



FRP JACKING PIPES



60+ years

COMPANY PROFILE



SUPERLIT Group Manufacturing Facilities belongs to the KARAMANCI HOLDING established in 1961. Since the beginning of the sixties SUPERLIT has been present in Türkiye market and an international market as a leader of pipe manufacturer supplying their products to 5 continents worldwide.

Superlit FRP products made using the Filament Continues Winding and Helical Discontinues Winding technologies covering diameter range of 2" – 156" , with a stiffness of 9psi,18psi, 36psi, 72psi Nominal Pressure Class is 14,5 psi – 464psi and for special design is much higher for both SN & PN.

The Products are corrosion resistant, chemical resistant, and high-resistant in water and sewage applications and light in weight used in the following applications:

- 1. Clean Water and Potable Water Application
- 2. Irrigation Application
- 3. Hydroelectric Power Plant Application
- 4. Sewer Application
- 5. Storm Water Application
- 6. Water Treatment Application
- 7. Seawater Application
- 8. Trenchless & Jacking Application
- 9. Water Tank Storage Application
- 10. Petroleum Tank Application
- 11. Chemical Industrial Tank Application

The entire products produce by SUPERLIT are also simple to handle and are manufactured to a high quality in accordance to an international standards such as EN, ISO, ASTM and AWWA. SUPERLIT is the only FRP pipe manufacturer in Türkiye that has 3 different pipe production technologies: Continuous Filament Winding, Centrifugal Casting technology and Helical Filament Winding.

Integrated Management Systems Certificates (ISO 9001, ISO 14001 & ISO 45001) have been granted by the internationally recognized and reputable independent organizations. Being one of the world's leading manufacturers in the pipe industry with an experience of more than half century, SUPERLIT supplies pipes for projects in many different regions around the world from Europe to Africa and from America to Asia and Australia.

 PRESENCE IN 6 CONTINENTS

 64 YEARS OF EXPERIENCE

 3 DIFFERENT PIPE PRODUCTION TECHNOLOGIES

 ENGINEERING AND R&D

 PROVIDING SITE SUPERVISION

 QUALITY MANAGEMENT

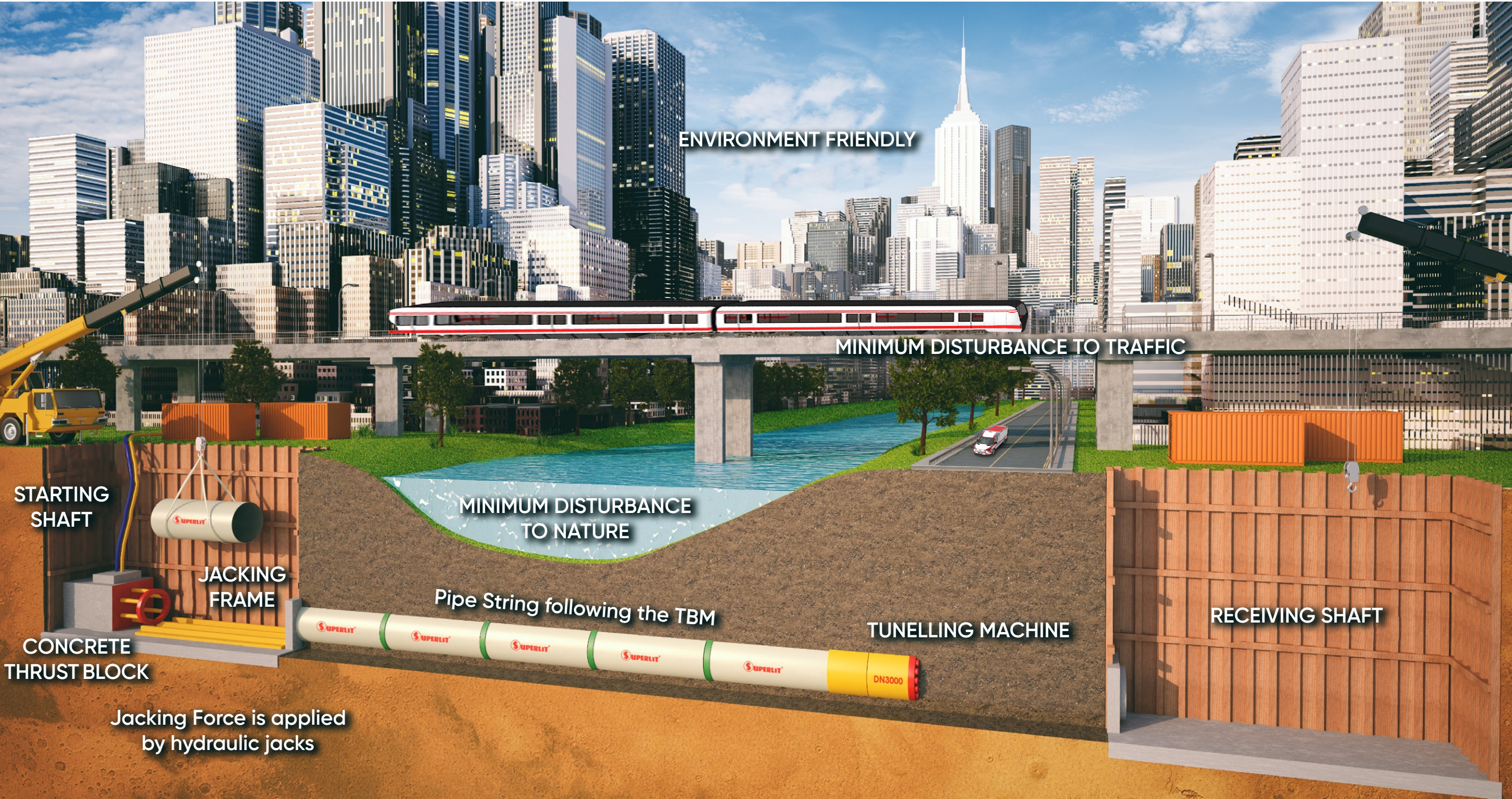
 ENVIRONMENT FRIENDLY AND SUSTAINABILITY

