THOMPSON PIPEGROUP FLOWTITE

THE FIRST CHOICE OF ENGINEERS **WORLDWIDE**

FLOWTITE
THE FRP PIPE SYSTEM BUILT AROUND YOUR NEEDS

At Flowtite Technology, we design and manufacture the world's best piping systems to provide unique, sustainable piping solutions and maximise the health and well-being of people around the world. We do this by manufacturing Flowtite FRP Pipe Systems.

We maintain our technological lead by investing in the highest level of R&D, by listening to what engineers around the world want and being satisfied with no less than 100 % customer satisfaction. This has been the driving force behind our success. It is built into every pipe we manufacture.

We will change the world for the better a pipe at a time! Welcome to Flowtite. The FRP Pipe System.

THE FIRST CHOICE OF ENGINEERS. WORLDWIDE.

WHY FLOWTITE IS THE FIRST CHOICE OF ENGINEERS WORLDWIDE

BECAUSE IT'S MORE RELIABLE

6 million Flowtite couplings and more than 45,000 miles of Flowtite pipes transport water every day – worldwide. We have the world's largest certified laboratory for testing of FRP pipes. We never release a product without the most rigorous testing!

LOWEST TOTAL COST

The cost of a project is more than the cost of a pipe. Flowtite has an excellent on-time delivery record, superior installation manuals, and experienced field technichians.

IT'S CARBON FRIENDLY

An independent study conducted at The Norwegian University of Life Sciences in 2012 concludes that FRP pipes have a minimal negative environmental impact.

UNMATCHED SUSTAINABILITY

Our Flowtite products have an estimated lifetime of 150 years or more! No coating needed. No cathodic protection needed. This is how Flowtite offers unmatched sustainability!

WE REINVENT THE INDUSTRY

We reinvent the pipe industry – a pipe at a time. We pioneered and patented the FRP laminate in the 1970's. Our pipes are longer and lighter. Flowtite has been the driving force in the development of the FRP pipe.

FLOWTITE. FIRST CHOICE OF ENGINEERS. WORLDWIDE.

Flowtite biaxial pipes were used on the world's largest desalination plant. More than 18,000 field joints were applied during the installation.

LOCATION: Ras Al-Khair, Saudi Arabia

CONTENT

FLOWTITE
PIPES FOR YOUR EVERY NEED

TYPE / USE	PICTURE	DESCRIPTION
PRESSURE PIPES Flowtite pipe with main reinforcement in the hoop direction. Used in applications without pressure end thrust, for example penstocks and pressure mains.		• Diameter range (DN): 12 - 156 in • Pressure (PN): up to 450 psi • Standard lengths: 10 - 40 ft • Stiffness (SN): 18, 36, 46 and 72 psi
BIAXIAL PIPES Flowtite pipe reinforced in the hoop and axial directions to resist pressure end thrust and bending loads. Common uses are cooling water and desalination and similar above ground applications.		• Diameter range (DN): 12 - 156 in • Pressure (PN): Up to 250 psi • Lengths: 10 - 40 ft • Stiffness (SN): 18, 36, 46 and 72 psi
JACKING PIPES Flowtite pipe designed to withstand high jacking forces. Typically used for jacking under structures like roads and railways.		• Diameter range (DN): 12 - 84 in • Pressure (PN): Gravity • Standard lengths: 10 - 40 ft • Stiffness (SN): 200+ psi

FLOWTITE PROPERTIES

TECHNICAL DATA FLOWTITE PIPES	
Main materials	Resin, fiberglass, sand
Operating temperatures	- 58 °F - + 158 °F
Standard lengths	10 - 40 ft
Diameter range	DN 12 - DN 156 in
Pressure range	PN 50 - PN 450 psi
Estimated lifetime	More than 150 years
Corrosion protection	None needed
Hydraulic roughness	k = 9.5 x 10^{15} ft / C = 150 (Hazen-Williams)/n=0.009 (Manning)
Assessment of conformity	CEN TS 14632
International Pipe Standards	ASTM D3262, ASTM D3754, ASTM D3517 AWWA C950 ISO 10639, ISO 10467 EN 1796, EN 14634

Installation of Flowtite pressure pipes.

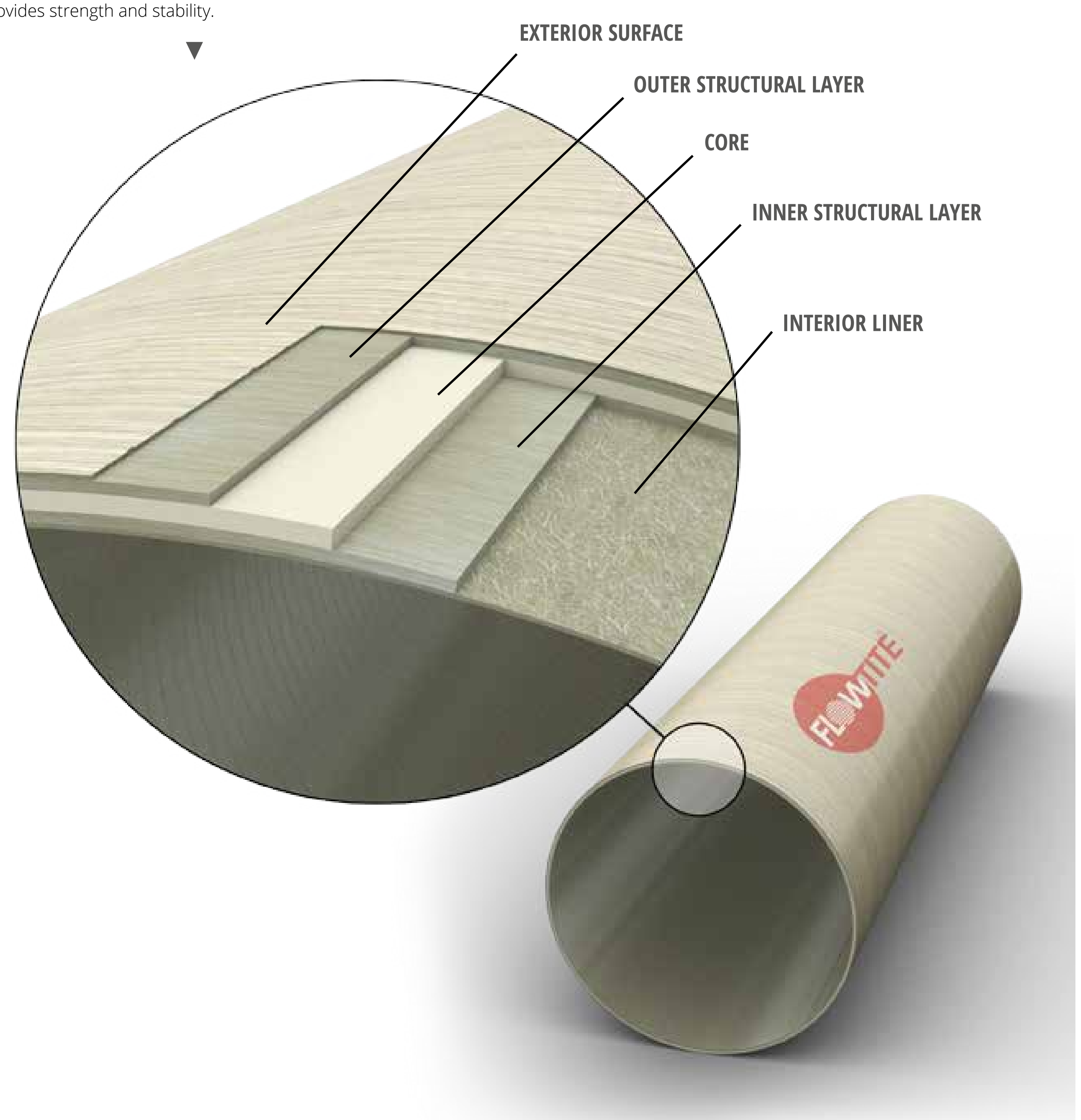
LOCATION: Turkey

Contact your local supplier for special liners, customized dimensions or other requirements.

HOW STRONG DO YOU NEED YOUR FLOWTITE PIPE?

PIPE WALL CONSTRUCTION
The pipe wall is built as a structural sandwich, using the Flowtite continuous filament winding technology. The high strength continuous glass-fibres resist the hoop stresses from internal pressure, while the chopped fibres provide excellent resistance to axial stresses, impact and handling loads. The structural laminate consists of heavily reinforced skins, separated by a compact, reinforced silica-filled core to provide optimal bending stiffness. Together with the protective layers, this construction provides capacity to resist high internal pressures and maintains excellent long-term stiffness.

The sandwich construction provides strength and stability.




At the Thompson Pipe Group manufacturing plant
LOCATION: USA

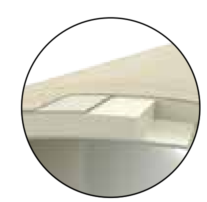
STANDARD STIFFNESS CLASSES

Flowtite pressure and sewer pipes are manufactured in four standard stiffness classes.

SN 18

SN 36

SN 46



SN 72

STANDARD PRESSURE RANGE

Flowtite pipes are manufactured in pressure classes ranging from PN 50 to PN 450

PN 50

PN 450

POISSON'S RATIO

- Poisson's ratio is influenced by the pipe construction. For Flowtite pipes, the ratio for hoop (circumferential) loads and axial response ranges from 0.22 to 0.29.

THERMAL COEFFICIENT

- The thermal coefficient of axial expansion and contraction for Flowtite pipes is 13 to 17 x 10^{-6} in/in/°F.

WHY ENGINEERS CHOOSE FLOWTITE PIPES

NO CORROSION

Flowtite pipes need no coating or anti-corrosion treatment. Flowtite pipes are manufactured with inherently corrosion-resistant materials, outperforming steel, ductile iron and steel-reinforced pipes that require corrosion protection.

Flowtite pipes solve corrosion problems and reduce costly maintenance.

