SUPERLIT® better pipes

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SUPERLIT®

better pipes

FIBERGLASS-REINFORCED / POLYESTER RESIN (GRP) / PIPES AND FITTINGS

www.superlit.eu

50 years. An international journey of innovation, adventure and partnership to deliver a cleaner, greener, more sustainable world.

SUPERLIT's success has been built on three principal foundations: the commitment of our workforce; a deep understanding of materials technology and manufacturing processes; and a recognition of the moral responsibility we, in partnership with our customers, have in creating a better world.

Whether it is the delivery of life-enhancing potable water across the challenging terrain of an African desert, the irrigation of critical agriculture on the Iberian peninsular, or building sewer networks to protect public health across Australia: SUPERLIT makes a world of difference.

INDEX

INTRODUCTION

Founded in 1961, **SUPERLIT** is an affiliate of KARAMANCI HOLDINGS, a major Turkish industrial conglomerate.

SUPERLIT manufactures and markets GRP (Glass-fibre Reinforced Polyester) pipes for both pressure and non-pressure applications. A world leader in its sector, SUPERLIT has an extensive international sales network. The focus is on product quality and range.

Production

SUPERLIT has five production facilities: four in Turkey (Ducze and Malatya) and one in Romania (Buzau). There are plans for further expansion as demand for SUPERLIT's products continues to grow.

SUPERLIT manufactures GRP pipes across a broad range of diameters, stiffnesses and pressure ratings:

- Nominal Diameters (DN): 300mm to 4000mm
- Pressure classes: 1 to 40 bar
- Stiffness classes: 1250, 2500, 5000, 10000, 20000N/m²
- NB – Bespoke GRP pipes with stiffness ratings greater than 20000N/m² can be manufactured on request

SUPERLIT produces GRP pipes using both 'continuous filament winding' and 'centrifugal casting' manufacturing processes. All products and production facilities comply with the relevant international standards including ISO, DIN, ASTM, AWWA and EN.

SUPERLIT GRP pipes are used in applications as diverse as potable water, irrigation, hydropower, wastewater and sewerage, purification, cooling, outfalls and discharge systems.

Markets

SUPERLIT has had an international presence since 1977 in markets as diverse as Europe, North Africa and the Middle East. Today, SUPERLIT continues to expand, supplying its products to water utilities, governmental and environmental agencies, and contractors across the globe.

Quality policy

SUPERLIT has received the following accreditations:

ISO 9001
1SO 14001
OHSAS 18000
TUV Integrated Management Certificate (Germany)

SUPERLIT GRP pipe and fittings also hold major international product approval certifications including:

GOST (Russia)
NSF (USA)
KIWA (Holland)

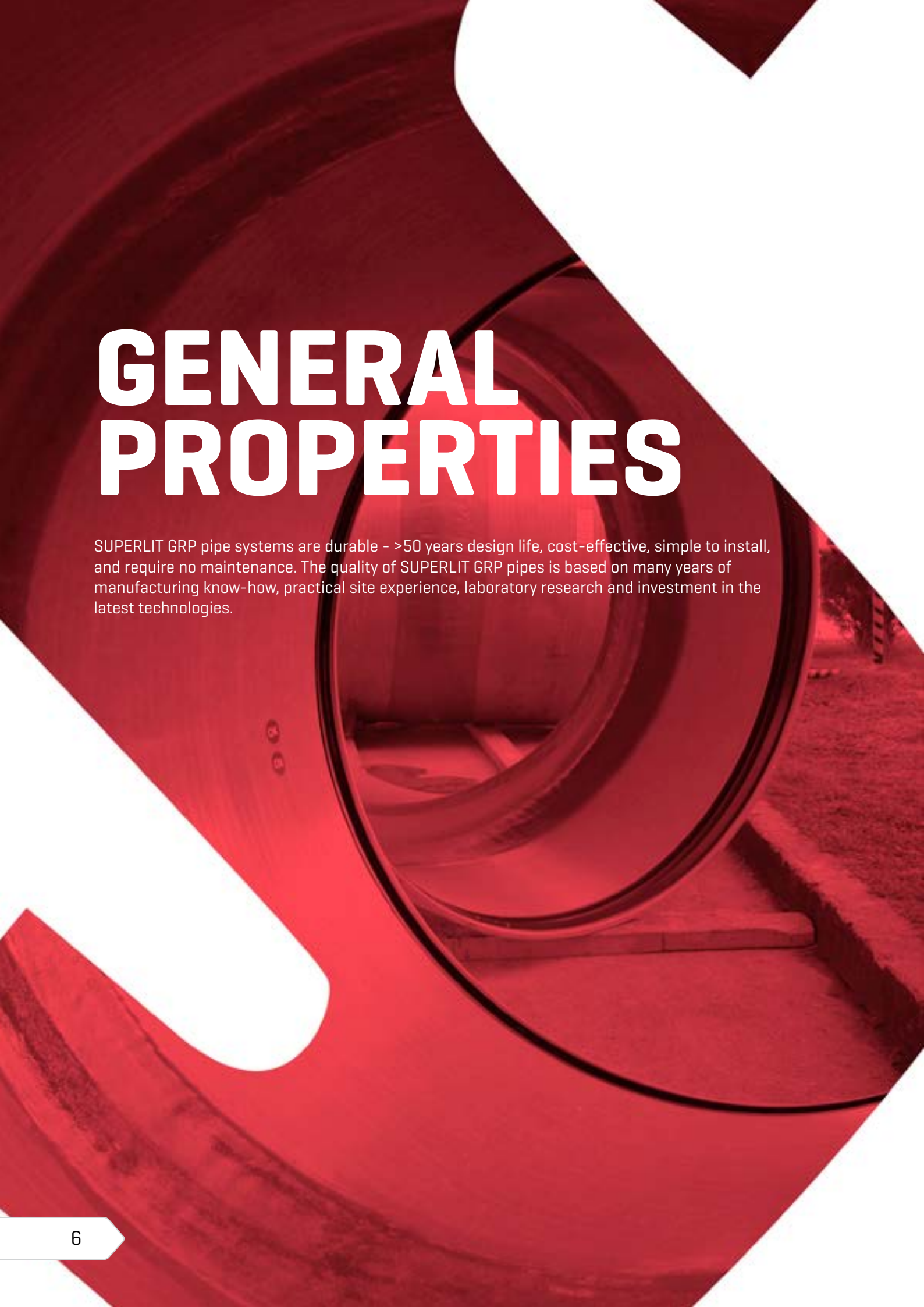
SUPERLIT's System:

- Has a fully automatic control mechanism
- Embraces the full production journey from the procurement of raw materials through to the finished product
- Focusses, at every stage of the production process, on impermeability, external load resistance and environmental protection, and provides assurance on these factors for customers
- Subjects all finished products to the tests demanded by international standards

SUPERLIT is the first GRP pipe manufacturer in Turkey to have a TURKAK certified and accredited laboratory.

Through its professional, qualified and experienced staff, SUPERLIT delivers comprehensive after-sales support.

SUPERLIT also provides supervisory services for the unloading, storage, installation, and initial onsite testing of its pipe and fittings.



GENERAL PROPERTIES

SUPERLIT GRP pipe systems are durable - >50 years design life, cost-effective, simple to install, and require no maintenance. The quality of SUPERLIT GRP pipes is based on many years of manufacturing know-how, practical site experience, laboratory research and investment in the latest technologies.

APPLICATIONS

SUPERLIT GRP pipe systems are used in the following applications:

- Potable and raw water transportation and distribution
- Rainwater infrastructure
- Pressure and non-pressure wastewater transportation and discharge
- Subsea pipelines, sea water intakes and cooling systems
- Chemical plants
- Power station water circulation, filling and discharge
- Hydroelectric power plants
- Pipe jacking and relining

PROPERTIES

Size: SUPERLIT GRP pipe systems are manufactured in diameters ranging from 300mm to 4000mm. Please refer to page 28 for the complete list of our standard pipe sizes.

Physical: SUPERLIT GRP pipes meet the following international standards...

Standards:

- TS EN 1796
- TS EN 14364
- ASTM D3262
- ASTM D3754
- AWWA C950
- DIN 16869
- ISO 10639

...and many other standards available on request.

Length

SUPERLIT GRP pipes are manufactured in a continuous process and can, therefore, be any length. However, transportation constraints typically make 15m the longest standard pipe length.

Fitting:

All SUPERLIT fittings are manufactured in accordance with the relevant international standards

Pressure: SUPERLIT GRP pipes are manufactured in the following pressure classes:

Pressure class (PN)	Pressure (Bar)
1	1
6	6
10	10
16	16
25	25
32	32
40	40

Rigidity: SUPERLIT GRP pipes are manufactured in the following standard stiffness classes...

Stiffness Classes (SN)	N/m² (Pa)
1250	1250
2500	2500
5000	5000
10000	10000
20000	20000

...up to 1.000.000 on request for jacking applications.

ADVANTAGES

Hydraulic efficiency

The smooth internal surface of SUPERLIT GRP pipes makes them hydraulically efficient, reduces pumping costs and rise the pressure inlet for a turbine (HEPP)

Long pipe lengths

SUPERLIT GRP pipes can be manufactured in any length up to 15m. Fewer joints make installation quicker and cost-effective.

Effective coupling

SUPERLIT GRP pipe couplings incorporate elastomeric seals which prevent root ingress.

Lightweight

SUPERLIT GRP pipes are less than 10% of the weight of concrete alternatives and 25% of the weight of steel alternatives! Transport costs are reduced, handling is straightforward, and installation is simple and fast.