 WIDE FIELD SERVICE

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1. JACKING PIPES & BENEFITS



1.1 Introduction

Trenchless technologies are an engineering solution where it is not a good option to make open cut excavation for installation of underground pipelines. Within several technologies in this area; micro tunnelling method which is an underground tunnel construction technique has a wide acceptance due to its advantages. The machinery in this system is also called as TBM when worked diameters are in larger sizes, compared to micro tunnelling machines. When pipes are pushed behind the cutting machine by hydraulic jacking from a drive shaft, this method of construction

is called "pipe jacking". Superlit Jacking pipes are designed to be used according to above shortly described technique.

When pipes are pushed or pulled inside an old or existing line, this system is another trenchless technology and generally called as "slip-lining" or "re-lining" and Superlit FRP products can be designed and used for this system also. Consult to Superlit for details of needs in this application area.

1.2 Purpose and Scope

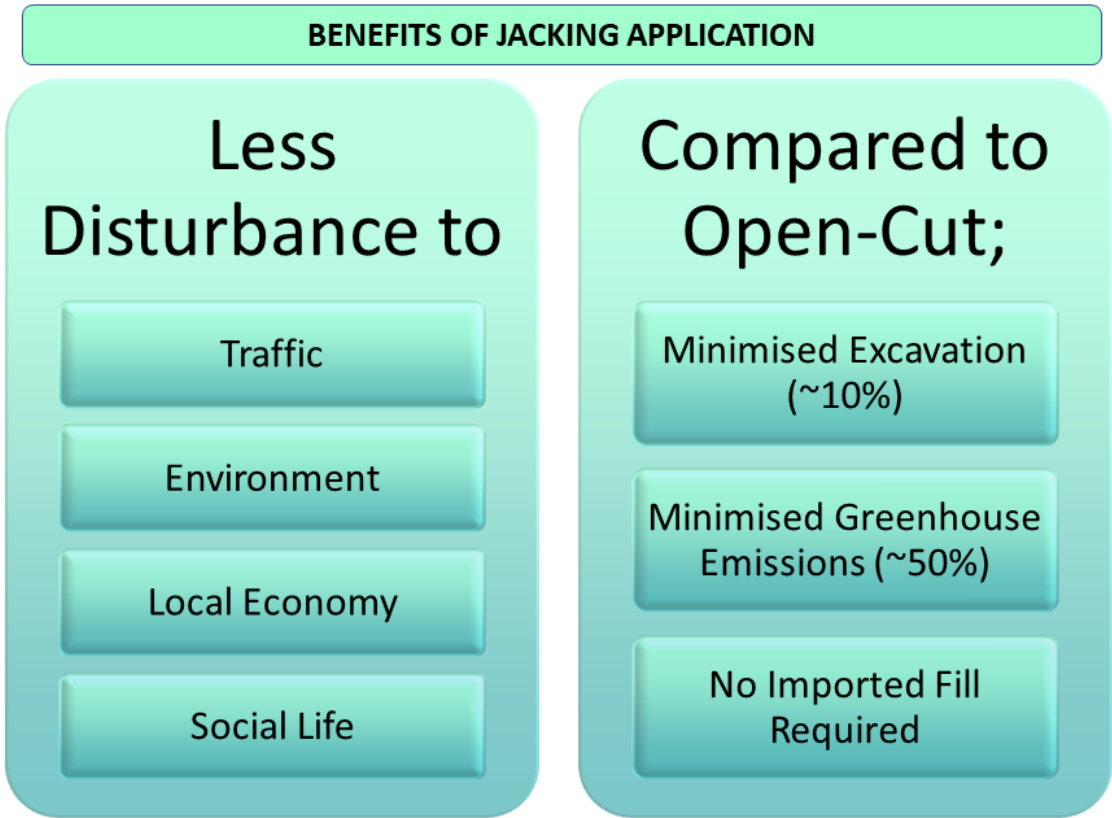
The purpose of this document is to guide on glass fiber reinforced thermosetting plastics – FRP piping systems (pipes and joints) intended to be installed with pipe jacking construction methodology.