LOCATION: Hydropower installation in Sweden

UV RESISTANCE

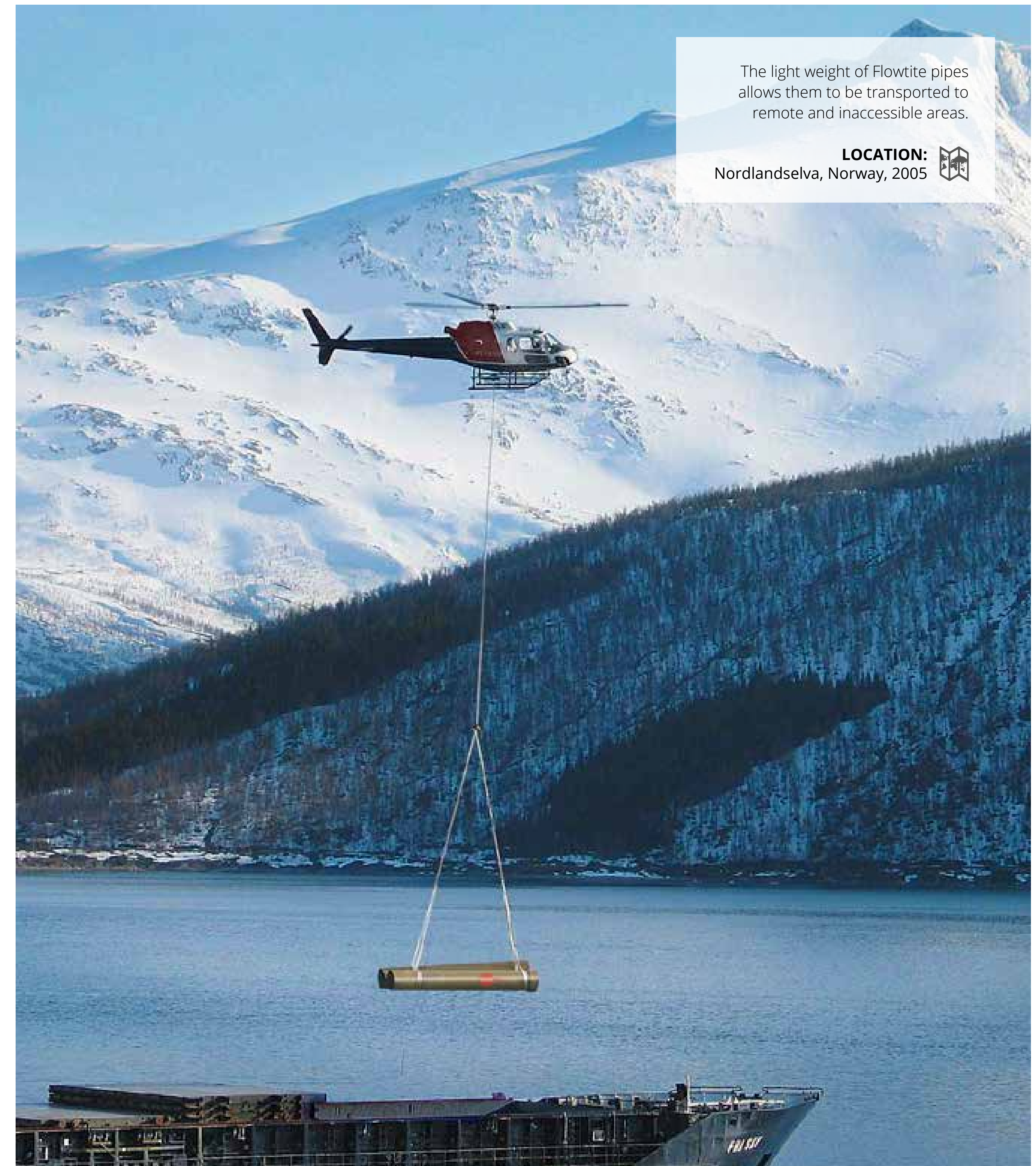
Flowtite pipes are resistant to UV light. For pipes installed above ground, the outside surface might see some change in color which has no impact on the long-term performance of the pipes.

ACID- AND CHEMICAL RESISTANCE

Flowtite pipes have an extraordinary acid- and chemical resistance. The unique resistance of Flowtite pipes is ensured by careful consideration of all materials, pipe designs and production process. Flowtite pipes resist the sulfuric acids that build up in sewer applications. They resist the actions of ground salts and salty waters in desalination plants. Flowtite pipes may also be used in other chemically demanding applications. Please see the table on chemical resistance in the technical data section.

LIGHT WEIGHT

Flowtite pipes are lighter than ductile iron, steel, concrete and non-reinforced plastic pipes. That makes transportation less expensive, and less expensive installation equipment can be used. Their light weight enables the pipes to be transported and handled in remote and inaccessible areas. Flowtite pipes can be nested, meaning that smaller pipes can be transported inside larger pipes, thus reducing cost of transportation.



The light weight of Flowtite pipes allows them to be transported to remote and inaccessible areas.

LOCATION: Nordlandselva, Norway, 2005

FLOWTITE COUPLINGS AND JOINTS

MORE THAN SIX MILLION FLOWTITE DOUBLE BELL COUPLINGS ARE IN SERVICE WORLDWIDE.

Assembly of a Flowtite Double Bell Coupling.
The Flowtite Coupling uses a Reka elastomeric gasket.

FLOWTITE DOUBLE BELL COUPLINGS
The majority of buried Flowtite pipelines are assembled with the trusted Flowtite Double Bell Coupling. These have been used on all continents of the world since 1979.

The expected lifetime of Flowtite Couplings is more than 150 years. Therefore, the Double Bell Coupling is a preferred coupling for Flowtite installations. The Double Bell Coupling comes in three different versions:

- **Pressure**
- **Biaxial Lockjoint and**
- **Angled Coupling.**

TECHNICAL DATA
FLOWTITE DOUBLE BELL COUPLING

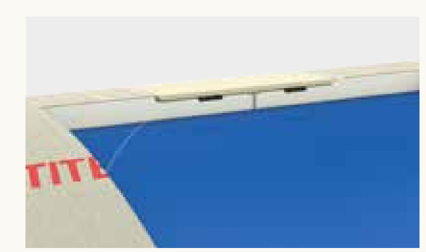
Operating pressure*:	Up to 450 psi
Main materials:	Resin, fiberglass, sand
Estimated lifetime:	More than 150 years
External waterhead:	462 ft
Operating temperature:	58 °F, - + 158 °F
Estimated gasket lifetime:	More than 150 years
Gasket:	EPDM, Reka

* The Flowtite coupling has been tested successfully to 1400 psi!

FLOWTITE DOUBLE BELL COUPLINGS

PRESSURE COUPLING Commonly used for penstocks, water supply, irrigation and pressure sewer applications.		• Diameter range (DN) : 12 - 156 in • Pressure (PN): up to 450 psi
BIAXIAL LOCK JOINT Used for applications where transfer of load between pipes is required. Commonly used on desalination and cooling applications.		• Diameter range (DN): 12 - 78 in • Pressure (PN): 50 - 250 psi
ANGLED COUPLING Flowtite coupling for increased angular deflections up to 3 degrees.		• Diameter range (DN): up to 156 in • Pressure (PN): up to 250 psi

JACKING AND SLIPLINE JOINTS

GR JOINT This joint is used for jacking and sliplining applications and includes an FRP sleeve with EPDM rubber seals fitted into grooves in the pipe spigot.		• Diameter range (DN) : 12 - 96 in • Pressure (PN): up to 100 psi
SE JOINT This joint is used for jacking and sliplining applications and includes a Gr.316 stainless steel band with an integral EPDM elastomeric seal.		• Diameter range (DN) : 12 - 96 in • Pressure (PN): up to 150 psi

FLOWTITE PATENTED BUTT WRAPS

Flowtite provides the necessary instructions for butt-wrap joining according to Flowtite's patented butt-wrap technology. This patented technology provides faster and more cost-efficient installation.

Flowtite pipes may be jointed using fiberglass reinforcement and resin. The butt-wrap joints are common in applications with axial thrust.

Butt-wrap joints used to join DN 48 pipes in a desalination plant in Carlsbad, California.

LOCATION: USA, 2015

FLOWTITE FLANGES

Flowtite manufactures and sells flanges in various designs and according to different standards and requirements. When connecting two FRP flanges, the standard bolt pattern to which flanges are manufactured is ISO2084. Other bolting dimension systems such as AWWA, ANSI, DIN and JIS can be supplied.

Steel flanges connected to Flowtite flanges.

LOCATION: Venezuela

USING STEEL COUPLINGS TO JOIN FLOWTITE PIPES

Flowtite pipes can be joined using steel couplings. Examples of steel couplings are the tangential bolt couplings of Straub, Tee-Kay and Arpol, and the axial bolt couplings Viking Johnson, Helden, Klamflex, Romac and Smith-Blair.

Steel coupling used for field closure at Fall Hydropower Station.

LOCATION: Norway

FLOWTITE FITTINGS

200,000 STANDARD FLOWTITE FITTINGS ARE AVAILABLE FOR YOUR APPLICATIONS.

Flowtite fittings are designed based on an extensive research program and patented concepts. Flowtite's researchers have rigorously analyzed critical strains in bends, tees and elbows. Flowtite fittings are moulded or fabricated using the same materials that are used to produce Flowtite pipes.

The possibilities for custom design are almost endless. Here is a sewage water retention system.

LOCATION: Winterberg, Germany

Tangential manhole on a novel aerial sewer installation.