Corrosion free and chemical resistant – SUPERLIT GRP pipes are:

- Non-metallic – they cannot corrode and, therefore, do not require additional internal or external coatings or cathodic protection. A huge cost saving over some alternatives.
- Inert – they can be used in high pH environments
- Chemical-resistant – For further information please refer to SUPERLIT's 'Guide to chemical resistance'.

Durable

SUPERLIT GRP pipes have a design life of 50 years.

Maintenance free

SUPERLIT GRP pipes require no maintenance over their design life

Electrical insulator

SUPERIT GRP pipes are not affected by induction currents

Surge pressure resistant

SUPERLIT GRP pipes are more resistant to pressure surges than ductile iron or steel.

Load distribution

The manufacturing processes for SUPERLIT GRP pipes enable tight tolerances to be achieved. These tolerances ensure effective load distribution, avoiding local stress concentration.

TECHNICAL PROPERTIES

» Performance Standards
» Performance Tests
» Design Features
» Classification and Standards

PERFORMANCE STANDARDS

GRP - Pipes

The ASTM, AWWA and ISO standards for GRP are all performance-based and prescribe the specific performance tests required for different GRP pipe applications.

ASTM

SUPERLIT GRP pipes are designed to meet the following ASTM standards:

ASTM	D4161	Hydrostatic pressure test for pipes with flexible couplings
ASTM	D3262	Non- pressure Wastewater Pipe
ASTM	D3517	Pressure Pipe for Fresh Water
ASTM	D3754	Pressure Wastewater Pipe

AWWA

SUPERLIT GRP pipes are designed to meet the following AWWA standards:

AWWA	C950	Glass Fibre Pressure Pipes, For Fresh Water
AWWA	M-45	Glass Fibre Pipe Design Guide

ISO

SUPERLIT GRP pipes meet the requirements of the following ISO standards:

ISO/DIS	10467.3	Wastewater and drainage
ISO/DIS	10639.3	Pressure and non-pressure pipes for clean water
ISO/TR	10465.3:1999	Underground installation of GRP pipes

DIN and EN

Standards organisations such as BS and DIN also publish performance specifications for GRP pipes. SUPERLIT GRP pipes meet the most restrictive performance requirements of these standards.

DIN 16869	Glass fibre reinforced polyester resin pipes and fittings
EN 1796	Pressure and non-pressure GRP pipe standard.

PERFORMANCE STANDARDS

GRP – RAW MATERIALS

SUPERLIT determines the quality criteria its raw materials have to meet. Each delivery of materials requires a conformity certificate confirming that these criteria have been met. In addition to the suppliers' conformity certificates, SUPERLIT also undertakes sample tests on all raw materials destined for pipe production.

Resin

Polyester resin is dissolved in styrene monomer. Organic peroxide catalyst is used to cure the resin.

Silica Sand

Sand with a high silica content is used to increase pipe rigidity.

Glass Fibre

Fibres are available in different tex and lengths

Direct Roving Fibres
These are supplied on bobbins in cylindrical packages to ensure the thread structures are not damaged

Chop Fibres
These are cut in a similar way as the single-direction continuous fibre to ensure even distribution across the pipe

Reinforcing Fibre Filaments
These are held together by adhesive resin

PERFORMANCE TESTS

SUPERLIT performs the following tests to ensure the performance standards listed on page 7 – ASTM, AWWA, TS, DIN, ISO – are met:

1. JOINT PERFORMANCE;
2. INITIAL RING DEFLECTION;
3. LONG TERM PRESSURE RESISTANCE
4. CORROSION STRAIN CAPACITY

1. JOINT PERFORMANCE

SUPERLIT couplings incorporating elastomeric gaskets are tested in accordance with ISO 10639, ASTM 4161 and EN 1796.

Under simulated installation conditions, the coupling must withstand a hydrostatic pressure of 100kPa (1 bar) in non-pressure applications, and 2 times the proposed operating pressure for pressure applications. In addition to hydrostatic pressure the tests also cover fatigue testing, differential loads and maximum angular deflection.

2. INITIAL RING DEFLECTION

2.1 Initial Ultimate Deflection

SUPERLIT produces GRP pipes to meet the following ISO standards:

- ISO/DIS 10639 – GRP Pipe Systems for Pressure and Non-Pressure Water Supply

- ISO/DIS 10467 – GRP Pipe Systems for Drainage and Waste Water Applications

SUPERLIT GRP pipes also meet the mechanical requirements of ANSI/AWWA C950 standard.

2.2 Minimum Axial Strength

ISO values are stated in N/mm per unit circumference with regard to the pipe pressure class and diameter.

AWWA values are stated in lbf/inch per unit circumference with regard to the pipe pressure class and diameter.

2.3 Initial Failure (Burst) Pressure

The initial failure – or bursting – pressure is based on the long-term safe bursting pressure. The regression factor is calculated from the long term static internal pressure. ISO and AWWA use similar static pressure test methodologies, but the long term safety factors applied are different.

3. LONG-TERM PERFORMANCE UNDER PRESSURE

3.1 Hydrostatic Design Base (HDB) testing

The HDB test guarantees the long-term performance of SUPELIT GRP pipes in pressure pipe applications.

The HDB test is undertaken in compliance with ASTM D2992 Procedure B or the ISO equivalent. A hydrostatic pressure is applied to a large number of pipe samples. The pressure is increased until the pipe leaks. The pressure at which the pipe leaks (ring strain resistance) and the time taken are extrapolated to calculate 50 year values. The 50 year HDB or 'strain' values must be at least 1.8 times the maximum operating pressure (pressure class) for the proposed pipe application (see Figure 2).

3.2 Leak test

There are two ISO leak test methodologies for GRP pipe systems:

- Pipe is pressurized to 1.5 times its pressure class rating. There is no specified test duration.
- A sample pipe length is subjected to a high pressure. The test pressure is determined from the regression curve obtained from the long term static pressure test. If the long term safety factor calculated from this test is equal to the value obtained from ISO DTR 10465-3 this will equate to a failure risk of 6.5%.
- Each pipe is tested 2 times of its nominal pressure class in factory production.

3.3 Long Term Ultimate Deflection

AWWA C950 requires pipe manufacturers to determine and publish the long-term deflection value for its pipes. This value is defined as the strain (Sb), calculated as the % elongation at the pipe's breaking point.

In ISO deflection tests, the value is shown as a %.

The requirement for both AWWA and ISO tests are the same. Pipes laid underground should be operating under a nominal pressure. The deflection of the laid pipe should also be taken into account. Our pipes are designed to give a 5% long term deflection service.

ISO DTR 10465-3 Attachment G provides further details.

3.4 Hydrostatic Design Base (HDB)

The safety factors for the long term average minimum values are given in the following table:

Pressure class	PN 32	PN 25	PN16	PN10	PN6	PN4	PN2
97.5% long term LCL value, nt PN (97.5% LCL)	1.3	1.3	1.45	1.55	1.6	1.65	1.7
Long term average value, nt, mean	1.6	1.6	1.8	1.9	2.0	2.05	2.1

Table 1. Long-term ISO Safety Factor

The values in Table 1 are based on a 9% deviation coefficient. For deviations greater than 9%, the safety factor should be increased.
In the AWWA standard, the long term safety factor for pipes laid above and below ground is a constant and set at 1.8. Calculations should be in accordance with AWWA M-45 Article 5.7.4.

4. CORROSION STRAIN CAPACITY

This is a test for non-pressure GRP pipes transporting wastewater, sewage and chemicals.

The testing procedure requires a minimum of 18 pipe ring samples to be subjected to varying degrees of deflection. The deflected samples are held under load for a period of time, in accordance with ASTMD3681 and ISO 10952, and the invert surface is subjected to 1.0N (5% by weight) of sulphuric acid (see **Figure 1**) to simulate septic wastewater conditions. These conditions are similar to those experienced in Central Asia where GRP pipe has been successfully used.

By using the smallest square analysis method, the minimum corrosion strain value is obtained. This value is used in the design of pipes destined for chemical, wastewater and sewage applications.

ISO standards require that level A and level B values (see **Figure 2**) are used to generate a regression formula. Calculations for 1,000, 3,000 and 10,000 hours are made, and test samples are kept at the calculated deflection value. The samples must not show any structural damage for the test period indicated by the regression formula.

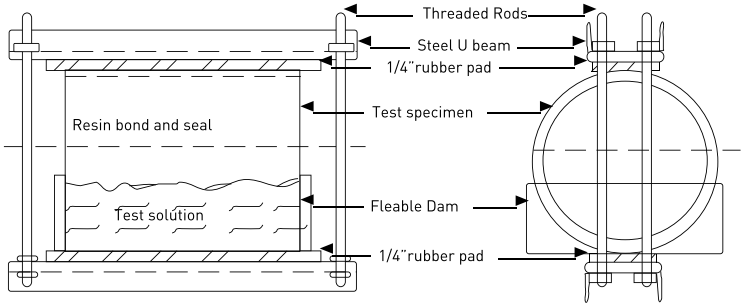


Figure 1: Corrosion Tension Capacity Test

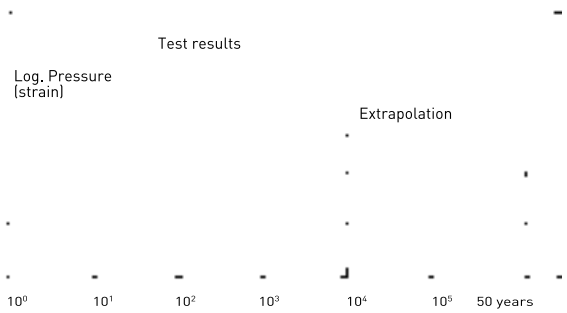


Figure 2: Test result evaluation ASTM D2392 procedure B

CONTROLS

The axial load–bearing capacity of SUPERLIT GRP pipes is routinely tested.
Pipe structure and composition are also controlled and approved.