1.3 Jacking Application and Benefits

There are various soil removal techniques in trenchless application such as steerable – non-steerable; manned – unmanned techniques. Each technique has its own different versions and machinery design. The selection of the trenchless technique depends on the borehole diameter, geological properties of the soil and ground water condition, jacking length and cover depth.

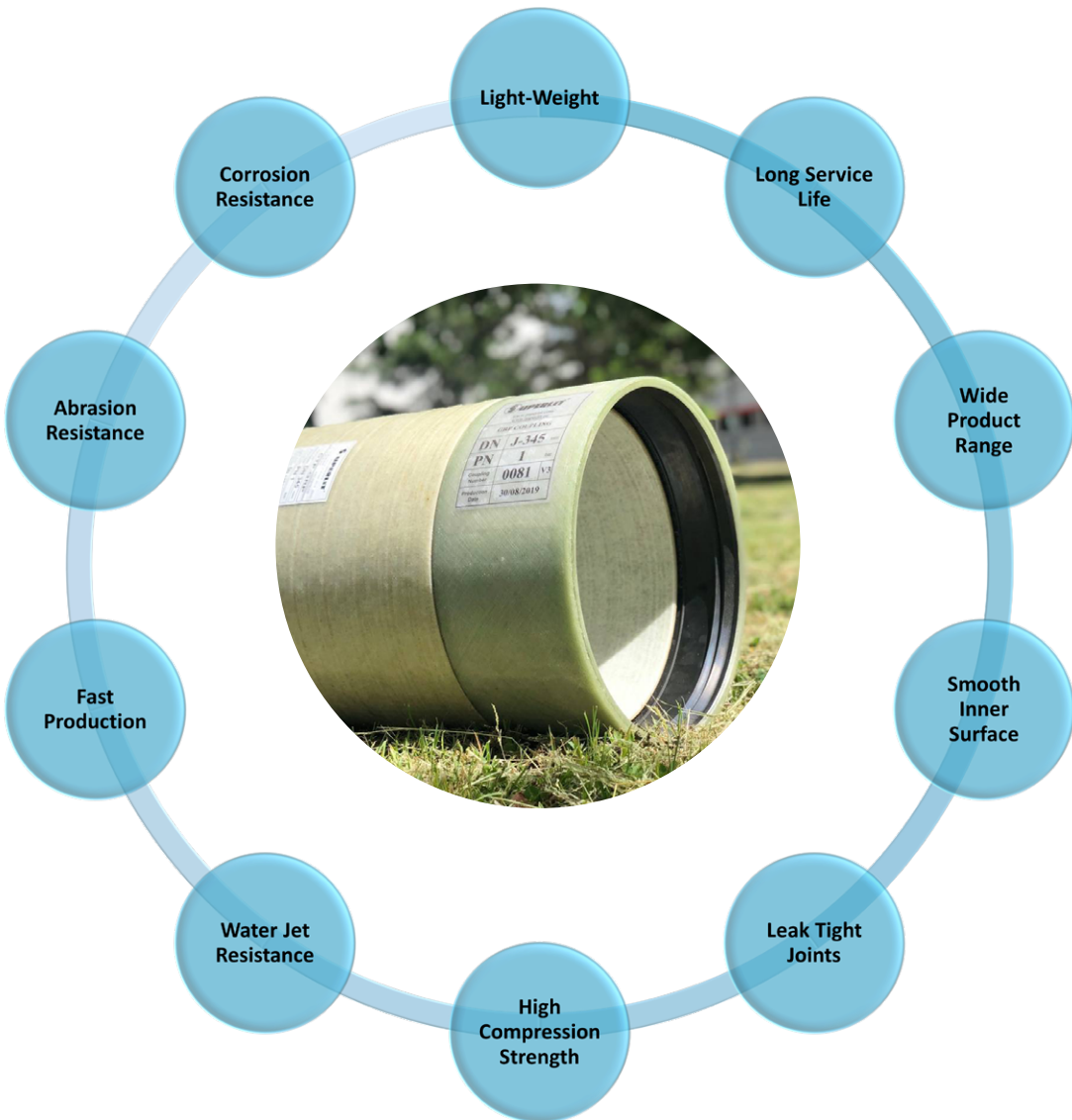
In non-steerable techniques there can be a misalignment on the route depending on the geological conditions and jacking distance. Steerable techniques are the choice where an accurate alignment is necessary for the project. Pipe jacking and micro-tunnelling technologies are mostly preferred where a precise alignment is required in order to avoid any damages to the other structures, service lines, adjacent building and civil engineering works. Laser beams, or navigation systems are located through the machine; measures, records and informs the machine operator related to any misalignment on the jacking route.

Pipe jacking systems also have, continuous lubricating system that reduces friction forces around pipe and soil and allows longer jacking lengths with less jacking forces.



1.4 FRP Jacking Pipes and Advantages

FRP jacking pipes have several advantages compared to the other rigid type of heavy weight jacking piping materials. Some of the benefits outcomes from the material properties of being a glass fiber reinforced composite and some of the benefits comes from the advantages from manufacturing processes as listed in below scheme.