LOCATION: Germany

MOST COMMON FLOWTITE FITTINGS TYPES

ELBOWS

SADDLES

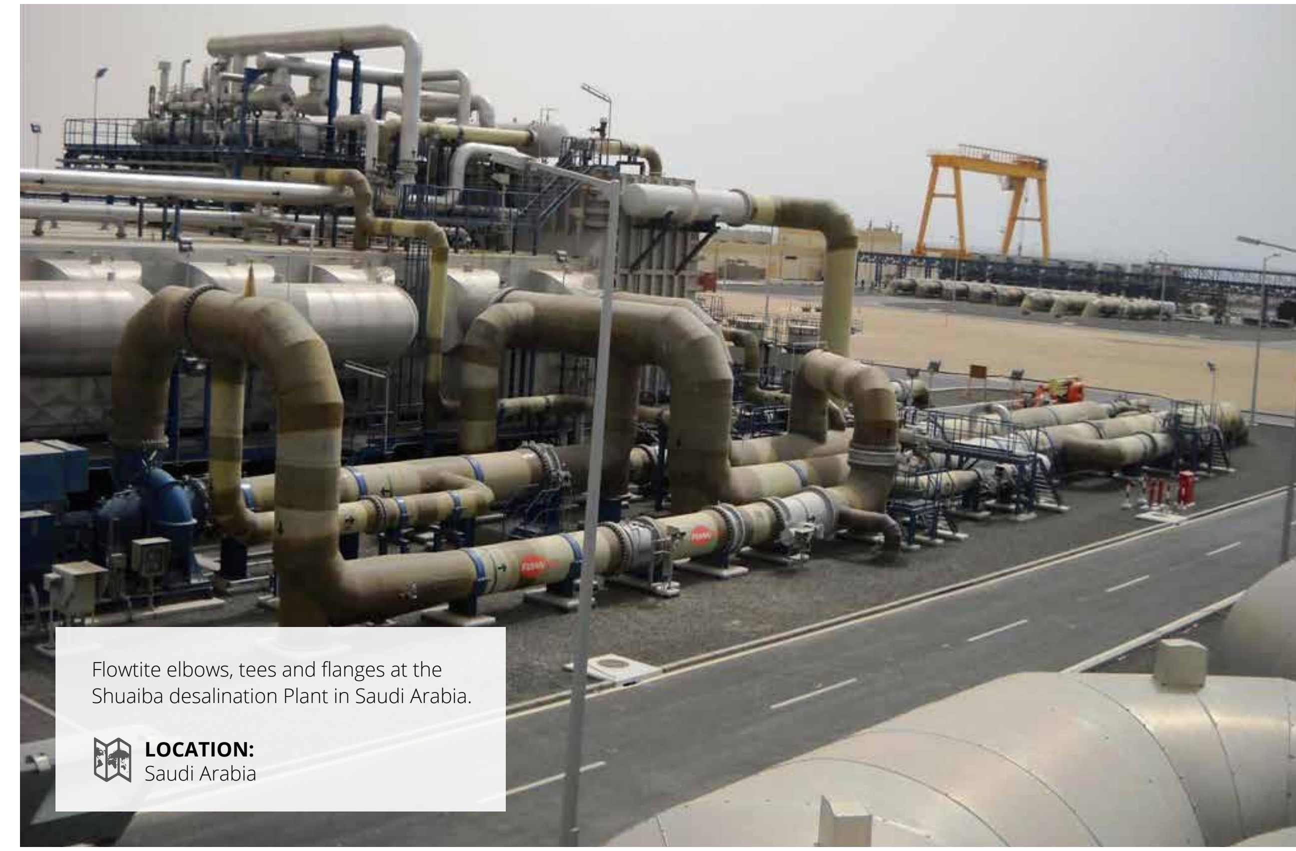
WYES

TEES

ECCENTRIC REDUCERS

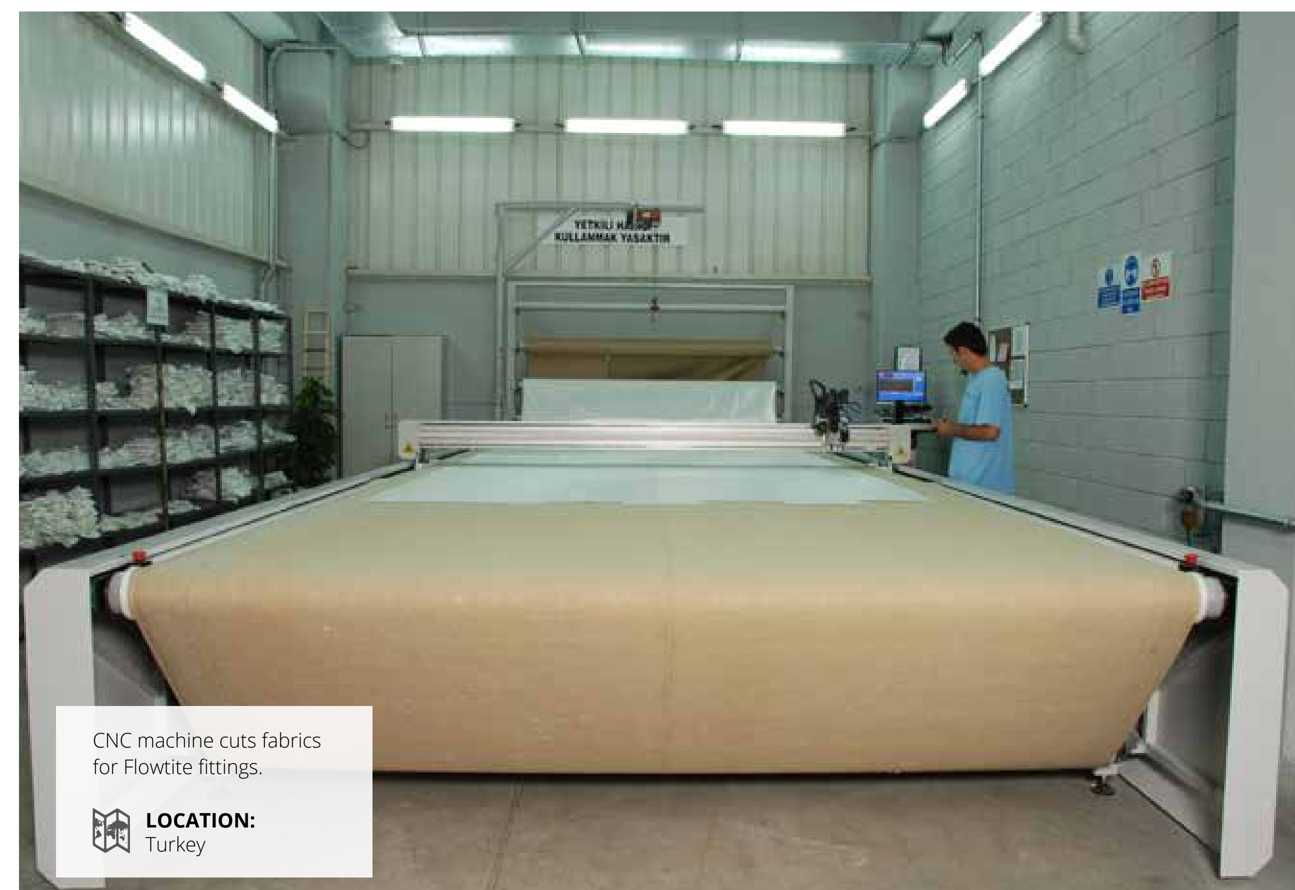
CONCENTRIC REDUCERS

FLANGES



Flowtite elbows, tees and flanges at the Shuaiba desalination Plant in Saudi Arabia.

LOCATION: Saudi Arabia



CNC machine cuts fabrics for Flowtite fittings.

LOCATION: Turkey

TOOLS
FOR THE ENGINEER

FLOWTITE PIPELINE DESIGN TOOLS GIVE THE ENGINEER THE NECESSARY SUPPORT FOR DESIGNING PIPELINES WORLDWIDE.

AMITOOLS PIPELINE DESIGN SOFTWARE

AMITOOLS is an online service offering software tools for static calculation of buried pipes and hydraulic calculation.

- Static calculation according to German (ATV 127), American (AWWA M45) and French (Fascicule 70) standards
- Hydraulic calculation
- Design of thrust blocks

The tools are free of charge, available in metric and imperial dimensions

Register and apply for your personal licence at www.ami-tools.net

Flowtite design tools should not be used for non-Flowtite manufactured pipes, as all calculations are based on Flowtite product design.

FLOWTITE TECHNICAL LITERATURE
An extensive library of technical literature can be found on www.flowtite.com, including manuals, application brochures, references and case studies.

WORLDWIDE CASE STUDIES
There are numerous case studies that provide ideas and data to support engineers as they design new pipelines.

WORLDWIDE FIELD SERVICE
Flowtite suppliers offer technical assistance and consultancy to designers and engineers both locally and worldwide.

Here is a list of some of our services:

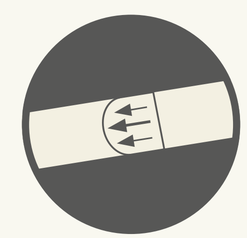
- Configuration of installation
- Burial analysis
- Hydraulic calculations
- Calculation of supports and anchorages
- Calculation of concrete thrust blocks
- Connection to other materials
- Stress and finite element analysis of installations
- Drawings of plants, isometrics and production sheets
- Field Engineering Services

You can find your local Flowtite supplier on www.flowtite.com

CONSIDERATIONS
FOR THE ENGINEER

EXPERIENCE, RESEARCH AND 45,000 MILES OF PIPELINE HAVE PROVIDED ENGINEERS WITH RELIABLE AND ACCURATE KNOWLEDGE OF DESIGNING PIPELINES.

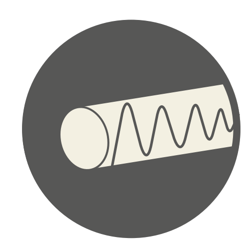
FLOW CALCULATIONS



The most economical flow velocity in pipes is usually 6 - 10 ft/s. This is also the case for Flowtite pipes. The maximum recommended flow velocity is 16 ft/s. Flowtite pipelines sustain velocities of up to 25 ft/s if the water is clean and contains no abrasive material. Flowtite Amitools flow calculation will help engineers to estimate the appropriate pipe diameter.

Due to the larger inner diameter the headloss in Flowtite pipes is less than for most other pipe materials.

SURGE AND WATER HAMMER



The most important factors influencing the water hammer pressure in a pipe system are the stiffness of the pipe in the hoop direction, the change in velocity of the fluid, the rate of change of the velocity (valve closing time), compressibility of the fluid, and physical layout of the pipe system. The maximum water hammer pressure expected for Flowtite pipes is approximately 50 % of that for steel and ductile iron pipes in similar conditions.

$$\Delta H = \frac{w \cdot \Delta V}{g}$$

Where:

ΔH = change in pressure ft

w = surge wave celerity (ft/s)

ΔV = change in water velocity $\left(\frac{ft}{s}\right)$

g = acceleration due to gravity (ft/s^2)

ANGULAR DEFLECTION ON JOINTS

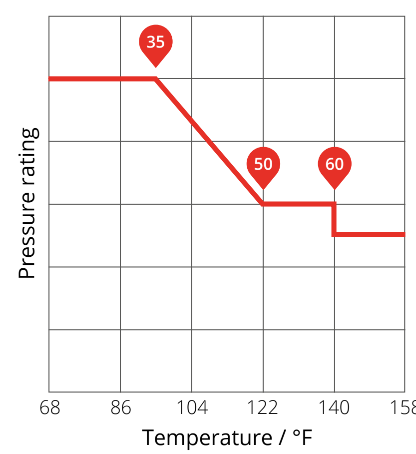
The maximum angular deflection (turn) at each coupling joint, taking the combined vertical and horizontal deflection into consideration, and measured as the change in adjacent pipe centre lines, shall not exceed 3 degrees. The pipes shall be joined in straight alignment and thereafter deflected angularly as required.

The table is valid for the Flowtite Angled Coupling up to PN 250. For all other joints, please find the details in the Flowtite Installation Guide for Buried Pipes.

