Comparison of materials

* Penstock DN800, l=1500m, discharge 1.5m^3/s, 100% production = 5375h/year

Water hammer

Water hammer or pressure surge is the sudden rise or fall in pressure caused by an abrupt change in the fluid velocity within the pipe system. The usual cause of these flow changes is the rapid closing or opening of valves or the sudden starting or stopping of pumps, e.g. during a power failure. The most important factors which influence the water hammer pressure in a pipe system are the change in velocity of the fluid, the rate of change in velocity (valve closing time), the compressibility of the fluid, the stiffness of the pipe in the circumferential "hoop" direction and the physical layout of the pipe system.

The water hammer pressure expected for FLOWTITE pipe systems is approximately 50% of that for steel and ductile iron pipe under similar conditions. Our GRP pipes have a surge pressure allowance of 40% of the nominal pressure. An approximate ratio for the maximum pressure variation at a given point in a straight pipeline with negligible friction loss can be calculated with the formula:

$$\Delta H = (w\Delta v)/g$$

Where: ΔH = change in pressure (m)
w = surge wave celerity (m/s)
Δv = change in liquid velocity (m/s)
g = acceleration due to gravity (m/s^2)

Extended support in arriving at an exact calculation is provided by our sales teams all over the world.

SN	PN	DN 300-400	DN 450-800	DN 900-2500
2500	6	365	350	340
	10	435	420	405
	16	500	490	480
5000	6	405	380	370
	10	435	420	410
	16	505	495	480
	25	575	570	560
10000	6	420	415	410
	10	435	425	415
	16	500	495	485
	25	580	570	560
	32	620	615	615

*Some figures are rounded. Exact values require a transient analysis. Please contact your local FLOWTITE supplier.

Surge wave celerity* for FLOWTITE pipes in m/s.

UV resistance

There is no evidence to suggest that ultraviolet degradation is a factor that affects the long-term service life of FLOWTITE pipes. With its long and vast experience in the Middle East under humid, desert conditions and in Scandinavia in alternating dark and cold winters and the use of aboveground pipes for more than 30 years, FLOWTITE has not shown any evidence of a structural effect of the radiation on its GRP pipes. Only the outermost surface may be affected by a discolouring of the surface. If requested, the installing contractor will paint the exterior surface but this, however, will then become an item requiring future maintenance.

Installation

Penstocks for hydropower applications are installed both in

- trenches and
- above ground.

With FLOWTITE GRP pipes, both installation methods are possible. The final decision is influenced by the engineering parameters. It is highly recommended that slopes steeper than 15° be verified through an established geotechnical investigation as the risk of instable supports increases depending on the soil quality.

Aboveground installation on steep slopes has many advantages:

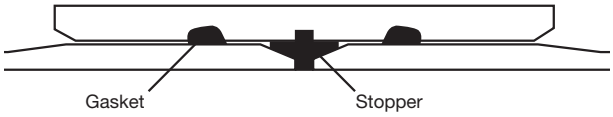
- The load on the pipe system is much less. This is important for the anchoring
- Concrete supports are easier to evaluate than soil structures
- The quality of installation is easy to monitor
- Settlement or sliding of supports is easier to detect and resulting problems can be solved fast.
- Failures in pipe systems are easy to repair

However, FLOWTITE GRP pipe systems have already been installed in trenches up to 30° without special anchoring and above ground on slopes with an angle of 46°.

Jointing

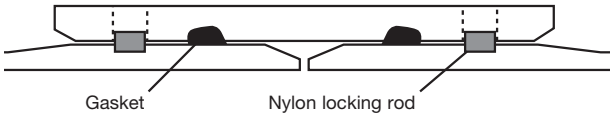
All FLOWTITE GRP pipe solutions have a proven jointing system that secures the systems work through its whole estimated service life. The system also offers solutions for transitions to other materials such as connection to valves or other accessories.

The pipes are typically jointed using FLOWTITE GRP couplings based on the REKA system. Pipes and couplings can be alternatively supplied separately or pre-assembled at one of the female pipe ends. The couplings have an elastomeric sealing gasket (REKA system) based in a precision-machined groove. They also include a stopper in the middle of the coupling.