Due to the above listed advantages, Superlit FRP Jacking pipes are the best choice for designers as an alternative to concrete and vitrified clay jacking pipes. Superlit FRP jacking pipes and joints are capable of resisting up to 16 bars internal pressure.

1.4.1 Raw Materials

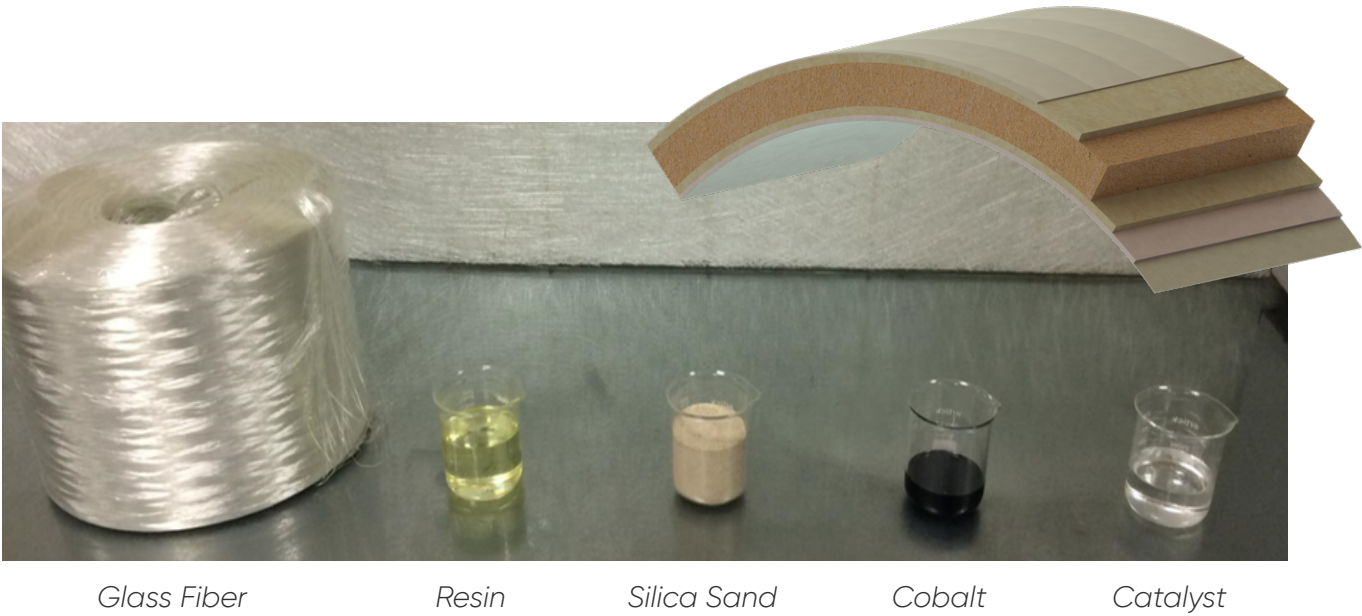
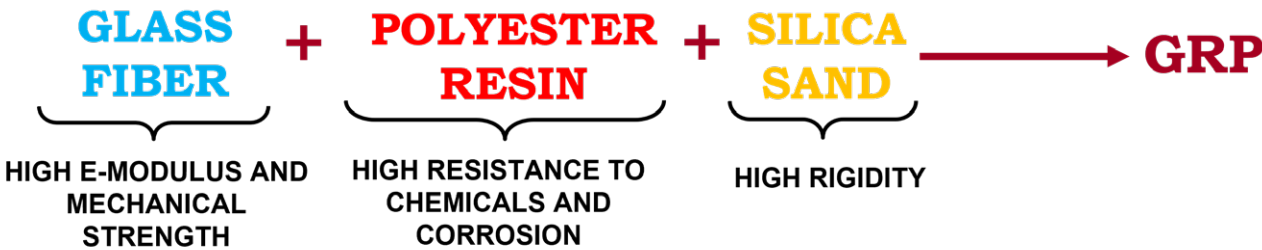
The main raw materials in the FRP composite structure are the polyester resin, glass fiber, silica sand filler and some chemicals such as cobalt and catalyst for proper curing of the structure. Type of the raw materials vary depending on the manufacturing technology in Superlit FRP Jacking Pipes. In accordance with the Quality Manual, only approved raw materials listed in vendor list can be used in production.

Quality plan is being followed for the testing of raw materials. At each delivery all raw materials are being tested in Superlit Raw Material Laboratory and can only be used in production after approval.

Glass Fiber: Glass fibers are the elements that gives the mechanical strength to FRP pipe. The most common type is E glass in production of FRP pipes. For a requirement of an improved properties against acid and chemicals ECR glass type is recommended. Fiberglass is generally used in the production as continuous roving cylindrical packages and can be directly used as a continuous hoop form and/ or chopped filament form depending on the selected manufacturing technology.