Minimum Radius of Curvature			
Angle of Deflection	Pipe Length		
	10 ft	20 ft	40 ft
3	190ft	383 ft	763 ft

OPERATING TEMPERATURE

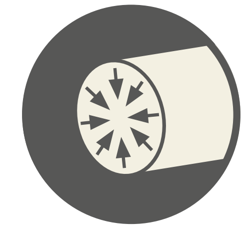
Flowtite pipes may be used with operating temperature from -58 to +158 °F. Requirements in the international pipe standards require a consideration for pressure rerating above 95 °F. At temperatures above 122 °F, vinyl ester resins are often recommended. Flowtite pipes may be used up to operating temperatures of 158 °F with appropriate consideration to pipe design, materials usage and gasket materials.



TRAFFIC LOADS

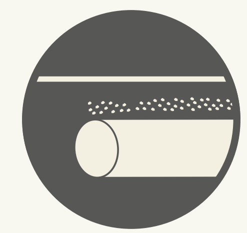
All backfill to grade should be compacted when continuous traffic loads are present. Minimum cover restrictions may be reduced with special installations such as concrete encasement, concrete cover slabs or casings.

NEGATIVE PRESSURE (VACUUM)



Negative pressure, or vacuum, may occur in pipelines. Flowtite recommends that a stiffer Flowtite pipe is used if high negative pressure is expected.

HIGH GROUND WATER TABLE



A minimum of 0.75 times the diameter of earth cover with minimum dry soil bulk density of 120 lb/ft³ is required to prevent an empty submerged pipe from floating. Alternatively, the installation may proceed by anchoring the pipes. Consult your Flowtite manufacturer for details on anchoring.

HIGH PRESSURE

High pressure (>250 psi) may require a deeper bury to prevent uplift and movement. The minimum burial should be 4 ft for pipes DN 12 and larger.

CHEMICALS EXPOSURE

Standard Flowtite pipes sustain excellent properties in contact with clean and dirty water, including sea water. However, re-rating and material selection must be considered if the pipe is to be used in contact with chemicals, process water or contaminated ground waters, with and without elevated operating and design temperatures. Flowtite have special pipe designs for most chemicals, including process water from pulp and paper industry.

FLOWTITE
PIPE INSTALLATION

LIGHT AND LESS EXPENSIVE EQUIPMENT CAN BE USED INSTALLING FLOWTITE PIPES.

Buried installation of Flowtite pipes.

LOCATION:
USA

Installation of buried flexible pipes takes advantage of the pipe and soil properties for optimal performance in terms of time and cost. The design and installation procedures are based on guidelines in international standards.

The Amitools design software (see page 20) follows these standards.

The resulting installation procedures do not require any special considerations, just good contractor practice and workmanship, to ensure excellent long-term performance of the pipeline.

For complete installation instructions consult the Flowtite Installation Guides.

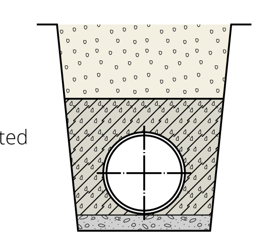
BURIED FLOWTITE INSTALLATION

The following information is a partial review of installation procedures and does not replace Flowtite Installation Guide for Buried Pipes on www.flowtite.com

1 Installation Types	Two installation types are most common: Type 1 for deep burials or heavy traffic loads, and Type 2 for less demanding installations, where cheaper backfill materials can be used.
2 Bedding	The trench bed should provide a uniform and continuous support for the pipe. Most granular soils are suited as bedding. The bed must be over-excavated at each joint location to ensure continuous support for the pipe.
3 Backfilling	For optimum pipe-soil interaction the prescribed backfill material for the installation type must be used. Care should be taken to ensure that the material does not include rocks, soil clumps, debris, or frozen or organic material.
4 Checking the Installed Pipe	After the installation of each pipe the maximum diametrical vertical deflection shall be checked. With Flowtite pipes this is fast and easy. For typical installations the initial deflection will be 1 - 2 %, and should be compared with the predicted value. The maximum allowable initial deflection is 3 % and the maximum allowable long-term deflection is 5 %.

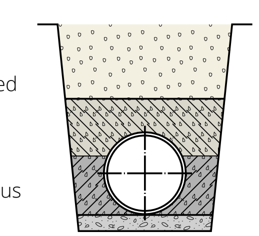
INSTALLATION TYPE 1

- Backfill the pipe zone to 12 in over the pipe crown with the specified backfill material compacted to the required relative compaction level.



INSTALLATION TYPE 2

- Backfill to a level of 60 % of pipe diameter with the specified backfill material compacted to the required relative compaction level.
- Backfill from 60 % of diameter to 12 in over the pipe crown with a relative compaction necessary to achieve a minimum soil modulus 200 psi.



FLOWTITE THRUST-BEARING PIPE INSTALLATIONS

Desalination project.

LOCATION: Saudi Arabia

Thrust-bearing pipe systems carry the fluid pressure and are also able to transfer longitudinal forces or bending moments resulting from end thrust. Both the pipe and the joints have axial load-bearing capacity. Unbalanced thrust can thereby be resisted by the piping system and thrust blocks are not necessary; correct location of support will ensure that the axial stress is under the allowable limits. Thrust-bearing piping systems require a detailed three-dimensional structural analysis. The piping engineer uses specialized computer software to determine all stresses and displacements, as well as support forces. Due to the inherent flexibility of Flowtite pipes, the force on components is usually considerably lower than in steel pipe installations.

FLOWTITE NON-THRUST-BEARING PIPE INSTALLATIONS

Wastewater Treatment Plant, DN60

LOCATION: Belleville, Illinois USA

Pipes are installed on supports or cradles and fastened with straps to ensure stability. The supports are usually concrete or steel; the fastening straps are made of steel. Non-thrust-bearing pipe systems carry the fluid pressure, but are not designed to transfer thrust forces and therefore require thrust blocks or other supports to resist unbalanced thrust. Flowtite Technology has designed and analyzed the most common installations. More information at Flowtite Installation Guide Above Ground with non-restrained Joints.

FLOWTITE JACKING AND SLIPLINING INSTALLATIONS

DN72 Jacking pipe during installation in Las Vegas, Nevada.

LOCATION: USA, 2015

With their high strength, Flowtite pipes are well suited for sliplining and jacking. For sliplining, the pipe can be jointed outside the existing pipe, culvert or borehole and pushed in. Alternatively, the pipes can be brought in, pipe by pipe, and jointed inside. Low flows can be permitted during installation.

Flowtite pipe design for jacking and micro-tunnelling takes advantage of non-corrodible materials. The smooth external surface and water repellency gives low friction during jacking.

LOCATION: Seattle, Washington, USA, 2014

Withdrawal of the push ring during a sliplining installation

LOCATION: USA

FLOWTITE SUBAQUEOUS INSTALLATIONS

Subaqueous Installation.

LOCATION: Turkey

Flowtite pipes are excellent for subaqueous installations. Dimensions up to 13 ft in diameter are common for Flowtite subaqueous pipelines. Flowtite pipes do not float.

FLOWTITE. FIRST CHOICE OF ENGINEERS. WORLDWIDE.

FLOWTITE. THE BEST SOLUTION FOR THE ENVIRONMENT

FLOWTITE PIPES HAVE A LOW CARBON FOOTPRINT.

Studies conducted by Flowtite show that Flowtite pipes have a low carbon footprint. Flowtite have conducted both cradle-to-gate and cradle-to-grave studies.

MATERIAL EFFICIENCY

An independent study conducted at The Norwegian University of Life Sciences in 2012 concludes that FRP pipes have a minimal negative environmental impact compared to other pipe materials. The main reason for this is the material efficiency.

Used with permission from The Norwegian University of Life Science and the author Katrine Steen Fjeldhus. Photo: Gisle Bjørneby.

RECYCLABLE

Flowtite pipes are recyclable. The Federation of Reinforced Plastics in Germany recommends that FRP pipes are used in cement production.

TRANSPORTATION EFFICIENCY

Flowtite pipes can be nested during transportation, which means lower carbon emissions from pipe transportation.

LOW ENERGY PRODUCTION

The amount of energy used in the production of Flowtite pipes is less than is required for most other pipe materials.

EXCELLENT HYDRAULICS

The smooth bore and good flow characteristics of Flowtite pipes reduce the amount of energy used for pumping. In penstocks, it increases the energy outtake!

• A full, third-party-verified Lifecycle Assessment has been conducted on Flowtite Pipes according to ISO 14040. The information may be provided upon request by Flowtite Technology.

FLOWTITE
WORLDWIDE PRODUCTION

FLOWTITE CLOSE TO YOU – ON FIVE CONTINENTS.

Flowtite pipes are produced worldwide by more than 40 specialized production lines. Flowtite plants are modern, efficient and reliable, located strategically on 5 continents of the world. Raw materials are delivered with vendor certification demonstrating their compliance with Flowtite quality requirements. In addition, all raw materials are sample tested prior to their use. These tests ensure that the pipe materials comply with the specifications as stated.

QUALITY CONTROL

All pipes are subjected to the following control checks:

- Visual inspection
- Barcol hardness
- Wall thickness
- Section length
- Diameter
- Hydrostatic leak tightness test to twice rated pressure for all pressure pipes

The following control checks are regularly performed on samples:

- Pipe stiffness
- Deflection without damage or structural failure
- Axial and circumferential tensile load capacity
- Material composition analysis

ON-TIME DELIVERY The picture shows transportation of DN96, DN60 and DN36 pipes.

LOCATION:
Fort Worth, USA

Flowtite manufacturers expect no less than 100 % customer satisfaction. Detailed quality inspections ensure the highest quality.

OVERVIEW OF FLOWTITE
MANUFACTURING PLANTS

ARGENTINA
AUSTRALIA
BRAZIL
COLOMBIA
DUBAI
EGYPT
GERMANY
KAZAKHSTAN
LIBYA
MEXICO
MOROCCO
POLAND
QATAR
SAUDI ARABIA
SOUTH AFRICA
TURKEY
USA
SPAIN

▶ See the complete list and contact information for factories and sales offices on www.flowtite.com.

PERFORMANCE STANDARDS

FLOWTITE`S COMPLIANCE TO STANDARDS – YOUR REASSURANCE.

Common to all standards is the need for a pipe manufacturer to demonstrate its compliance with the standards' performance requirements. In the case of FRP pipe, these minimum performance requirements fall into both short-term and long-term requirements.

POTABLE WATER APPROVALS

Flowtite has been tested and approved for the conveyance of potable water all over the world. Here is a list of the most prominent institutes and authorities:

Standard	Country of certifying body
NSF (Standard No. 61)	United States
DVGW	Germany
ACS - Carso	France
WRAS	United Kingdom
Russia 002389.10.12	Russia
PZH	Poland
OVGW	Austria
Belgaqua	Belgium
KIWA	Netherlands
ITA	Italy
EPAL	Portugal
OTECRIERA	Spain

For other more extensive information on potable water certifying bodies and local standards, please contact your local Flowtite supplier.