Controls at the stage of production:

» Visual examination
» Barcol hardness
» Wall thickness
» Pipe length
» Diameter
» Hydrostatic leak test

Controls based on production samples:

» Pipe rigidity
» Deflection test
» Ring tensile strength
» Axial tensile strength

QUALITY CONTROL

SUPERLIT has a culture of 'total quality'. The skill and dedication of the SUPERLIT engineering and manufacturing team are fundamental to the success of this 'total quality' approach within the framework of SUPERLIT's ISO 9000 quality certification.

SUPERLIT GRP pipe production technology facilitates the implementation of an extensive and detailed quality control programme. This programme ensures the production and testing of pipe and fittings comply with international standards.

Raw materials are tested before they enter the production chain.

Measured Qualities	Limits of change
Pipe wall thickness	at single spot (-10% of nominal thickness)
Visual inspection	standard
Pipe length	+ 100 mm
Pipe diameter	± 0.5 rnm
Pipe hardness	± 5 Barcol
Pipe stiffness	ASTM D-2412 Standard
Longitudinal tensile strength	ASTM Standard D-638 Standard
Peripheral tensile strength	ASTM Standard D-2290 Standard

Pipe operating pressure classification is in accordance with the criteria set out in AWWA C950 and the characteristics included in M45.
SUPERLIT GRP pipes absorb up to 40% additional pressure arising from water hammer

FUNDAMENTAL DESIGN FEATURES

FLOW VELOCITY

The recommended flow velocity for a standard GRP pipe is calculated as follows:

$v = \frac{48}{(\rho)^{0.33}}$; v = fluid speed (ft/sec) , ρ = fluid density (lb/ft^3) (for water; 62.4 lb/ft^3)

(AWWA M45 Manual)

FLOW COEFFICIENT

The roughness coefficients to be used for SUPERLIT GRP pipes in hydraulic calculations are:
- Hazen-William flow coefficient : C= 150
- Manning coefficient : n= 0.009
- Colebrook- White coefficient : k= 0.029 mm

UV RESISTANCE

There is no evidence to indicate that ultra-violet light effects the long-term performance of SUPERLIT GRP pipes.

The only impact of ultra-violet light is that it gradually changes the colour of the outer surface of the pipe. If desired, this can be countered by painting the outer surface with a two-part urethane paint which is compatible with GRP material. However, it should be noted that this coating will require future maintenance.

POISSON RATIO

For SUPERLIT GRP pipe, the Poisson ratio for the circumferential load in the axial direction is between 0.22 and 0.29.

The Poisson ratio for the axial load in the circumferential direction is slightly less.

TEMPERATURE

The maximum permissible temperature at which industrial waste can be transported in SUPERLIT GRP pipes without a reduction in pressure class is 35^{0}C. For a pipeline that will be under continuous use between 35^{0}C and 50^{0}C, the recommendation is that the pipe pressure class should be reduced by one level i.e. a PN16 pipe would become a PN10 pipe.

For temperatures above 50^{0}C please contact SUPERLIT for guidance on the resin to select and pipe pressure reclassification.

THERMAL COEFFICIENT

The thermal coefficient for the elongation and shortening of SUPERLIT GRP pipe in the axial direction is:

(24) to (30) x $\frac{1}{10^6}$ mm/mm/°C

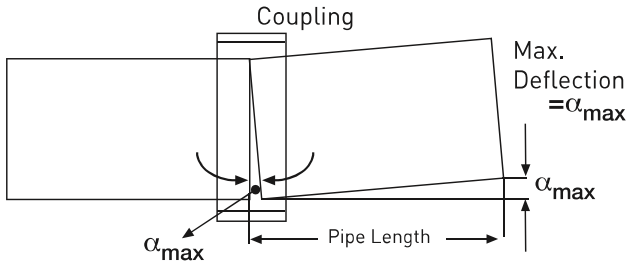
COUPLING ANGULAR DISPLACEMENT

SUPERLIT couplings are tested in accordance with ASTM D 4161 and EN 1796. The maximum angular displacement, measured as the angle between the centre lines of the pipes to be joined, should not exceed the values given in the following table:

Angular Deflection in SUPERLIT sleeve connection

DN (mm)	Angular Deflection (Degree)
DN ≤ 500	3.0
500 < DN ≤ 900	2.0
900 < DN ≤ 1800	1.0
1800 < DN	0.5

Angular Joint Deflection



SUPERLIT GRP couplings can accommodate an angular deflection of 0.5^0 to 3^0 depending on pipe diameter and pressure. This angular deflection means that, for long radius bends, it may be possible to eliminate, or at least reduce, the number of elbows.

Pipe should be connected in line and then correction for the desired angular displacement should be made (see the figure above – Angular Joint Deflection)

CLASSIFICATION AND REFERENCE STANDARDS

STIFFNESS CLASSIFICATION

The stiffness calculation in ISO standards is measured in N/m². In **Table 1**, the minimum initial rigidity is defined for two different series:

Original GRP Series	Thermoplastic Pipes
SN 630	SN 500
SN 1250	SN 1000
SN 2500	SN 2000
SN 5000	SN 4000
SN 10000	SN 8000

Table 1 Nominal stiffness values (ISO)

In AWWA C950, rigidity is defined in psi.

ISO	AWWA
SN 1250	9 psi
SN 2500	18 psi
SN 5000	36 psi
SN 10000	72 psi

Table 2: Stiffness comparison between ISO/AWWA

There are no requirements for long-term stiffness testing in either ISO or AWWA standards **Table 2**.

PRESSURE CLASSES

ISO pressure classes (PN) are based on bar pressure ratings.
Nominal pressure classifications: PN1, (2.5), 6, (9), 10, (12), (15), 16, (18), (20), 25, 32. The classifications in brackets are less common.

PN 1 pressure classification is for non-pressure pipes i.e. where liquids flow due to gravity.
AWWA C950 pressure classifications are given in psi: 50, 100, 150, 200, 250

INITIAL ULTIMATE DEFLECTION

Initial deflection parameters are the same in ISO and AWWA C950. The classification system shown in **Table 3** is valid for both standards:

Class	Level A	Level B
SN 2500	15 %	25 %
SN 5000	12 %	20 %
SN 10000	9 %	15 %

Table 3: Initial deflection requirements 10 150/AWWA C 950

Level A shows the deflection which must be achieved without any pipe damage (bore cracking) occurring. Level B is the required structural strength. Values in parentheses are requirements of AWWA C950.

CONTINUOUS FILAMENT WINDING

PROCESSES: SUPERLIT GRP pipes are produced by the continuous filament winding process using fully automatic machinery. The pipe wall is made from glass fibre reinforced polyester and fillers. The inner and outer layers of the pipe wall have a high concentration of glass fibre reinforced polyester. This gives the pipe outstanding chemical resistance.

The mid-layer of the pipe provides both the longitudinal and circumferential strength to withstand pressure and the required stiffness.

MATERIAL: The glass fibre reinforced polyester used in the manufacture of SUPERLIT GRP pipes is a thermoset. Its properties are unaffected by the temperature changes which occur just after curing.

The polyester resin used in SUPERLIT GRP pipes determines its level of chemical resistance. All polyester resins used in the manufacture of SUPERLIT GRP pipes – orthophtalic, isophtalic – are suitable for the transportation of potable water, wastewater and sewage. They have a working temperature range of -40°C to +50°C.

PRODUCTION

The principal machine used in the manufacturing process consists of a continuous steel band formed into a cylindrical mandrel.

The mandrel is controlled by a Programmable Logic Control (PLC) system managed by a computer (PC) interface. The PLC-PC modules ensure that fully integrated process control is achieved based on a series of pre-programmed commands.

The first step in the production process is for the operator to enter the basic pipe data into the PC including pipe diameter, rigidity, and pressure class. The PC then calculates the correct machine settings. As the mandrel moves, glass fibre, polyester resin, sand, fillers and surface coating materials are added to the process in exact quantities. The process parameters and pipe thickness are continuously monitored and recorded.

Laminate curing is activated along the mandrel by heating elements. Laminate temperature is measured at multiple points throughout the curing zone, and displayed graphically on the PC control system.
Two separate resin delivery lines mean it is possible to apply a special resin to the internal pipe surface – for example, if the pipe is to be used to transport chemically aggressive liquids – whilst using standard resin for the mid and outer layers.

Pipe length is one of the initial parameters entered into the system. Once the manufacturing process is in operation, clean perpendicular cuts are achieved automatically by the integrated cutting unit. Pipes can be cut at any length between 0.3m and 15m.