Resin: The second main component of the composite structure is the resin and it effects the chemical, thermal and mechanical properties of the structure. In the production of FRP pipes unsaturated polyester type thermosetting resins are used. Resin is the matrix of the composite structure, that keeps glass fibers and silica sand filler together in the designed orientation.

Filler: The other component that has a positive performance effect on the FRP structure is the silica sand filler. Silica sand filler which has a minimum 98% SiO₂ content provides stiffness and compressive strength to the FRP pipe.



1.4.2 Certificates, Standards and Performance Tests

SUPERLIT is the only FRP pipe manufacturer in Türkiye that has 3 different pipe production technologies: Continuous Filament Winding, Centrifugal Casting technology, Helical Filament Winding. Integrated Management Systems Certificates (ISO 9001, ISO 14001 & ISO 45001) have been granted by the internationally recognized and reputable independent organizations.



Standards developed by EN, ISO, AWWA, and ASTM cover a series of glass fiber reinforced pipe applications including conveyance of water, domestic wastewater and chemical substances. The common ground of all these standards is that all are performance-based. In other words, the performance tests required for the FRP pipe are defined in these standards. These standards include many Quality Control and performance tests. In addition to regular FRP pipe tests offered by the product standards, FRP jacking pipes are also subjected to longitudinal compressive strength test in order to prove jacking load limits.

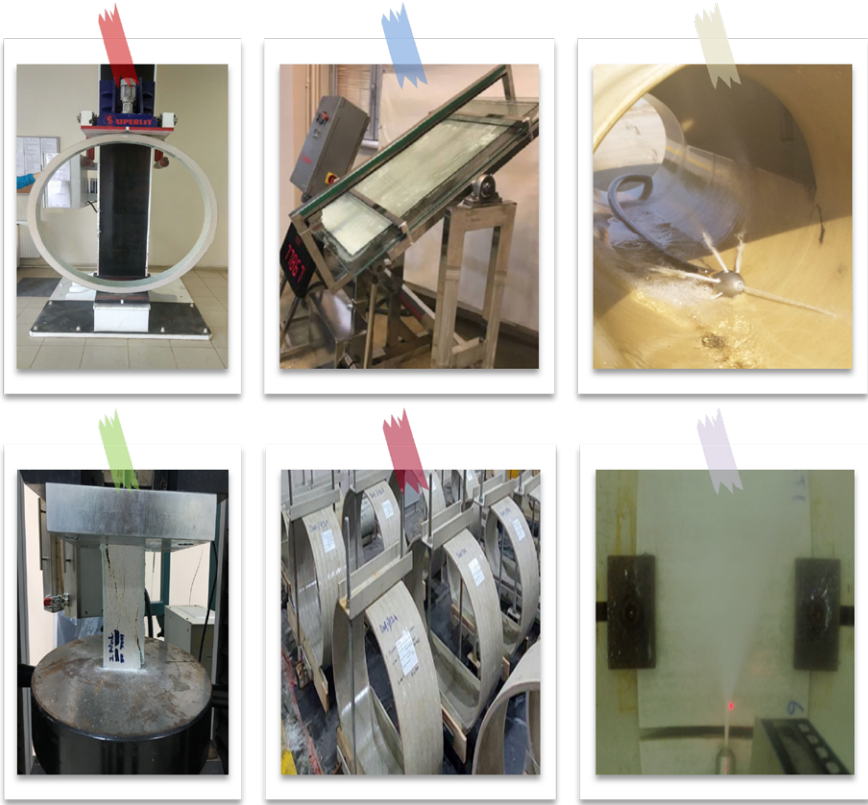
International product standard for FRP jacking pipes is ISO 25780. The main product standard for FRP pipes is ISO 23856 which is published recently. The full name of the standards is:

***ISO 25780:** Plastics piping systems for pressure and non-pressure water supply, irrigation, drainage or sewerage – Glass-reinforced thermosetting plastics (FRP) systems based on unsaturated polyester (UP) resin – Pipes with flexible joints intended to be installed using jacking techniques