FLOWTITE PIPE HAS BEEN RIGOROUSLY TESTED TO VERIFY CONFORMANCE TO THE FOLLOWING INTERNATIONAL PERFORMANCE STANDARDS:

STANDARD	PURPOSE
AWWA C950	Water supply
AWWA M45	Design manual
ISO 10639	Water supply
ISO 10467	Sewer and drainage
EN 1796	Water supply
EN 14364	Sewer and drainage
ASTM D3262	Sewer
ASTM D3517	Water supply
ASTM D3754	Pressure sewer

Flowtite is in addition approved by most national standards

FLOWTITE MATERIAL AND PRODUCT QUALIFICATION

FLOWTITE PRODUCTS ARE KNOWN WORLDWIDE FOR THEIR RELIABILITY. THIS REPUTATION IS MAINTAINED BY AN EXTENSIVE MATERIAL AND PRODUCT QUALIFICATION PROGRAM.

MATERIAL QUALIFICATION
The suitability of raw materials for use in Flowtite pressure pipes is carefully considered with reference to international standards and guidelines. Raw materials are tested using a combination of short-term testing in production and laboratory environments, as well as long-term testing extending over many months, even years. Only after materials are proven to perform well in all tests, they may be permitted for use in a Flowtite pipe.

FLOWTITE THE WORLD'S LARGEST FRP LABORATORY

FLOWTITE QUALIFICATIONS TESTS – YOUR REASSURANCE

STRAIN CORROSION TESTING

Flowtite has been subjecting pipes to strain corrosion tests continuously since 1978 in order to develop the world's best sewer pipes. Sewer pipes are exposed to sulfuric acid, which causes corrosion and eventually sewer leakage. ASTM D3681 therefore demands that pipes are chemically tested while under strain.

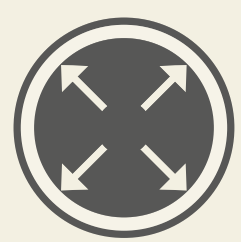
Flowtite pipes with extreme chemical resistance are the result of decades of continuous testing. Flowtite sewer pipes are popular in regions such as the Middle East where most other pipe materials fail.

◀ Flowtite Technology carries out strain corrosion testing in accordance with ASTM D3681. The standard requires a minimum of 18 ring samples of the pipe to be deflected to various levels and held constant.

HYDROSTATIC DESIGN BASIS – HDB

To remain a world leader in composite pressure pipes, Flowtite Technology has been conducting Hydrostatic Design Testing (HDB) since the 1970s. These tests have enabled Flowtite Technology to design reliable pipes for penstocks, drinking water and other pressure applications.

The HDB testing verifies that the pipes will tolerate 1.8 times the pressure to which they are rated over their certified lifetime.



◀ Flowtite Technology performs HDB tests in accordance with ASTM D2992 Procedure B. The standard requires hydrostatic pressure testing of many pipe samples for failure (leakage) at a variety of high constant pressure levels.

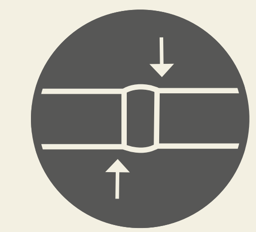
LONG-TERM RING BENDING

Flowtite pipes are designed to tolerate loads from traffic, landfill and buildings. The pipe designs are therefore rigorously tested to make sure they will sustain these elements – over the long term. AWWA C950 requires the test to be carried out and the resulting 50-year predicted value is used in the pipes' design. Flowtite pipes are tested using the guidelines of ASTM D5365 "Long-Term Ring Bending Strain of Fiberglass Pipe" and meets both requirements.

JOINT TESTING

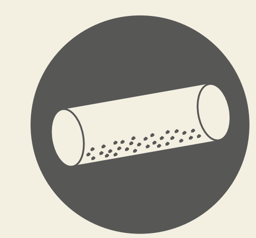
Flowtite has an extensive testing program to verify that Flowtite couplings will remain sealed and behave consistently under severe conditions. Joint prototypes for elastomeric gasket-sealed couplings are tested in accordance with ASTM D4161. It incorporates some of the most stringent joint performance requirements in the piping industry for pipe of any material within the pressure and size ranges of Flowtite pipe.

ASTM D4161 requires these flexible joints to withstand hydrostatic testing in configurations that simulate very severe in-use conditions. The pressures used are twice those rated. Joint configurations include straight alignment, maximum angular rotation and differential shear loading. A partial vacuum test and cyclical pressure tests are also included.



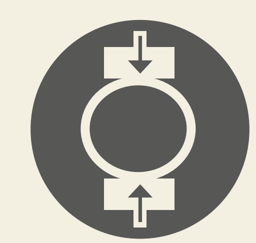
ABRASION RESISTANCE

Flowtite pipes are used across the world in penstocks and other applications where substances such as gravel impact the inner surface of the pipe. While there is no widely standardized testing procedure or ranking method, Flowtite abrasion resistance has been evaluated using the Darmstadt Rocker method. Using gravel obtained from the same source as that used at Darmstadt University, the average abrasion loss of Flowtite pipe is 0.013 inches per 100,000 cycles.



LONG-TERM STIFFNESS

The long-term stiffness of Flowtite pipes is considerably higher than most other plastic pipes. Creep tests according to ISO 10468, lasting more than 10,000 hours, have demonstrated a 50 year stiffness between 60 % and 75 % of the initial.



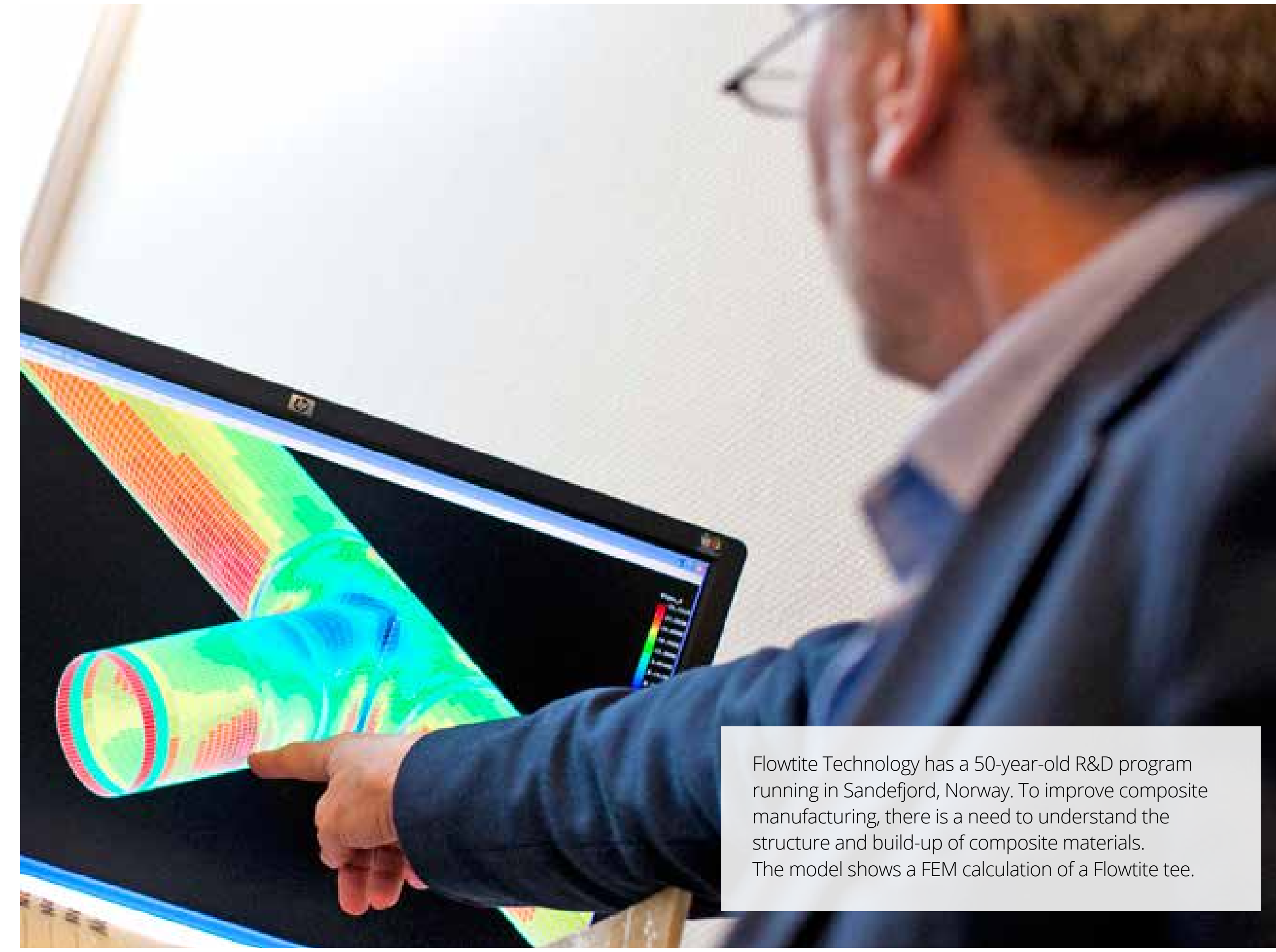
FLOWTITE
RESEARCH & DEVELOPMENT

FLOWTITE. BEST RESEARCH – BEST PIPES.

Research and development is the cornerstone of all industrial successes. The owners of Flowtite have used more resources than any other FRP producer, developing the best FRP pipes in the world. The largest FRP pipe laboratory in the world is the Flowtite laboratory in Norway.

This is the best guarantee to any pipe customer!

Acid number titration for resin approvals - a low acid number means good polyester. All new resins are tested.



Flowtite Technology has a 50-year-old R&D program running in Sandefjord, Norway. To improve composite manufacturing, there is a need to understand the structure and build-up of composite materials. The model shows a FEM calculation of a Flowtite tee.