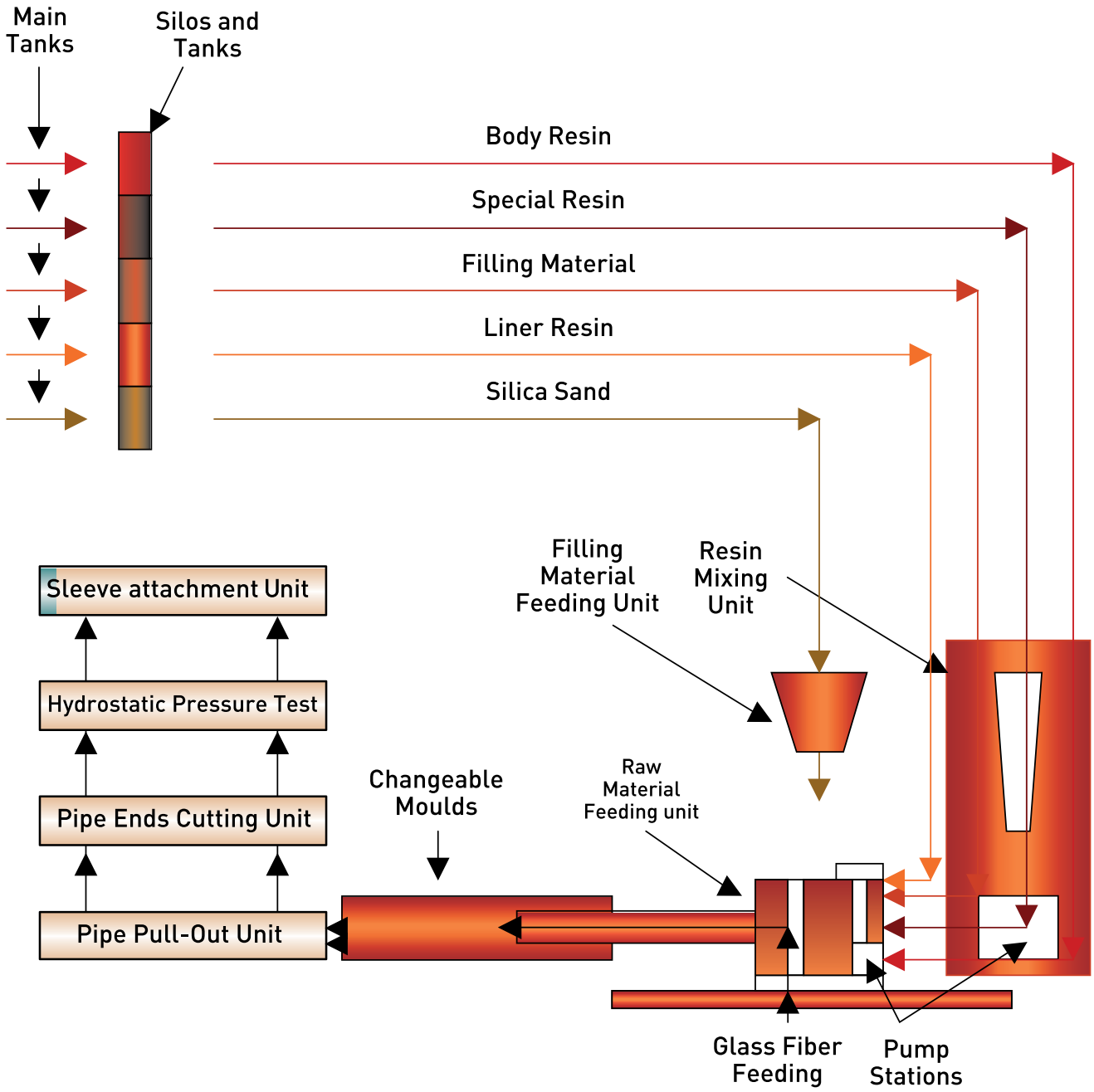
Once cut, the pipes transfer to the lifting tables. From the tables they pass to the chamfering and calibration unit and then, finally, to the hydrostatic testing unit.


012

CENTRIFUGAL CASTING PROCESS

In the centrifugal casting process, SUPERLIT GRP pipes are produced by feeding the raw materials – glass fibre, polyester resin, silica sand – into a rotating mould. The raw materials continue to be added until the desired wall thickness has been achieved.

PRODUCTION FLOW CHART



PRODUCTION PROCESSES:

The centrifugal casting process is automatically electronically controlled. The following parameters are continuously measured:

- Raw material quantities,
- Mould rotation speed,
- Pipe lamination
- Internal mould temperature

A feeder arm introduces the raw materials into the mould in the desired quantities. The resin – specially formulated not to polymerise during the filling process – and the glass fibres – cut to the desired design length – are poured into the mould from the head at the end of the feeder arm.

The distribution of glass fibres across the different layers within the pipe in the centrifugal casting process is controlled by using variable cutters and mould speeds. This ensures the pipe meets the axial and circumferential resistance parameters specified in the pipe design.

The mould is initially rotated relatively slowly. When all raw materials have been added, the rotation speed is accelerated to increase compression which initiates the curing process.

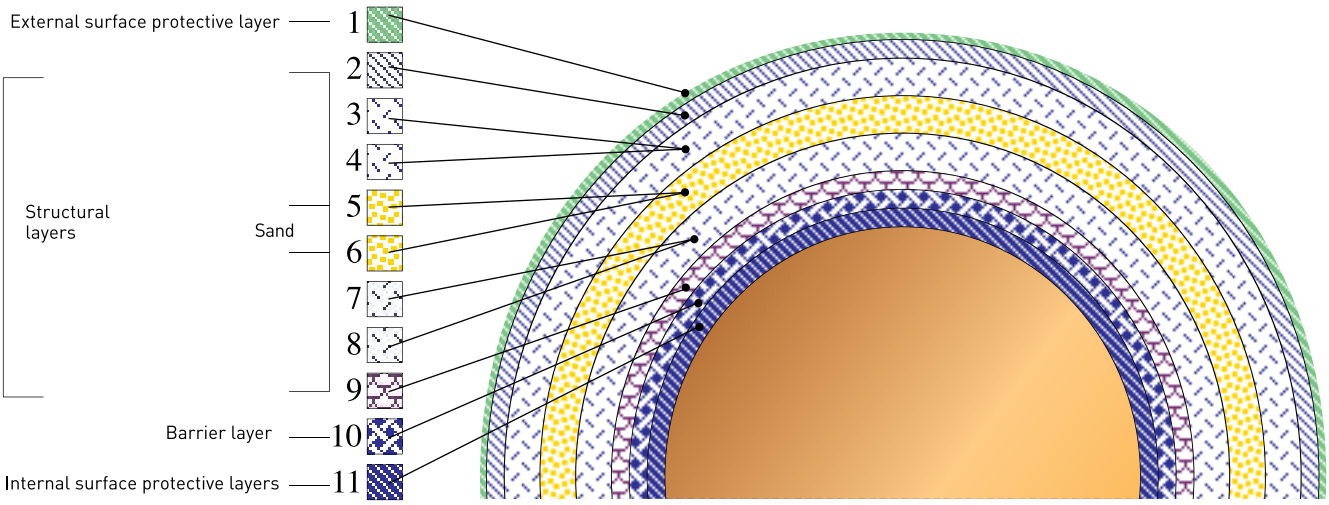
The linear movement up and down the mould of the feeder arm ensures the required pipe wall thickness is achieved.

WALL THICKNESS DESIGN

SUPERLIT has developed a new system to optimise the distribution of glass fibres across the pipe wall regardless of pipe diameter. The new system facilitates greater accuracy in pipe design and in determining the long-term behavioural properties of the pipe.

During the production process, the distribution of glass fibres across the pipe wall is controlled by using variable cutter and mould speeds. Each layer of the pipe wall has a specific function. If you take a cross-section of the pipe, the innermost layer consists entirely of flexible resin. This layer is designed to ensure that no fluids or solids carried by the pipe can penetrate to the structural layers.

The structural layers vary according to the design pressure and rigidity class of the pipe. The surface layer protects the pipe against impact damage during the pipe laying process. It also acts as a UV barrier.



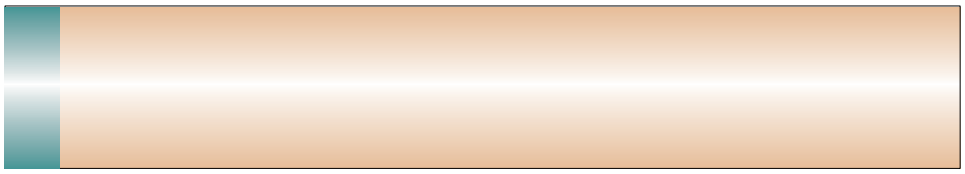
SUPERLİT GRP Pipe section (Typical)

PIPE DIAMETERS

SLEEVE EXTERNAL DIAMETER MEASUREMENTS.
SUPERLIT GRP Sleeve and External Diameter Measurements are given in mm. External diameters are given approximately.

PIPE DIAMETERS

SUPERLIT GRP pipe and fittings are produced in the following standard sizes. Please note, non-standard sizes can be manufactured upon request.