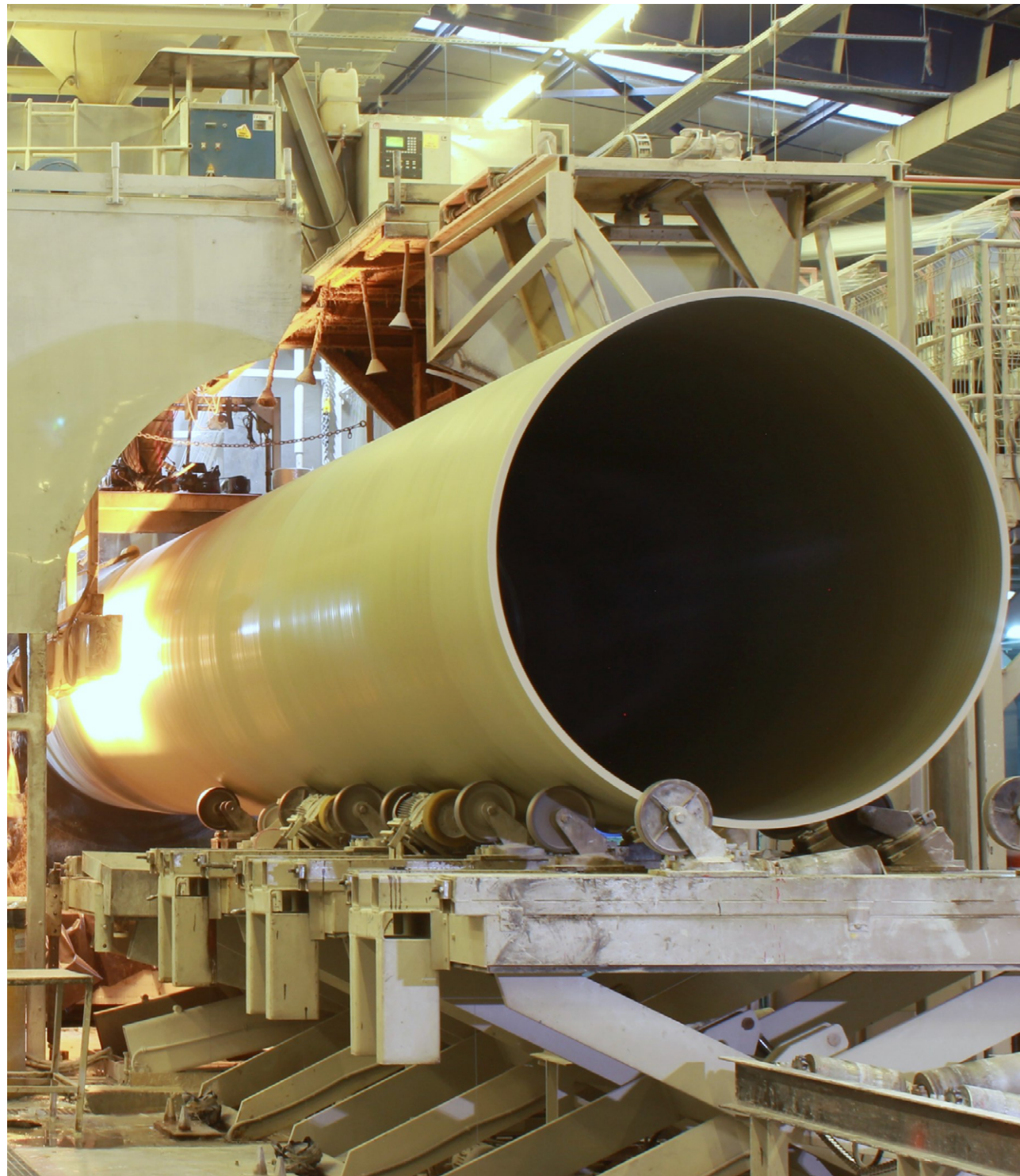
***ISO 23856:** Plastics piping systems for pressure and non-pressure water supply, drainage or sewerage – Glass-reinforced thermosetting plastics (FRP) systems based on unsaturated polyester (UP) resin

***ISO 10467 and ISO 10639** were the main reference standards for FRP pipes and test methods specified within ISO 25780. The main product standard of FRP Pipes is ISO 23856 which supersedes well known FRP standards: EN 1796, EN 14364, ISO 10467 and ISO 10639.

ISO 23856 merges and supersedes previous mentioned standards therefore it suits for all types of water supply and sewerage with or without pressure.



2. DESIGN & MANUFACTURING



2.1 Design of FRP Jacking Pipes

Jacking load is calculated based on compressive strength test results which is defined in ISO25780 standard; by applying compression force to a prismatic test sample taken from jacking pipe in longitudinal direction. Ultimate compressive strength results vary between 12300 psi to 16000 psi depending on the manufacturing technology and composition of pipe structure. In the design of jacking load, minimum values are used as 12300 psi for CFW and HW pipes and 13000 psi value is used for pipes manufactured with CC technology.



Allowable Jacking force is calculated by multiplying the minimum ultimate compression strength with minimum cross-sectional area (generally calibrated section at the joint zone). After that, $F_{sm}=1.75$ applied as material safety factor and $F_{se}=2$ applied as eccentric loading factor. In total $F_s=3.5$ applied and allowable jacking load is declared on product datasheets. Project Design Engineer can decide to use lower safety factors of F_s 3 or F_s 2.5 on straight lines considering the actual project conditions.

Depending on the geological conditions and soil loads, road-rail-aircraft traffic loads, influences related to jacking methodology i.e., route, annular gap grouting; stresses, deformations and buckling verifications should be checked in order to prove that pipe SN class is suitable for project conditions. DWA-A 161E standard has a detailed static calculation methodology for jacking pipeline designers in order to verify these mentioned controls. Due to this design approach pipe SN class is another classification of FRP jacking pipes presented for Jacking applications. Superlit propose SN class up to 7200 psi for jacking pipes depending on the pipe diameter.