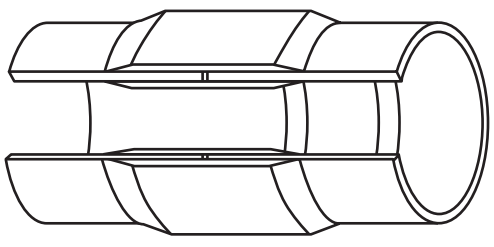


Pressure pipes systems with unbalanced and axial thrust forces need support by thrust blocks or by the use of restrained jointing systems. For standard pipe systems, thrust blocks are used to transfer the forces to the soil.

Another method involves using biaxial pipes and/or key lock joint systems which reliably absorb the axial forces. This often supersedes the installation of concrete blocks and makes the investment more time- and cost-effective.

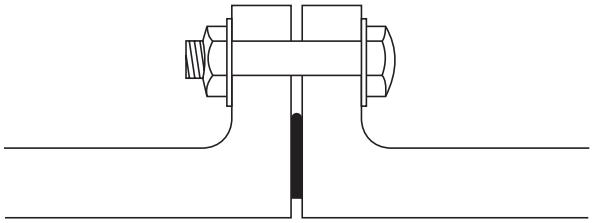


Butt and strap joints or laminated joints also absorb these additional forces. These are permanent joints which consist of a laminate of glass mats and tissues with resin. Predominantly used directly at the jobsite, this type of joint guarantees a safe and long-lasting connection that accommodates all axial strengths.

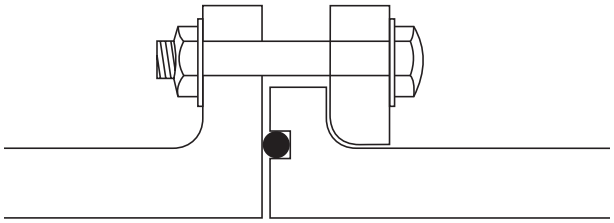


Laminated joint

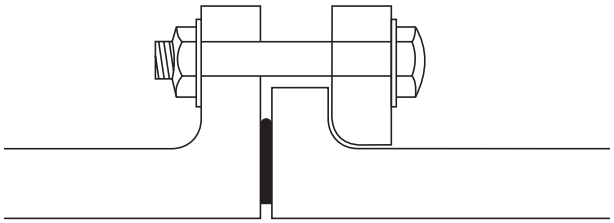
Flanged joints offer the same safety and allow the dismantling of the installation at a later stage. Flanges are also a good solution for connections with other pipe materials, valves and accessories. They are available as fixed and loose flanges.



Flanged joint

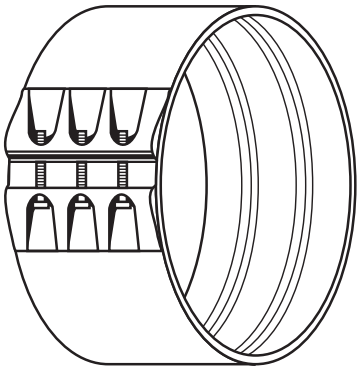


Loose ring flange with O-ring gasket



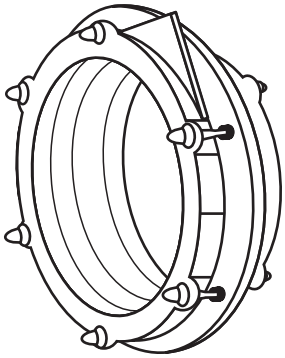
Loose ring flange with steel ring gasket

When connecting FLOWTITE pipes to other pipe materials with different outside diameters, flexible steel couplings for example from Straub, TeeKay or Arpol are one of the preferred jointing methods. These couplings consist of a steel mantle with an interior rubber sealing sleeve. They may also be used to join FLOWTITE pipe sections together, for example, during repair work or for closure.



Flexible steel coupling

Mechanical couplings, e.g. from Viking Johnson or Helden have also been used successfully to join pipes of different materials and diameters and to adapt to flange outlets. There is a wide variation in the design of these couplings, including bolt size, the number of bolts and the gasket design. Large variations also exist in the diameter tolerance of other materials. This often results in a higher bolt torque than necessary in order to achieve a tight seal on the FLOWTITE side.