Nominal diameter of the pipe (mm)	Nominal diameter of the pipe (inch)	External diameter of the pipe (mm)
300	12”	324.3
350	14”	376.1
400	16”	427.1
450	18”	475.3
500	20”	530.1
600	24”	633.1
700	28”	718.3
800	32”	819.9
900	36”	924.1
1000	40”	1026.1
1100	44”	1125.0
1200	48”	1228.8
1300	52”	1331.5
1400	56”	1433.6
1500	60”	1535.6
1600	64”	1637.6
1700	68”	1739.4
1800	72”	1841.7
1900	76”	1943.4
2000	80”	2045.8
2100	84”	2147.9
2200	88”	2250.0
2300	92”	2351.4
2400	96”	2453.0
2500	100”	2555.0
2600	104”	2657.0
2700	108”	2758.0
2800	112”	2860.0
2900	116”	2962.0
3000	120”	3065.0
3100	124”	3167.0
3200	128”	3269.0
3300	132”	3371.0
3400	136”	3473.0

FITTINGS

SUPERLIT GRP couplings and accessories are integral to a wide range of applications including the transportation of potable water, wastewater, and sewage in pressure and non-pressure pipelines. The range of fittings includes:

- Couplings
- Tees
- Reducers
- Flanges
- Elbows
- Manhole sections

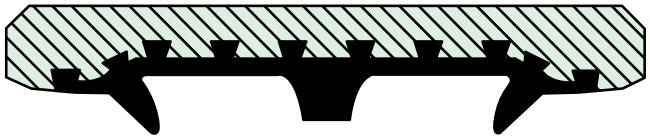
The manufacture of all SUPERLIT GRP fittings complies with strict quality standards.
Please see page 13 for further information.

GRP COUPLINGS

SUPERLIT GRP pipe coupling parts are developed for GRP pipes in compliance with international standards and are being used in transport of the irrigation water, potable water, wastewater sewage water by gravity or pressure and hydro power applications.

GRP COUPLINGS

Pipe and external coupling diameters



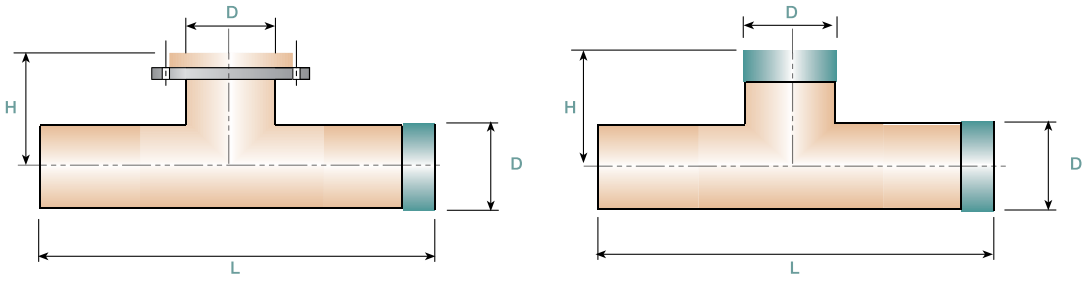
Special design internal surface coated with EPDM provides tightness unger high pressures. The internal surface of SUPERLIT GRP couplings is coated completely with EPDM material and when compared with the similar systems, it guarantees safer joining tightness and leak proofing.

SUPERLIT GRP pipes produced by centrifugal casting and continuous filament winding systems, have the same external diameters. Doue to this reason, the same GRP couplings can be used in the pipes produced by both methods.

All measurements are in mm. External pipe diameters are approximate.

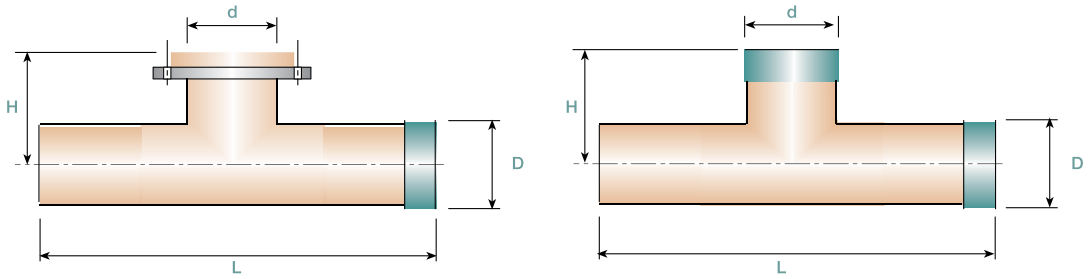
Pipe Diameters	Couplings Width	Couplings Diameter - Dc (mm)					
DN (mm)	L (mm)	PN (1-10)	PN 12	PN 16	PN 20	PN 25	PN 32
250	220	305	305	305	307	308	310
300	220	356	356	356	357	359	361
350	220	408	408	408	409	411	413
400	242	460	460	462	464	465	467
450	242	509	509	511	512	514	515
500	242	564	566	567	569	572	575
600	242	668	670	671	674	679	684
700	260	757	758	760	763	769	775
800	260	859	862	864	367	873	880
900	260	963	964	967	971	977	985
1000	260	1067	1068	1071	1075	1081	1089
1100	260	1169	1170	1174	1179	1185	1194
1200	260	1271	1274	1276	1282	1290	1297
1300	260	1375	1378	1381	1387	1394	1403
1400	275	1479	1481	1483	1490	1498	1507
1500	275	1582	1585	1587	1593	1602	1611
1600	275	1686	1689	1691	1697	1705	1715
1700	?75	1788	1791	1794	1801	1809	1820
1800	275	1893	1895	1898	1907	1915	1925
1900	275	1995	1997	2002	2010	2018	2029
2000	275	2098	2101	2106	2114	2122	2133
2100	275	2199	2203	2208	2216	2224	2235
2200	275	2302	2307	2312	2320	2328	2338
2300	275	2405	2410	2415	2423	2431	2442
2400	275	2508	2513	2518	2526	2534	2545
2500	330	2605	2609	2613	2619	2627	2635
2600	330	2707	2712	2715	2722	2730	2738
2700	330	2811	2815	2819	2825	2833	2841
2800	330	2914	2919	2922	2929	2937	2945
2900	330	3018	3022	3026	3032	3040	3048
3000	330	3121	3126	3129	3136	3144	3152
3100	330	3230	3235	3238	3245	3253	3261
3200	330	3329	3334	3337	3344	3352	3360
3300	330	3433	3438	3441	3448	3456	3463
3400	330	3536	3541	3544	3551	3559	3567

EQUAL T'S



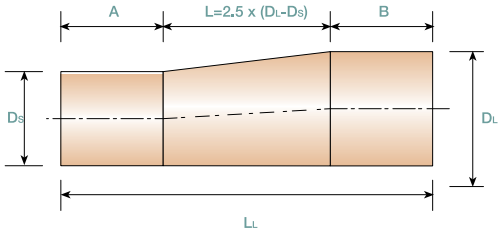
D	L	H
mm	mm	mm
300	1200	550
350	1300	575
400	1400	600
450	1500	625
500	1600	650
600	1800	800
700	2000	850
800	2200	900
900	2400	950
1000	2600	1000
1100	2800	1300
1200	3000	1350
1300	3200	1400
1400	3400	1450
1500	3600	1500
1600	3800	1550
1700	4200	1650
1800	4200	1650
1900	4600	2000
2000	4600	2000
2100	5000	2100
2200	5000	2100
2300	5400	2200
2400	5400	2200
2500	5800	2400
2600	5800	2400
2700	6200	2600
2800	6200	2600
2900	6600	2800
3000	6600	2800
3100	7000	3000
3200	7000	3000
3300	7400	3200
3400	7400	3200

UNEQUAL T'S

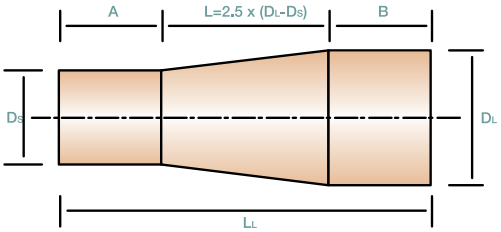


D	d	L	H
mm	mm	mm	mm
300	50 - 250	1100	550
350	50 - 300	1200	575
400	50 - 350	1300	600
450	50 - 400	1400	625
500	50 - 450	1500	650
600	50 - 500	1600	800
700	50 - 600	1800	850
800	50 - 700	2000	900
900	50 - 800	2200	950
1000	50 - 900	2400	1000
1100	50 - 1000	2600	1300
1200	50 - 1100	2800	1350
1300	50 - 1200	3000	1400
1400	50 - 1300	3200	1450
1500	50 - 1400	3400	1500
1600	50 - 1500	3600	1550
1700	50 - 1600	4000	1650
1800	50 - 1700	4000	1650
1900	50 - 1800	4400	2000
2000	50 - 1900	4400	2000
2100	50 - 2000	4800	2100
2200	50 - 2100	4800	2100
2300	50 - 2200	5200	2200
2400	50 - 2300	5200	2200
2500	50 - 2400	5600	2400
2600	50 - 2500	5600	2400
2700	50 - 2600	6000	2600
2800	50 - 2700	6000	2600
2900	50 - 2800	6400	2800
3000	50 - 2900	6400	2800
3100	50 - 3000	6800	3000
3200	50 - 3100	6800	3000
3300	50 - 3200	7200	3200
3400	50 - 3300	7200	3200

REDUCERS



Reducer (Eccentric)

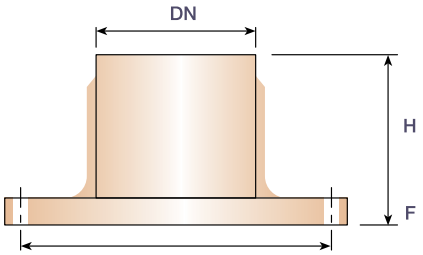


Reducer (Concentric)