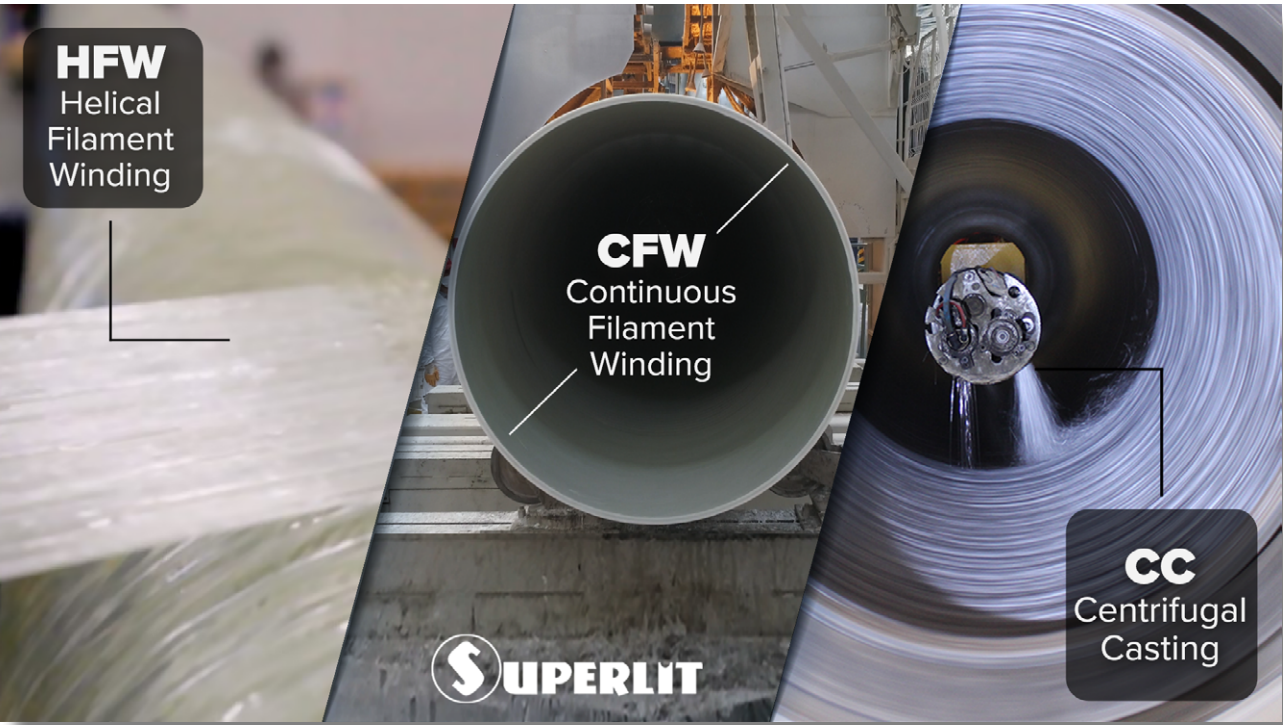


Below material characteristics given in technical parameters table and pipe geometry related characteristics documented in Superlit FRP Jacking Pipe Datasheets will help designers to choose correct pipe for their projects.

TECHNICAL PARAMETERS	
Product Standard	ISO 25780 – ISO 23856
Ultimate Axial Compression Strength	FW : min 12300 psi CC : min 13000 psi
Hoop Flexural Modulus	1,3 x 10 ⁶ – 1,6 x 10 ⁶ psi
Specific Unit Weight	114,5 – 133,5 lb/ft ³
Flow Coefficient	Hazen-Williams C=150 Manning n= 0,009
Service Temperature	-40°F +95°F (Higher temp. available up on request)
Thermal Expansion Coefficient	(13-17) x 10 ⁻⁶ in. /in./°F
Poisson's Ratio	0,22 – 0,29

2.2 Manufacturing of Jacking Pipes

Superlit FRP jacking pipes can be produced with both manufacturing technologies of Continuous Filament Winding, Centrifugal Casting and Helical Winding. Selection of the production technology depends on project specification and product dimensional properties.



2.2.1 Continuous Filament Winding Method (CFW)

The Continuous Filament Winding Process is the manufacturing of FRP pipes from continuously flowing glass fiber by winding it on an automatic machine.

The inner and outer walls of the pipe are constructed by pressing glass fiber and resin together, and filling material(sand) is then added.

As a result of reinforcing a high ratio of polyester by glass fiber, the inner and outer surfaces of the pipe become extremely robust against chemicals. Since the mid-section of the pipe is highly durable, the required stiffness is obtained and the resistance against working pressures is obtained throughout the length of the pipe.

Manufacturing:

The main machine in the Continuous Filament Winding manufacturing process comprises of a continuous steel band supported by beams that form a cylindrical mandrel.