Dual bolt mechanical coupling

Services

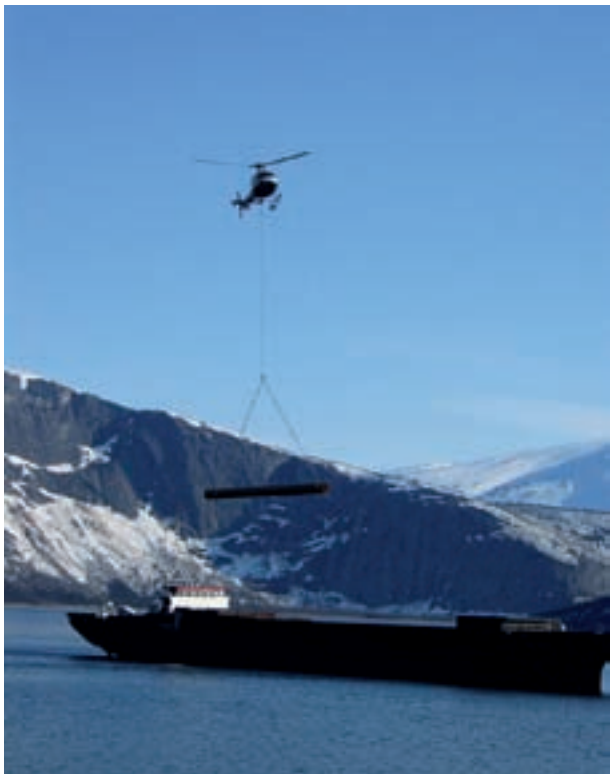
Throughout the world, specialists in our field and sales offices offer a wide range of products and support. They will assist you in:

- Project study and selection of the most suitable materials according to the conditions of corrosion, temperature and pressure
- Configuration of the installation and calculation of supports and anchorages
- Hydraulic calculations
- Stress Analysis for underground and aboveground installations
- Workshop premounting of spools
- Jobsite supervision

References

Due to the worldwide product availability, the Amiantit group has established penstocks all over the world. The list below only represents a small extract of the available references. In Norway alone, more than 200 penstocks have been installed with FLOWTITE GRP pipes since 1975.

For further information please visit our reference page at **www.amiantit.com**!



Project	Country	Diameters (mm)	Pressure (bar)	Length (m)	Remark
Al Bayadh Al Kharj	Saudi Arabia	400	16	10740	
Arskog	Norway	600	6-25	720	Helicopter transport
Bang Pakong	Thailand	600	6	400	
Camserney	UK	600	6-20	1400	
Canalete	Costa Rica	2600-2900	6-16	2400	
Djupfjord	Norway	1200	6	300	Build as curved pipe string
Glenowen	Ireland	600	10	560	
Hillsborough, New Hampshire	USA	2100	3,5	730	
Kelchsau	Austria	1200/1300	16	3500	
La Esperanza	Honduras	600-1400	1-32	5600	
Langfjorden	Norway	1200	32	284	Installed in a tunnel
Majdan	Bosnia	700	6-32	2500	
Malangkap	Malaysia	600-1000	6	2700	
Matanzas	Guatemala	1300-1700	6-28	2000	
Montechristo	Guatemala	2400-2600	6-16	2100	
Mularvikjun	Iceland	1400	6-10	1540	
Paliori	Greece	1700-1900	6-16	1300	
Songyuan	China	400	10	14000	
Storfors	Sweden	2200	6	250	
Twimberg	Austria	1800	6-10	4300	
Vangpollen	Norway	700-800	6-32	700	Max. slope 47°

Utmost care has been taken to ensure that all the contents of this brochure are accurate. However, Amiantit and its subsidiaries do not accept responsibility for any problems which may arise as a result of errors in this publication. Therefore customers should make inquiries into the potential product supplier and convince themselves of the suitability of any products supplied or manufactured by Amiantit and/or its subsidiaries before using them.

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