DL (mm)	DS (mm)	A = B (mm)	L (mm)	LL (mm)
300	200	400	250	1050
300	250	400	125	925
350	250	400	250	1050
350	300	400	125	925
400	300	400	250	1050
400	350	400	125	925
450	350	400	250	1050
450	400	400	125	925
500	350	400	375	1175
500	400	400	250	1050
600	400	400	500	1300
600	500	400	250	1050
700	500	400	500	1300
700	600	400	250	1050
800	600	400	500	1300
800	700	400	250	1050
900	700	400	500	1300
900	800	400	250	1050
1000	800	400	500	1300
1000	900	400	250	1050
1100	900	400	500	1300
1100	1000	400	250	1050
1200	1000	500	500	1500
1200	1100	500	250	1250
1300	1100	500	500	1500
1300	1200	500	250	1250
1400	1200	500	500	1500
1400	1300	500	250	1250
1500	1300	500	500	1500
1500	1400	500	250	1250
1600	1500	600	250	1450
1600	1400	600	500	1700
1700	1500	600	500	1700
1700	1600	600	250	1450

DL (mm)	DS (mm)	A = B (mm)	L (mm)	LL (mm)
1800	1400	600	1000	2200
1800	1600	600	500	1700
1900	1700	600	500	1700
1900	1800	600	250	1450
2000	1600	600	1000	2200
2000	1800	600	500	1700
2100	1900	600	500	1700
2100	2000	600	250	1450
2200	2000	600	500	1700
2200	2100	600	250	1450
2300	2100	600	500	1700
2300	2200	600	250	1450
2400	2200	600	500	1700
2400	2300	600	250	1450
2500	2300	750	500	2000
2500	2400	750	250	1750
2600	2400	750	500	2000
2600	2500	750	250	1750
2700	2500	750	500	2000
2700	2600	750	250	1750
2800	2600	750	500	2000
2800	2700	750	250	1750
2900	2700	750	500	2000
2900	2800	750	250	1750
3000	2800	750	500	2000
3000	2900	750	250	1750
3100	2900	900	500	2300
3100	3000	900	250	2050
3200	3000	900	500	2300
3200	3100	900	250	2050
3300	3100	900	500	2300
3300	3200	900	250	2050
3400	3200	900	500	2300
3400	3300	900	250	2050

FLANGES

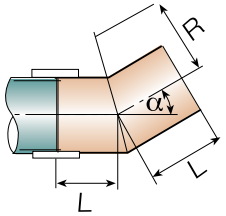


(Plain) Flange

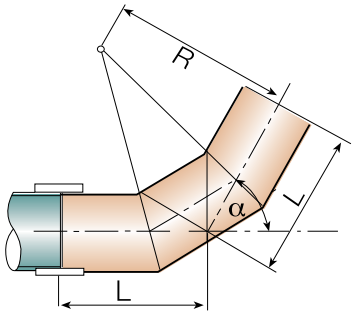
PN 0-16	
DN	H (mm)
300	600
350	600
400	600
450	600
500	600
600	600
700	600
800	600
900	600
1000	600
1100	700
1200	700
1300	800
1400	800
1500	800
1600	900
1700	900
1800	1000
1900	1000
2000	1000
2100	1100
2200	1100
2300	1200
2400	1200
2500	1300
2600	1300
2700	1400
2800	1400
2900	1500
3000	1500
3100	1600
3200	1600
3300	1800
3400	1800

Flanges comply with all relevant international standards

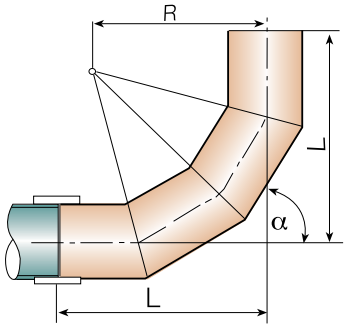
ELBOWS



α ≤ 30°



30°< α ≤ 60°



60°< α ≤ 90°

DN	R	11.25° L	22.5° L	30° L	45° L	60° L	90° L
300	450	275	300	325	400	450	650
350	525	275	300	325	425	500	700
400	600	325	350	375	475	550	800
450	675	325	375	400	525	625	950
500	750	325	375	400	525	625	950
600	900	325	400	450	600	700	1075
700	1050	400	425	475	650	775	1200
800	1170	400	450	525	700	850	1350
900	1200	400	475	550	725	875	1400
1000	1270	425	500	575	750	925	1450
1100	1320	475	525	600	800	1000	1550
1200	1370	475	525	600	825	1025	1600
1300	1420	500	550	650	875	1075	1650
1400	1470	500	575	675	900	1100	1700
1500	1570	550	650	725	1025	1250	1900
1600	1670	600	675	800	1100	1300	2000
1700	1770	675	775	850	1200	1400	2200
1800	1870	675	775	850	1200	1400	2200
1900	1970	700	800	900	1300	1500	2400
2000	2070	700	800	900	1300	1500	2400
2100	2170	775	875	950	1400	1600	2600
2200	2270	775	875	950	1400	1600	2600
2300	2370	800	900	1000	1500	1700	2800
2400	2470	800	900	1000	1500	1700	2800
2500	2600	1000	1100	1200	1700	1900	3000
2600	2700	1000	1100	1200	1700	1900	3000
2700	2800	1100	1200	1300	1800	2000	3200
2800	2900	1100	1200	1300	1800	2000	3200
2900	3000	1200	1300	1400	1900	2100	3400
3000	3100	1200	1300	1400	1900	2100	3400
3100	3200	1300	1400	1500	2000	2200	3600
3200	3300	1300	1400	1600	2000	2200	3600
3300	3400	1400	1500	1700	2100	2300	3800
3400	3500	1400	1500	1700	2100	2300	3800

Please contact SUPERLIT for the dimensions of non-standard elbow sizes

SPECIAL APPLICATIONS

SUPERLIT GRP pipe is used in pipe jacking/tunnelling and re-lining/sliplining applications. In each application it delivers significant benefits compared to alternative materials:

Pipe jacking and tunnelling

- Long service life with minimal maintenance
- High compression strength
- Smooth non-absorbent external surface
- Accommodates long drives thereby reducing the number of jacking pits required
- High flow rates mean smaller pipe diameters may be possible
- Thin wall thicknesses minimise the parent tunnel diameter
- Close tolerances ensure improved load distribution
- Special flush couplings
- Uniformity and continuity of pipe properties

Re-lining / Sliplining

- Long service life with minimal maintenance
- High compression strength
- Light weight enables longer pushes to be achieved
- Thin wall thickness minimises capacity loss
- High flow rates often mean the original design flow can be maintained
- Pipe stiffness provides added structural strength
- Low profile couplings

Pipe Jacking

Pipe jacking is a trenchless technique for installing underground pipelines, ducts and culverts. Apart from the launch and reception pits for the TBM (Tunnel Boring Machine), no excavation is required.

UNIQUE DESIGN DEVELOPED BY SUPERLIT

Please consult SUPERLIT for guidance regarding pipe dimensions and other technical aspects of GRP pipes in pipe jacking applications.

Relining/Sliplining

Sliplining involves a GRP pipe being inserted inside an existing host pipe which is no longer fit for purpose.

PIPE INSTALLATION

General installation rules

Following best practice guidance when handling and installing SUPERLIT GRP pipes is vital to ensure optimum performance.

SUPERLIT GRP pipes are designed to accommodate the proposed bedding and backfill materials. Experience has shown that compressible granular materials are best suited for backfill. The following notes provide a general overview of best installation practice. The SUPERLIT project engineering team can provide detailed installation guidance. You can contact them on: **project@superlit.com.**

Trenching

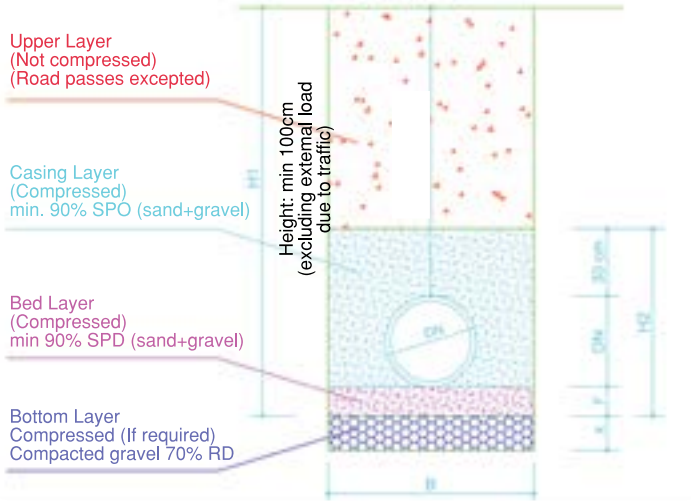
Standard trench details are shown in the diagram on page 44. The trench should be wide enough to allow sufficient backfill to be laid and compacted such that the sides of the pipe are adequately supported. The installation depths provided in this catalogue assume the trench width will be 1.75 times the nominal diameter of the pipe. Pipes may be installed in trenches only 1.5 times the nominal diameter of the pipe, but the depth of the trench will change accordingly.

If you are facing installation conditions outside these parameters, please contact the SUPERLIT team for technical support and guidance.

Bedding

The bedding material should ensure a smooth and regular surface for optimal pipe installation.

STANDARD INSTALLATIONS



GRP pipes standard trench configuration

B : Ditch Width (cm)
H1 : Ditch Depth (cm)
H2 : Casing Layer (cm)
y : Bed Layer (cm)
x : Bottom Layer (cm)

DN : Outer Diameter (cm)
DN < 600 mm : B=D + 2 x 30 cm
DN < 1000 mm : B=D + 2 x 40 cm
DN ≥ 1000 mm : B=D + 2 x 45 cm

y = min. 15 cm
x = min. 20 cm
H1 = 100 + y + DN (excluding extemal load due to traffic)
H2 = 30 + DN + y

Checking the installed pipe

The maximum vertical deflection value of each pipe installed should be controlled.
This method is very easy and fast.