DECADES OF INNOVATIONS

- **1965** The company Vera Fabrikker in Sandefjord started experimenting with the material later known as FRP for pipe production
- **1967** The continuous filament winding process was invented and patented
- **1968** Vera introduced the first tanks and pipes made by the continuous winding process
- **1973** The DN 138 Flowtite pipe was introduced, allowing pipes 11'10" feet wide and 59 feet long
- **1979** The double bell coupling introduced
- **1996** Special sewer pipe design introduced
- **2000** New catalyst FC 100 (patented) intro-duced, increasing the Flowtite pipe production speed
- **2003** Inventing the Flowtite butt wrap joint (patented)
- **2006** New multiaxial fittings design based on Flowtite patent
- **2006** Diameter range for 450 psi extended from DN 54 to DN 72
- **2009** Flowtite reaches 200,000 standard fittings designs
- **2014** Angled Joint introduced

THE HISTORY OF FLOWTITE PIPES

IN 1927, IN SANDEFJORD, A SMALL SHIPPING TOWN ON THE COAST OF NORWAY, ODD GLEDITSCH STARTED A MANUFACTURING PLANT FOR VEGETABLE OILS CALLED VERA FABRIKKER, THIS PLANT WAS THE CRADLE OF FLOWTITE PIPES.

Linseed oil was an ingredient needed in the production of paint for the Jotun paint company. In 1965, a group of engineers at the plant started experimenting with polyester resin and fiberglass. Along with the Danish company Drostholm, they invented the continuous winding method for the manufacture of FRP pipes and tanks. The material was revolutionary – it did not corrode, it was light, and with the FRP sandwich construction, it achieved strength, stability, and durability.

Owens Corning took over 100 % of the company from Jotun in 1993.

In cooperation with Owens Corning, Vera Fabrikker developed Flowtite FRP pipes and tanks as they are known today. Since 2001 Flowtite Technology is owned by the Saudi Arabian Amiantit Company. Flowtite has now built pipe factories in five continents.

In 1927, in Sandefjord, a small shipping town on the Norwegian coast, Odd Gleditsch started a manufacturing plant called Vera Fabrikker, which later became a manufacturing plant for Flowtite pipes.

LOCATION:
Sandefjord, Norway

TIMELINE / A WORLDWIDE SUCCESS

- **1929** – Vera Fabrikker established
- **1968** – Produced the first FRP pipes and tanks
- **1977** – Veroc Technology established 50/50 between Jotun and Owens Corning for sale of technology
- **1993** – Owens Corning takes over Veroc Technology 100 %
- **1998** – Name changed to Flowtite Technology
- **2001** – Amiantit acquires Flowtite Technology

TECHNICAL DATA

The following tables provide a selection of technical data. Comprehensive information can be found in the relevant Flowtite literature, such as installation instructions, test reports, technical notes, and other documents.

The numbers in these tables are approximate, nominal values, and are subject to change without notice. For current, accurate values, please contact your local Flowtite supplier.

STIFFNESS CLASS 18

18	PSI	FLOWTITE PIPE - ID MIN (INCHES)									WEIGHT SPAN U.S. Pound / Feet	
DN	**DOS max**	**PN 50**	**PN 100**	**PN 150**	**PN 200**	**PN 250**	**PN 300**	**PN 350**	**PN 400**	**PN 450**	**from**	**to**
12	13.19	12.75	12.75	12.76	12.81	12.81	12.85	12.83	12.81	12.78	5	6
14	15.33	14.84	14.84	14.85	14.91	14.91	14.95	14.93	14.91	14.88	7	9
16	17.40	16.86	16.86	16.88	16.94	16.94	16.98	16.97	16.94	16.90	8	11
18	19.49	18.89	18.90	18.93	18.99	18.99	19.03	19.02	18.98	18.94	11	14
20	21.61	20.96	20.98	21.01	21.07	21.07	21.11	21.11	21.07	21.02	13	17
24	25.79	25.02	25.06	25.09	25.16	25.17	25.21	25.20	25.15	25.09	18	26
30	32.01	31.10	31.14	31.19	31.26	31.28	31.31	31.31	31.24	31.14	28	39
36	38.31	37.26	37.30	37.36	37.44	37.46	37.50	37.50	37.38	37.26	39	55
42	44.49	43.29	43.34	43.41	43.51	43.52	43.57	43.56	43.44	43.31	53	73
48	50.79	49.45	49.50	49.59	49.69	49.70	49.75	49.74	49.59	49.44	69	95
54	57.56	56.07	56.11	56.22	56.33	56.35	56.40	56.40	56.27	56.11	87	121
60	61.61	60.03	60.08	60.20	60.31	60.33	60.38	60.36	60.18	60.00	101	138
63	64.45	62.80	62.85	62.98	63.09	63.11	63.16	63.13	62.98	62.79	111	151
66	68.46	66.72	66.78	66.92	67.03	67.06	67.10	67.09	66.96	66.77	124	170
72	72.48	70.65	70.70	70.85	70.97	71.00	71.04	70.98	70.83	70.63	140	190
75	76.50	74.56	74.63	74.79	74.91	74.94	74.98	74.96			155	212
78	80.51	78.49	78.56	78.72	78.85	78.88	78.93	78.93			169	234
81	84.53	82.42	82.49	82.66	82.79	82.82	82.87	82.87			186	257
84	88.54	86.34	86.41	86.60	86.73	86.76	86.81	86.81			203	282
90	92.56	90.26	90.34	90.53	90.67	90.70	90.75	90.75			222	308
96	96.57	94.19	94.26	94.47	94.61	94.65	94.69	94.70			242	334
99	100.59	98.11	98.20	98.41	98.55	98.59	98.64				266	362
102	104.61	102.04	102.12	102.34	102.49	102.53	102.58				287	391
108	112.64	109.89	109.97	110.21	110.37	110.41	110.46				332	452
120	120.67	117.73	117.82	118.09	118.25	118.29	118.35				381	518

STIFFNESS CLASS 18 *continues*

18	PSI	FLOWTITE PIPE - ID MIN (INCHES)									WEIGHT SPAN U.S. Pound / Feet	
DN	DOS max	PN 50	PN 100	PN 150	PN 200	PN 250	PN 300	PN 350	PN 400	PN 450	from	to
126	128.70	125.58	125.68	125.96	126.13						459	609
132	136.73	133.43	133.53	133.83	134.01						516	688
138	140.75	137.35	137.46	137.77							658	728
144	144.76	141.28	141.39	141.70							696	768
150	152.80	149.13	149.24	149.57							774	855
156	160.83	156.98	157.09	157.44							857	948

STIFFNESS CLASS 36

36	PSI	FLOWTITE PIPE - ID MIN (INCHES)									WEIGHT SPAN U.S. Pound / Feet	
DN	DOS max	PN 50	PN 100	PN 150	PN 200	PN 250	PN 300	PN 350	PN 400	PN 450	from	to
12	13.19	12.67	12.67	12.68	12.74	12.74	12.79	12.79	12.78	12.78	6	8
14	15.33	14.74	14.74	14.76	14.83	14.83	14.88	14.87	14.87	14.87	8	11
16	17.40	16.74	16.74	16.78	16.84	16.85	16.89	16.90	16.90	16.90	10	14
18	19.49	18.76	18.76	18.81	18.88	18.89	18.93	18.93	18.94	18.93	13	18
20	21.61	20.82	20.82	20.87	20.95	20.96	21.01	21.01	21.01	21.01	16	22
24	25.79	24.88	24.88	24.94	25.02	25.04	25.08	25.09	25.09	25.09	23	31
30	32.01	30.91	30.91	30.98	31.08	31.11	31.16	31.16	31.17	31.14	35	48
36	38.31	37.03	37.03	37.12	37.22	37.26	37.31	37.31	37.32	37.26	49	68
42	44.49	43.04	43.04	43.13	43.26	43.29	43.35	43.35	43.35	43.31	66	90
48	50.79	49.16	49.16	49.26	49.40	49.44	49.50	49.50	49.51	49.44	86	117
54	57.56	55.72	55.72	55.86	56.00	56.05	56.11	56.12	56.12	56.11	110	151
60	61.61	59.66	59.66	59.81	59.96	60.01	60.07	60.08	60.09	60.00	125	172
63	64.45	62.42	62.42	62.57	62.72	62.77	62.84	62.85	62.85	62.79	137	188
66	68.46	66.32	66.32	66.47	66.64	66.69	66.76	66.77	66.78	66.77	153	211
72	72.48	70.22	70.22	70.39	70.56	70.61	70.68	70.69	70.70	70.63	172	237
75	76.50	74.12	74.12	74.29	74.47	74.53	74.60	74.62			196	263
78	80.51	78.02	78.02	78.20	78.39	78.45	78.52	78.54			217	290
81	84.53	81.92	81.92	82.11	82.30	82.37	82.44	82.46			238	320
84	88.54	85.82	85.82	86.02	86.22	86.29	86.37	86.39			261	350
90	92.56	89.72	89.72	89.93	90.14	90.21	90.29	90.31			286	382
96	96.57	93.63	93.63	93.84	94.06	94.13	94.21	94.23			310	415

STIFFNESS CLASS 36 *continues*

36	PSI	FLOWTITE PIPE - ID MIN (INCHES)									WEIGHT SPAN U.S. Pound / Feet	
DN	DOS max	PN 50	PN 100	PN 150	PN 200	PN 250	PN 300	PN 350	PN 400	PN 450	from	to
99	100.59	97.53	97.53	97.75	97.97	98.05	98.13				343	450
102	104.61	101.43	101.43	101.66	101.89	101.97	102.06				371	486
108	112.64	109.23	109.23	109.48	109.72	109.81	109.90				429	563
120	120.67	117.03	117.03	117.30	117.55	117.65	117.74				493	645
126	128.70	124.83	124.83	125.11	125.39						605	759
132	136.73	132.64	132.64	132.93	133.22						682	856
138	140.75	136.54	136.54	136.85							851	907
144	144.76	140.44	140.44	140.76							900	958
150	152.80	148.24	148.24	148.57							1002	1067

STIFFNESS CLASS 46

46	PSI	FLOWTITE PIPE - ID MIN (INCHES)									WEIGHT SPAN U.S. Pound / Feet	
DN	DOS max	PN 50	PN 100	PN 150	PN 200	PN 250	PN 300	PN 350	PN 400	PN 450	from	to
12	13.19	12.63	12.63	12.64	12.70	12.71	12.76	12.76	12.76	12.76	6	9
14	15.33	14.70	14.70	14.72	14.79	14.80	14.84	14.84	14.84	14.85	9	12
16	17.40	16.70	16.70	16.73	16.80	16.81	16.85	16.86	16.86	16.86	11	15
18	19.49	18.71	18.71	18.75	18.83	18.84	18.89	18.89	18.90	18.90	14	20
20	21.61	20.77	20.77	20.81	20.90	20.91	20.96	20.96	20.97	20.97	17	24
24	25.79	24.81	24.81	24.87	24.95	24.98	25.03	25.03	25.04	25.04	24	34
30	32.01	30.84	30.84	30.91	31.00	31.03	31.09	31.09	31.10	31.10	37	51
36	38.31	36.94	36.94	37.00	37.13	37.17	37.22	37.24	37.24	37.24	53	73
42	44.49	42.93	42.93	43.01	43.14	43.19	43.25	43.26	43.27	43.27	71	97
48	50.79	49.03	49.03	49.12	49.27	49.32	49.39	49.40	49.41	49.41	92	127
54	57.56	55.59	55.59	55.69	55.86	55.91	55.98	56.00	56.01	56.01	118	162
60	61.61	59.52	59.52	59.63	59.80	59.86	59.94	59.95	59.96	59.97	134	185
63	64.45	62.27	62.27	62.38	62.56	62.62	62.70	62.72	62.72	62.73	147	202
66	68.46	66.16	66.16	66.28	66.46	66.54	66.61	66.63	66.64	66.65	166	228
72	72.48	70.05	70.05	70.17	70.37	70.44	70.52	70.54	70.56	70.56	185	255
75	76.50	73.94	73.94	74.07	74.28	74.35	74.44	74.46			215	283
78	80.51	77.83	77.83	77.97	78.18	78.26	78.35	78.37			237	313
81	84.53	81.72	81.72	81.87	82.09	82.18	82.26	82.29			261	345