Pipe deflection during installation

The vertical deflection of each installed pipe should be measured. The maximum permissible initial deflection is 3% for pressure pipe applications and 6% for non-pressure: these values are applicable to pipes in all rigidity classes. Pipes installed outside these tolerances may not achieve optimal performance.

Traffic loading

It is important that backfill is sufficiently compressed to accommodate continuous traffic loading. In certain circumstances, minimum installation depths can be reduced by encasing the pipe in concrete.
SUPERLIT's project design and construction support team can supervise pipe installations for clients if required.

Vehicle type	Kilo Newton	Traffic (Wheel) load	Minimum burial depth
		lbs. force	metre
AASHTO H20 (C)	72	16.000	1.0
BS 153 HA (C)	90	20.000	1.5
ATV LKW 12 (C)	40	9.000	1.0
ATV SLW 30 (C)	50	11.000	1.0
ATV SLW 60 (C)	100	22.000	1.5
Cooper E80	Railroad		3.0

Based on a minimum pipe zone encasement with 6.9 MPa module material.

High Water Table

A minimum depth of earth cover (min. dry soil bulk density of 1900 kg/m^3) equivalent to one pipe diameter is required to prevent an empty submerged pipe from floating. Alternatively, the pipes could be anchored. If anchoring is used, restraining straps must use a flat material with a minimum width of 25mm and be placed at 4m intervals.

Please contact the SUPERLIT project team for further details on anchoring and minimum earth cover calculations.

Trenchless Technology

In urban environments, open trench excavations may be prohibitively expensive, disruptive or impracticable. 'Trenchless Technology' covers techniques such as pipe jacking and sliplining which minimise excavation requirements.

Sliplining

SUPERLIT GRP pipes can be manufactured to meet project-specific dimensions. Consequently, for the purposes of sliplining, the external GRP pipe diameter can be optimised by making it match the internal diameter of the host pipe.

SUPERLIT GRP pipe used in the sliplining of non-pressure pipes has a 'flush' coupling which ensures the simple and straightforward installation of the pipe whilst optimising potential flow capacity. SUPERLIT's ability to manufacture pipes in any length up to 15m has the potential to further reduce installation times. Faster installation times reduce overall installation costs and minimise service losses incurred whilst the original pipe is out of action.

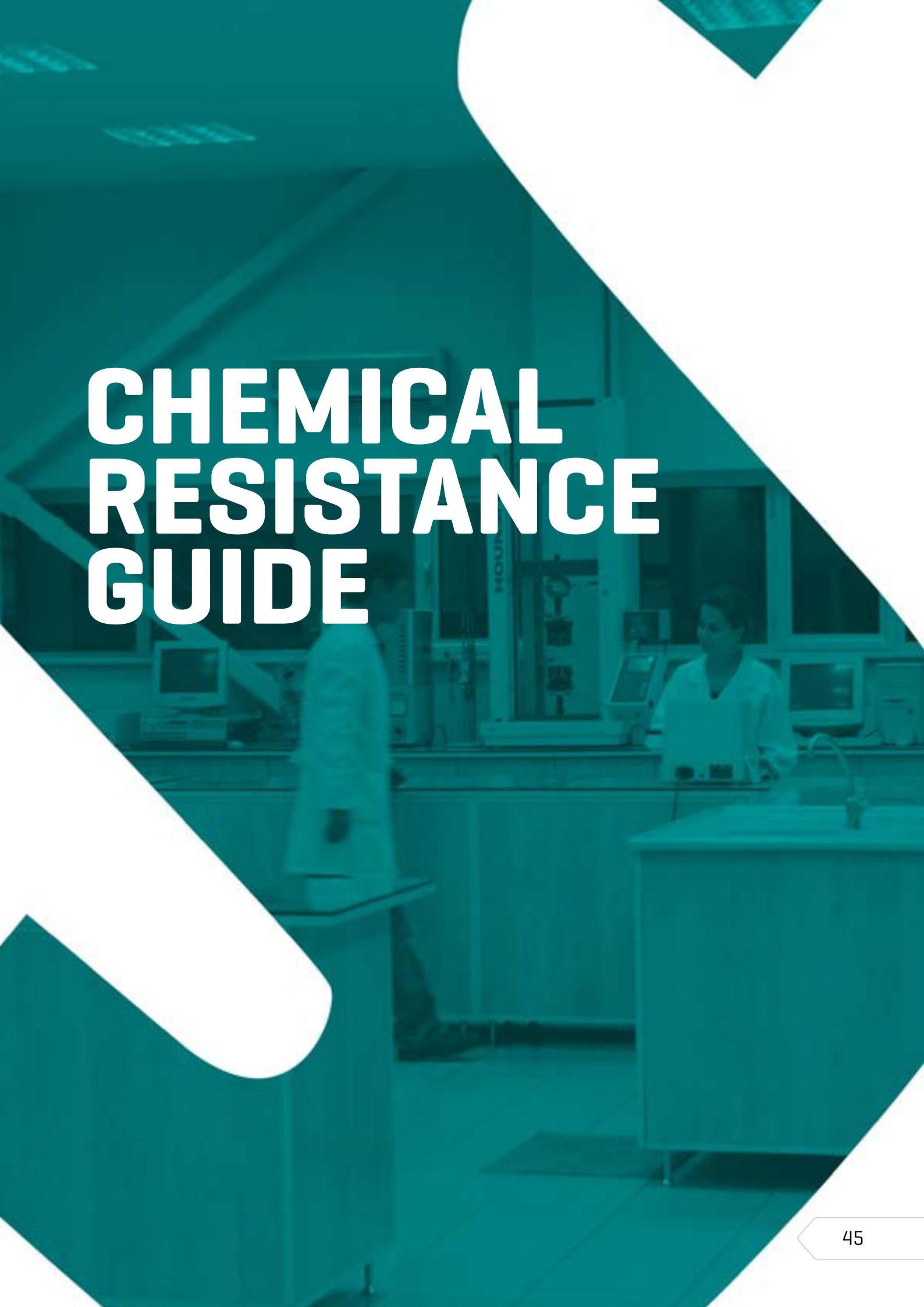
FEATURES	BENEFITS
Custom diameter capabilities	Minimize interior diameter less of excisting pipe, maximizes flow capabilities.
Custom length	Easier, faster installation, less pipe line service downtime.
Non-projecting coupling joint	Eases installation, maximizes outside diameter of new pipe.

Pipe jacking and micro-tunnelling

SUPERLIT GRP pipes are ideally suited for both pressure and non-pressure pipe jacking and micro-tunnelling applications. The internal layer of the pipe provides a pressure-rated chemical resistant layer surface. The remaining composite layers provide the strength required to withstand the considerable forces needed to 'jack' the pipe.

FEATURES	BENEFITS
Corrosion-resistant material	AU the benefits of standard SUPERLIT GRP pipes
SUPERLIT coupling technology	Pressure rating same as standard SUPERLIT GRP pipes
GRP outer layer	Permits pipe to be "jacked" in the same manner as non-GRP pipes

CHEMICAL RESISTANCE GUIDE



CORROSION RESISTANCE

The chemical resistance of SUPERLIT GRP pipes depends on a number of factors: the selected resin; the temperature of the material being transported in the pipeline; and the concentration of chemicals contained in the material. In extreme cases, special rubber compounds are needed to ensure the seals used in the couplings have the same service life as the pipe. The barrier layer underneath the internal pipe surface prevents materials reaching the structural layers of the pipe wall in the event of a surface crack. The centrifugal process removes air and styrene vapour which provides further protection against materials or gas penetrating the pipe wall. Furthermore, the glass fibres are completely 'wetted out' during the manufacturing process thus preventing stress corrosion.

The following pages focussing on chemical resistance provide a general overview only and should not be used as a design guide. SUPERLIT's technical team are happy to provide assistance regarding design considerations where chemical resistance is a concern. SUPERLIT, working in partnership with resin manufacturers, can design and manufacture pipes for specific conditions. However, no responsibility can be accepted without prior consultation by the customer with the SUPERLIT technical team.

In the following tables, where both standard and special pipes are indicated for a particular chemical this implies that the standard pipe is suitable for lower concentrations of the chemical at lower temperatures whereas custom-designed pipes are required for higher concentration and higher temperature levels.

Chemical	Standard Pipe	Special Pipe
Acetic Acid		×
Acrylic Acid		×
Alcohol Ethyl	×	×
Atcohol Isopropyl	×	×
Alcohol Methyl Isobutyl		×
Alcohol Secondary Butyl		×
Alun	×	×
Aluminium Chloride	×	×
Aluminium Flouride	×	×
Aluminium Hydroxide		×
Aluminium Nitrate	×	×
Aluminium Potassium Sulfate	×	×
Ammonia Aqueous		×
Ammonia Gas		×
Ammonium Bicarbonate		×
Ammonium Bisulfate		×
Ammonium Carbonate		×
Ammonium Chloride	×	×
Ammonium Citrate		×
Ammonium Flouride		×
Ammonium Hydroxide		×
Ammonium Nitrate	×	×
Ammonium Persulfate		×
Ammonium Phosphate	×	×
Ammonium Sulfate	×	×
Analine Sulfate		×
Barium Carbonate		×
Barium Chloride	×	×
Barium Hydroxide		×

Chemical	Standard Pipe	Special Pipe
Barium Sulphate	×	×
Beer	×	×
Benzine Sulphonic Acid		×
Benzoic Acid		×
Cadium Chloride		×
Calcium Bisulfite		×
Calcium Carbonate		×
Calcium Chlorate		×
Calcium Chloride	×	×
Calcium Hydroxide		×
Calcium Nitrate	×	×
Calcium Sulfate	×	×
Calcium Sulfite		×
Cane Sugar Liquid		×
Caprylic Acid		×
Carbon Dioxide	×	×
Carbon Monoxide in gas form	×	×
Chlorine, dry gas		×
Chlorine, wet gas		×
Citric Acid	×	×
Copper Chloride	×	×
Copper Cyanide		×
Copper Flouride		×
Copper N traie:	×	×
Copper Sulphate	×	×
Crude Oil, sour	×	×
Crude Oil, sweet	×	×
Diesel Fuel	×	×
Ethylene Glycol	×	×

If you require guidance on a chemical not featured in the above table, please contact SUPERLIT for more information.