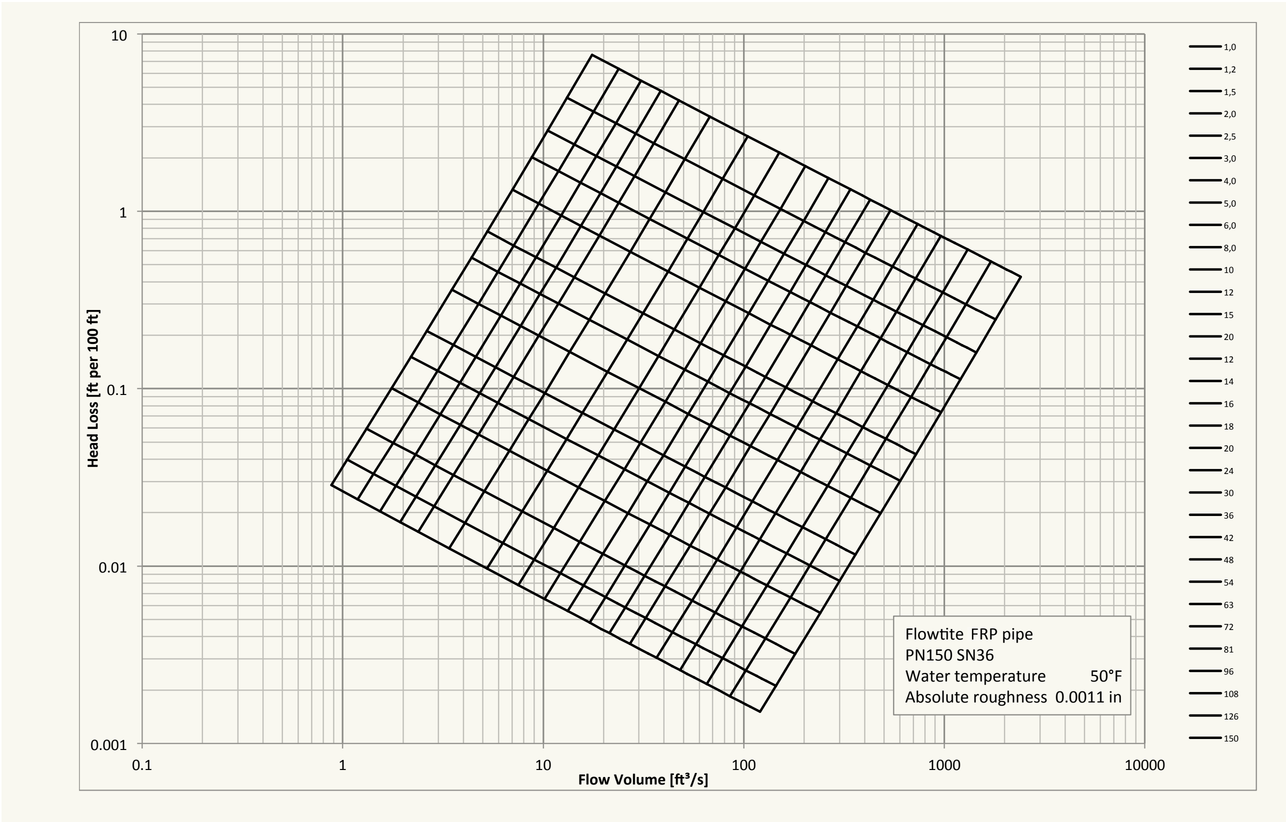
STIFFNESS CLASS 46 *continues*

46	PSI	FLOWTITE PIPE - ID MIN (INCHES)									WEIGHT SPAN U.S. Pound / Feet	
DN	**DOS max**	**PN 50**	**PN 100**	**PN 150**	**PN 200**	**PN 250**	**PN 300**	**PN 350**	**PN 400**	**PN 450**	**from**	**to**
84	88.54	85.62	85.62	85.76	86.00	86.09	86.18	86.20			287	377
90	92.56	89.51	89.51	89.67	89.90	90.00	90.09	90.11			312	412
96	96.57	93.39	93.39	93.56	93.81	93.91	94.00	94.03			340	448
99	100.59	97.28	97.28	97.46	97.71	97.82	97.91				377	486
102	104.61	101.18	101.18	101.36	101.62	101.73	101.83				407	525
108	112.64	108.96	108.96	109.15	109.43	109.55	109.65				471	608
120	120.67	116.74	116.74	116.95	117.24	117.37	117.48				540	696
126	128.70	124.52	124.52	124.74	125.06						669	822
132	136.73	132.31	132.31	132.54							884	925
138	140.75	136.20	136.20	136.43							938	980
144	144.76	140.09	140.09	140.33							991	1036

STIFFNESS CLASS 72

72	PSI	FLOWTITE PIPE - ID MIN (INCHES)									WEIGHT SPAN U.S. Pound / Feet	
DN	**DOS max**	**PN 50**	**PN 100**	**PN 150**	**PN 200**	**PN 250**	**PN 300**	**PN 350**	**PN 400**	**PN 450**	**from**	**to**
12	13.19	12.61	12.61	12.60	12.64	12.65	12.70	12.70	12.70	12.70	8	10
14	15.33	14.66	14.66	14.67	14.70	14.72	14.77	14.78	14.78	14.78	10	14
16	17.40	16.66	16.66	16.67	16.71	16.73	16.78	16.78	16.79	16.79	13	18
18	19.49	18.66	18.66	18.69	18.72	18.74	18.80	18.81	18.81	18.81	17	22
20	21.61	20.72	20.72	20.73	20.78	20.80	20.86	20.87	20.88	20.88	20	27
24	25.79	24.74	24.74	24.75	24.81	24.85	24.91	24.92	24.93	24.93	29	39
30	32.01	30.74	30.74	30.75	30.82	30.87	30.94	30.95	30.96	30.97	44	59
36	38.31	36.81	36.81	36.82	36.92	36.97	37.05	37.07	37.08	37.09	62	83
42	44.49	42.76	42.76	42.77	42.89	42.96	43.04	43.06	43.08	43.09	84	113
48	50.79	48.83	48.83	48.84	48.99	49.06	49.15	49.17	49.19	49.20	108	146
54	57.56	55.36	55.36	55.37	55.53	55.62	55.71	55.74	55.76	55.78	140	186
60	61.61	59.28	59.28	59.28	59.45	59.55	59.65	59.68	59.70	59.72	159	213
63	64.45	62.00	62.00	62.01	62.19	62.30	62.39	62.43	62.45	62.47	174	232
66	68.46	65.88	65.88	65.88	66.08	66.19	66.29	66.33	66.35	66.36	197	262
72	72.48	69.75	69.75	69.75	69.96	70.07	70.18	70.22	70.24	70.26	219	293
75	76.50	73.62	73.62	73.63	73.85	73.96	74.07	74.12			254	326
78	80.51	77.50	77.50	77.50	77.73	77.85	77.97	78.02			281	360
81	84.53	81.36	81.36	81.37	81.61	81.75	81.86	81.91			310	397
84	88.54	85.24	85.24	85.24	85.50	85.63	85.76	85.81			340	435
90	92.56	89.11	89.11	89.11	89.38	89.53	89.65	89.70			371	475
96	96.57	92.98	92.98	92.98	93.26	93.42	93.54	93.60			403	515
99	100.59	96.85	96.85	96.85	97.15	97.31	97.44				450	560
102	104.61	100.72	100.72	100.72	101.03	101.20	101.33				486	604
108	112.64	108.47	108.47	108.47	108.80	108.98	109.12				563	699
120	120.67	116.21	116.21	116.21	116.56	116.76	116.91				645	802
126	128.70	123.96	123.96	123.96	124.33						810	945
132	136.73	131.69	131.69	131.69	132.09						915	1006

HEAD LOSS – FLOWTITE PIPE



SURGE WAVE CELERITY FOR FLOWTITE PIPES

DN	12	16	20	24	36	48	72	120
SN18								
PN50	1400	1280	1200	1160	1140	1120	1120	1100
PN100	1400	1300	1280	1240	1200	1200	1160	1140
PN150	1500	1480	1440	1420	1400	1380	1360	1340
PN200	1580	1550	1550	1530	1510	1500	1490	1480
PN250	1700	1690	1660	1650	1630	1630	1620	1610
PN300	1820	1780	1770	1750	1740	1730	1720	1720
PN350	1880	1870	1850	1840	1840	1840	1870	
PN400	1960	1940	1930	1920	1960	1960	1950	
PN450	2020	2010	2000	2020	2080	2070	2050	

DN	12	16	20	24	36	48	72	120
SN36								
PN50	1440	1340	1280	1280	1260	1240	1240	1240
PN100	1440	1340	1280	1280	1260	1240	1240	1240
PN150	1520	1500	1460	1440	1400	1380	1380	1360
PN200	1590	1560	1560	1540	1520	1510	1500	1490
PN250	1710	1690	1670	1660	1640	1630	1620	1620
PN300	1800	1780	1770	1760	1740	1740	1730	1720
PN350	1890	1870	1850	1850	1840	1830	1820	
PN400	1950	1940	1930	1920	1950	1940	1930	
PN450	2020	2020	2020	2030	2080	2070	2050	

- Celerity values are in ft/s calculated for non-restrained pipes using the Korteweg formulation. A modulus of compressibility of water of 300,000 psi and Flowtite pipe design properties are assumed.
- The values above are rounded. Please contact your Flowtite supplier if more accurate values are required for transient analysis. For pipe DNs not listed, the values can be interpolated. For DNs larger than listed, use the value for the largest DN listed.
- The values above are valid for pipe with joints every 40 feet. The effect of other pipe structures like surrounding soils, fittings, thrust blocks etc. has to be evaluated separately

SURGE WAVE CELERITY FOR FLOWTITE PIPES *continues*

DN	12	16	20	24	36	48	72	120
SN46								
PN50	1460	1360	1320	1320	1300	1300	1280	1280
PN100	1460	1360	1320	1320	1300	1300	1280	1280
PN150	1540	1500	1460	1440	1420	1400	1380	1360
PN200	1590	1570	1550	1550	1530	1520	1510	1500
PN250	1700	1690	1670	1660	1650	1640	1630	1620
PN300	1800	1780	1770	1760	1750	1740	1730	1730
PN350	1900	1860	1850	1850	1840	1830	1820	
PN400	1950	1940	1930	1930	1910	1910	1900	
PN450	2030	2010	2000	2000	2070	2060	2050	

DN	12	16	20	24	36	48	72	120
SN72								
PN50	1500	1420	1420	1400	1400	1380	1380	1360
PN100	1500	1420	1420	1400	1400	1380	1380	1360
PN150	1540	1500	1480	1460	1420	1400	1380	1380
PN200	1600	1570	1560	1550	1530	1520	1510	1510
PN250	1710	1690	1670	1670	1650	1640	1630	1630
PN300	1800	1790	1770	1770	1760	1740	1740	1730
PN350	1880	1870	1860	1860	1840	1830	1830	
PN400	1960	1950	1930	1930	1910	1910	1900	
PN450	2030	2010	2000	2000	2040	2030	2010	

- Celerity values are in ft/s calculated for non-restrained pipes using the Korteweg formulation. A modulus of compressibility of water of 300,000 psi and Flowtite pipe design properties are assumed.
- The values above are rounded. Please contact your Flowtite supplier if more accurate values are required for transient analysis. For pipe DNs not listed, the values can be interpolated. For DNs larger than listed, use the value for the largest DN listed.
- The values above are valid for pipe with joints every 40 feet. The effect of other pipe structures like surrounding soils, fittings, thrust blocks etc. has to be evaluated separately

GUIDELINES FOR PIPE STIFFNESS SELECTION

Type 1 Traffic Load AASHTO HS 20 – No Internal Vacuum – Ground Water to Level

DN ≥ 12

	Standard Trench. Bd/D = 1.8												**Wide Trench. Bd/D = 3.0**												
Backfill	**CL I**			**CL II**			**CL III**			**CL IV**			**CL I**			**CL II**			**CL III**			**CL IV**			
Burial Depth ft	18	36	72	18	36	72	18	36	72	18	36	72	18	36	72	18	36	72	18	36	72	18	36	72	**Native soil**
3.3	D	D	D	85	85	85	90	85	85		95	95	D	D	D	85	85	85	90	90	85			95	1
4.9	D	D	D	85	85	85	85	85	85	95	95	95	D	D	D	85	85	85	90	85	85			95	
6.6	D	D	D	85	85	85	85	85	85	95	95	95	D	D	D	85	85	85	90	90	85			95	
9.9	D	D	D	85	85	85	90	85	85			95	D	D	D	85	85	85	90	90	90				
16.4	D	D	D	85	85	85	90	90	90				D	D	D	90	90	85	95	95	95				
26.2	D	D	D	90	90	90	95	95	95				D	D	D	90	90	90	95	95	95				
39.4	D	D	D	90	90	90	95	95	95				D	D	D	90	90	90							
65.6	D	D	D	95	90	90							D	D	D	95	95	95							
98.4	C	D	D	100	95	95							C	D	D	100	95	95							
3.3	D	D	D	85	85	85	90	85	85			95	D	D	D	85	85	85	90	90	85			95	4
4.9	D	D	D	85	85	85	85	85	85	95	95	95	D	D	D	85	85	85	90	90	85			95	
6.6	D	D	D	85	85	85	85	85	85	95	95	95	D	D	D	85	85	85	90	90	85			95	
9.9	D	D	D	85	85	85	90	90	85			95	D	D	D	85	85	85	90	90	90				
16.4	D	D	D	90	90	85	95	95	95				D	D	D	90	90	90	95	95	95				
26.2	D	D	D	95	95	90							D	D	D	90	90	90							
39.4	C	C	C	100	100	100							D	D	D	95	95	95							
65.6													C	D	D	100	95	95							
98.4														C	C		100	100							
3.3	D	D	D	95	95	90							D	D	D	90	90	85	95	95	90				6
4.9	D	D	D	95	90	90			95				D	D	D	90	85	85	95	95	90				
6.6	D	D	D	95	95	90			95				D	D	D	90	90	85	95	95	90				
9.9	D	D	D	95	95	95							D	D	D	90	90	85	95	95	95				
16.4			C			100							D	D	D	90	90	90			95				
26.2													D	D	D	95	95	95							
39.4													D	D	D	95	95	95							
65.6														C	C		100	100							
98.4																									

NATIVE SOIL CLASSIFICATION ACCORDING TO M45

Native in Situ Soils					
Granular			Cohesive		
			q_u		
Group	Blows/ft* (0.3 m)	Description	ton/sf	kPa	Description
1	>15	compact - very dense	2.0 -> 6.0	200 -> 600	very stiff - very hard
2	8-15	slightly compact	1.0-2.0	100-200	stiff
3	4-8	loose	0.50-1.0	50-100	medium
4	2-4		0.25-0.50	25-50	soft
5	1-2	very loose	0.125-0.25	13-25	very soft
6	>0-1	very, very loose	>0-0.125	0-13	very, very soft

* Standard penetration test per ASTM D1586
According to M45.

BACKFILL SOIL CLASSIFICATION ACCORDING TO M45

Soil Classes	Unified Soil Classification System Soil Groups*
CL I	Crushed rock: </= 15 % sand, maximum 25 % passing the 3/8-in. sieve and maximum 5 % passing No. 200 sieve
CL II	Clean, course-grained soils: SW, SP, GW, GP or any soil beginning with one of these symbols with 12 % or less passing No. 200 sieve
CL III	Coarse-grained soils with fines: GM, GC, SM, SC or any soil beginning with one of these symbols with more than 12 % fines
	Sandy or gravelly fine-grained soils: CL ML (or CL-ML, CL/ML, ML/CL) with 30 % or less retained on a No. 200 sieve
CL IV	Fine-grained soils: CL, ML (CL-ML, CL/ML, ML/CL) with 30 % or less retained on a No. 200 sieve

* ASTM D2487, Standard Classification of Soils for Engineering Purposes (Unified Soil Classification System)

CHEMICAL RESISTANCE TABLE

	Standard Pipe Resin or Vinyl Ester	Vinyl Ester Only
Acetic Acid < 20 %*		X
Adipic Acid*		X
Alum (Aluminum Potassium Sulfate) (113 °F)	X	
Aluminum Chloride, Aqueous (104 °F)	X	
Ammonia, Aqueous < 20 %		X
Ammonium Chloride, Aqueous (104 °F)	X	
Aniline Hydrochloride		X
Beet Sugar Liquor		X
Benzene Sulfonic Acid (10 %)*		X
Benzoic Acid*		X
Black Liquor (Paper)		X
Borax (104 °F)	X	
Boric Acid		X
Calcium Bisulfite*		X
Calcium Carbonate		X
Calcium Chlorate, Aqueous (104 °F)*	X	
Calcium Chloride (Saturated) (104 °F)	X	
Calcium Hydroxide, 100 %		X
Calcium Hypochlorite		X
Calcium Nitrate (104 °F)	X	
Calcium Sulfate NL AOC (104 °F)	X	
Cane Sugar Liquors		X
Carbon Dioxide, Aqueous (104 °F)	X	
Casein	X	
Caustic Potash (KOH) (104 °F)		X
Chlorine, Dry Gas*		X
Chlorine, Water*		X
Chlorine, Wet Gas*		X
Citric Acid, Aqueous		X
Copper Acetate, Aqueous (104 °F)	X	
Copper Nitrate, Aqueous (104 °F)	X	
Copper Sulfate, Aqueous (104 °F)	X	
Crude Oil (Sour) (86 °F)*	X	
Crude Oil (Sweet) (86 °F)*	X	
Crude Oil, Salt Water (77 °F)*		X
Cyclohexane (104 °F)*		X

	Standard Pipe Resin or Vinyl Ester	Vinyl Ester Only
Cyclohexanol (86 °F)*		X
Fuel Oil (77 °F)*	X	
Gasoline, Ethyl*		X
Glycerine		X
Green Liquor, Paper		X
Kerosene*		X
Lactic Acid, 10 % (86 °F)	X	
Lead Acetate, Aqueous (77 °F)	X	
Lead Nitrate, Aqueous (77 °F)	X	
Linseed Oil*	X	
Lithium Chloride, Aqueous (104 °F)*	X	
Magnesium Bicarbonate, Aqueous (86 °F)*	X	
Magnesium Carbonate (104 °F)*		X
Mineral Oils*	X	
n-Heptane (77 °F)*	X	
Naphthalene (86 °F)*	X	
Naptha*		X
Oleic Acid (104 °F)	X	
Oxalic Acid, Aqueous		X
Paraffin (86 °F)*	X	
Perchloric Acid (77 °F)		X
Petroleum, Refined & Sour*		X
Phosphoric Acid		X
Potassium Nitrate, Aqueous (104 °F)	X	
Potassium Sulfate (104 °F)	X	
Propylene Glycol (86 °F)	X	
Sea Water (104 °F)	X	
Sewage (122 °F)	X	
Silicone Oil (104 °F)	X	
Silver Nitrate, Aqueous (104 °F)	X	
Sodium Hydroxide 10 %		X
Sodium Mono-Phosphate		X
Sodium Nitrate, Aqueous (104 °F)	X	
Sodium Nitrite, Aqueous (104 °F)*	X	
Sodium Silicate		X
Stannous Chloride, Aqueous (104 °F)	X	

	Standard Pipe Resin or Vinyl Ester	Vinyl Ester Only
Stearic Acid (104 °F)*	X	
Sulfuric Acid, < 25 % (77 °F)*	X	
Tannic Acid, Aqueous (95 °F)	X	
Tartaric Acid (86 °F)	X	
Triethylamine (104 °F)*		X
Turpentine*		X
Urea, Aqueous (86 °F)*	X	
Vinegar (77 °F)	X	
Water, Distilled (104 °F)	X	
Water, Tap (104 °F)	X	
Zinc Chloride, Aqueous (104 °F)	X	

* Current EPDM type gasket can not be used. Use of NBR type gasket is recommended, or consult your local gasket supplier.

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