Chemical	Standard Pipe	Special Pipe
Ferric Chloride	×	×
Ferric Nitrate	×	×
Ferric Sulphate	×	×
Ferrous Chloride	×	×
Ferrous Nitrate	×	×
Ferrous Sulphate	×	×
Flobonic Acid	×	×
Fluosilicic Acid	×	×
Formic Acid	×	×
Fuel Oil	×	×
Gas, natural		×
Gluconic Acid		×
Glucose	×	×
Glycerine	×	×
Heptane		×
Hexane		×
Hexylene Clycol		×
Hydraulic Fluid		×
HydrohSoric Acid		×
Hydroyanid Acid		×
Hydrofluosilicic Acid		×
Hydrogen Bronide, wet gas		×
Hydrogen Chloride, dry gas		×
Hydrogen Chloride, wet gas		×
Hydrogen Sulfide, liquid	×	×
Hydrogen Flouride, vapour		×
Hydrosulfide Bleach		×
Hydrochlorous Acid		×
Isopropyl Amine		×

Chemical	Standard Pipe	Special Pipe
Isopropyl Palmitate		×
Kerosene		×
Lactic Acid		×
Laurel Chloride		×
Laurie Acid		×
Lead Acetate		×
Levulinic Acid		×
Lithium Bromide		×
Lithium Sulfate		×
Magnesium Bisulfit		×
Magnesium Carbonate		×
Magnesium Chloride	×	×
Magnesium Hydroxide		×
Magnesium Sulfate	×	×
Maelic Acid		×
Mercuric Chloride	×	×
Mercurous Chloride	×	×
Mineral Oils	×	×
Motor Oil		×
Myristic Acid		×
Naptha		×
Napthalene		×
Nickel Chloride	×	×
Nickel Nitrate	×	×
Nickel Sulfate	×	×
Octanoic Acid		×
Oleic Acid		×
Oxalic Acid		×
Perchloretylene		×

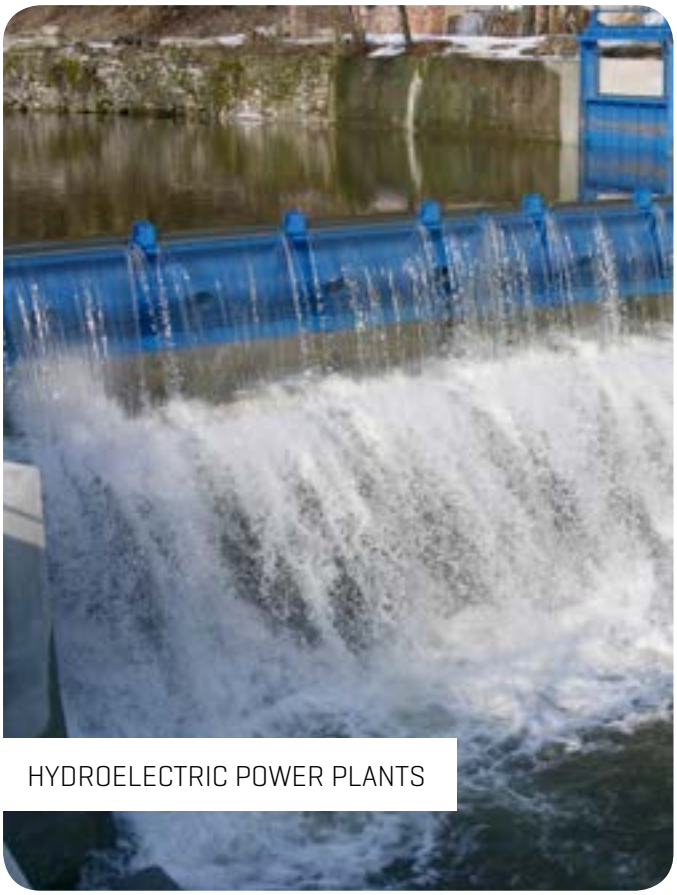
If you require guidance on a chemical not featured in the above table, please contact SUPERLIT for more information.

Chemical	Standard Pipe	Special Pipe
Phosphoric Acid	×	×
Phosphorous Pentoxide		×
Phtalic Acid		×
Potassium Alum Sulfate	×	×
Potassium Bicarbonate		×
Potassium Bromide	×	×
Potassium Carbonate		×
Potassium Chloride	×	×
Potassium Dichromate		×
Potassium Ferrocyanid		×
Potassium Hydroxide		×
Potassium Nitrate	×	×
Potassium Persulfate		×
Potassium Sulphate	×	×
Propylene Glycol		×
Salicylic Acid		×
Sebacic Acid		×
Soaps	×	×
Sodium Acetate		×
Sodium Aluminate		×
Sodium Benzoate		×
Sodium Bicarbonate		×
Sodium Biflouride		×
Sodium Bisulfate	×	×
Sodium Bisulfite	×	×
Sodium Bromide	×	×
Sodium Chlorate		×
Sodium Chloride	×	×
Sodium Chlorite		×

Chemical	Standard Pipe	Special Pipe
Sodium Chromate		×
Sodium Cyanide		×
Sodium Dichromate		×
Sodium Diphosphate		×
Sodium Ferricyanide		×
Sodium Ferrocyanide		×
Sodium Flouride		×
Sodium Flouro Silicate		×
Sodium Laryl Sulfate		×
Sodium Nitrate	×	×
Sodium Nitrite	×	×
Sodium Silicate		×
Sodium Sulfate	×	×
Sodium Sulfide		×
Sodium Sulfite	×	×
Stannic Chloride		×
Stearic Acid	×	×
Sugar Cane Liquor		×
Sulfuric Acid	×	×
Tartaric Acid		×
Trichlor Acetic Acid		×
Trisodium Phosphate		×
Vegetable Oils	×	×
Vinegar	×	×
Water, demineralised	×	×
Water, distilled	×	×
Water, fresh	×	×
Water, sea	×	×
Zinc Chlorate		×

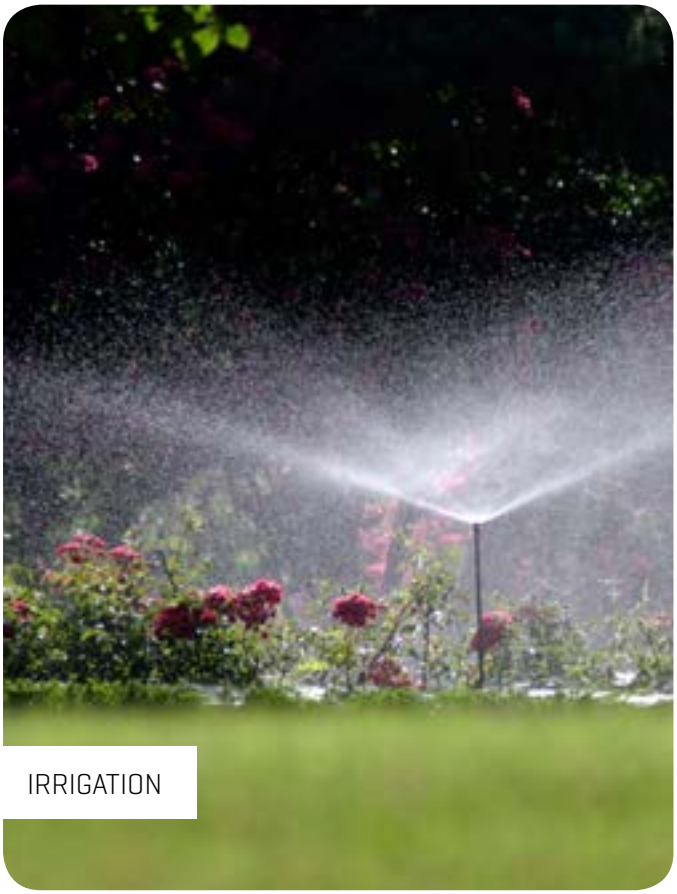
If you require guidance on a chemical not featured in the above table, please contact SUPERLIT for more information.

PROJECTS & APPLICATIONS



HYDROELECTRIC POWER PLANTS

INFRASTRUCTURE



IRRIGATION

SPECIAL APPLICATIONS

Conclusion

SUPERLIT is committed to remaining an international leader in the design and manufacture of GRP pipes and fittings. This commitment is based on the following key factors:

- Nominal Diameters: 300mm to 4000mm
- Pressure classes: 1 to 40 bar
- Stiffness classes: 1250, 2500, 5000, 10000, 20000N/m²
- NB – Bespoke GRP pipes with stiffness ratings greater than 20000N/m² can be manufactured on request

Notes