By the motion of the mandrel under the control of the Program Logic Controller (PLC) and the computers (PC), the glass fiber, the resin, the filling material and the surface materials are applied by precision measurements. The PLC-PC modules provide an integrated process control in line with the pre-programmed

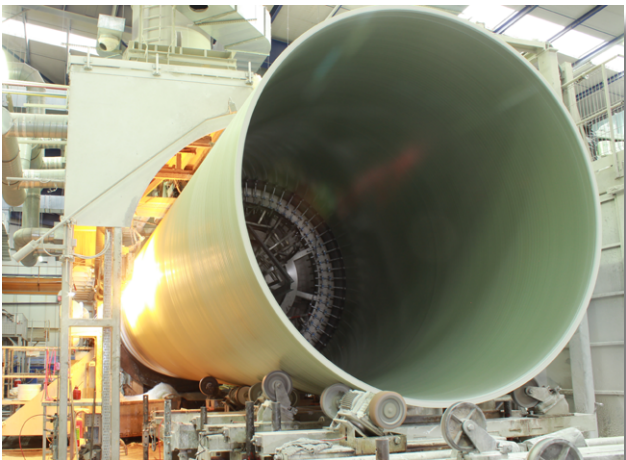
designs. Basic data, such as diameter, stiffness and pressure class are entered into the program. The PC calculates all the setting values of the machine. The process parameters and the thickness of the pipe are continuously monitored and traceability is provided by storing these data.

Curing of the laminate develops depending on the heat. Direct heating of the laminate ensured by heating elements. Laminate temperature is measured on the cure region from various points. Temperature distribution is monitored on the PC monitor graphically.

Extraction of resin is administrated from two different lines. Special resin for the inner layer of the pipe can be used for highly corrosive applications, while a normal resin for the body and outer layer can be utilized.

A cutting unit compatible with the pipe, which has an axial and radial stroke, enables the pipe to be cut smoothly and perpendicularly. Cutting operations take place automatically by entering the length of the pipe into the control system.

Pipes that have been cut are transferred to specifically designed lifting stands, then to the chamfering and calibration section, and from there to hydrostatic test section.



2.2.2 Centrifugal Casting Method (CC)

By using the latest computer technology involved in FRP pipe manufacturing with SUPERLIT Centrifugal Casting, raw material distribution and raw material consumption are kept under control. Following the entry of the class and diameter of the pipe to be manufactured into the computer, all manufacturing steps are controlled by the computer until the pipe comes out of the mold.

Manufacturing:

In SUPERLIT FRP pipes manufactured by the Centrifugal Casting method, glass fiber, polyester resin, and silica sand are used.

SUPERLIT FRP pipes, in this completely automatic and electronically controlled process, are manufactured by feeding the raw materials into the rotating mold, beginning from the outer surface of the pipe until reaching a predefined wall thickness.

A feeder leaves the amount of material, which is predefined in the system, within the mold. The resin that is formulated in a way that it is not polymerized during the whole process of loading, and fibers that are cut with a length in compliance with the design are molded from the head at the end of the feeder.

Distributions and organization of the fibers within layers are fabricated to counterbalance the resistance of the pipe in the designed circumferential and axial directions.

When the feeding of all the raw materials is completed, the cast rotation speed is increased in order to increase the compressive strength. By increasing the rotation speed of the mold, a full-compression and transition to a solid material(curing) are ensured.



By the reciprocating motion of the feeder within the mold, the wall thickness of the pipe is manufactured layer by layer. Glass fibers, which are reinforcing materials, are placed on both sides of the neutral axis on the pipe wall, and the gap remaining in between is filled by silica sand, resin, and glass fiber.

The mechanical properties of SUPERLIT FRP pipes are calibrated by changing the amounts, ratios, and direction of the material within the layers of the pipe. Thus, the flexibility of the design of the pipes enabled in a wide range of pressures, from non-pressure pipes to pressure pipes.



Design of Wall Thickness:

The layers of the pipes are polymerized in the form of 'solid blocks. Glass fiber distribution in the manufacturing process is kept completely under control, in line with the requirements of the circumferential and axial strength, by the use of varying cutters and mold speeds.

Each layer, forming the wall of the pipe, has a specific function. When the interior of the pipe is examined, a flexible resin layer, having no glass fiber on the inner surface can be seen. The thickness of this layer, which is composed of a pure distinctive resin, is minimum 1 mm, and gives the pipe its hydraulic properties and a high abrasion resistance.

A barrier layer exists behind the liner layer. The liner and barrier layers, together, function to prevent the penetration of foreign substances into the structural layers of the pipe.

Behind the barrier layer is the structural layer, which differs in design according to the pressure and stiffness class of the pipe. On the external surface of the pipe there is the outer layer, which protects the pipe from impacts and scratches during the loading processes. This layer, additionally, protects the pipe against UV radiation penetration.

2.2.3 Helical Winding Method (HW)

SUPERLIT Helical Filament Wound glass-reinforced thermosetting resin pipe offers superior corrosion resistance and a combination of high mechanical and physical properties which have been proved in most severe operating conditions all over the world.

Production Method:

Pipes are manufactured using the discontinuous filament winding process on computer-controlled machines by adjusting the relative speed of mandrel rotation with the controlled

winding of the impregnated fibers on desire pattern, angle, and thicknesses over a rotating mold synchronous with glass distribution head movement.

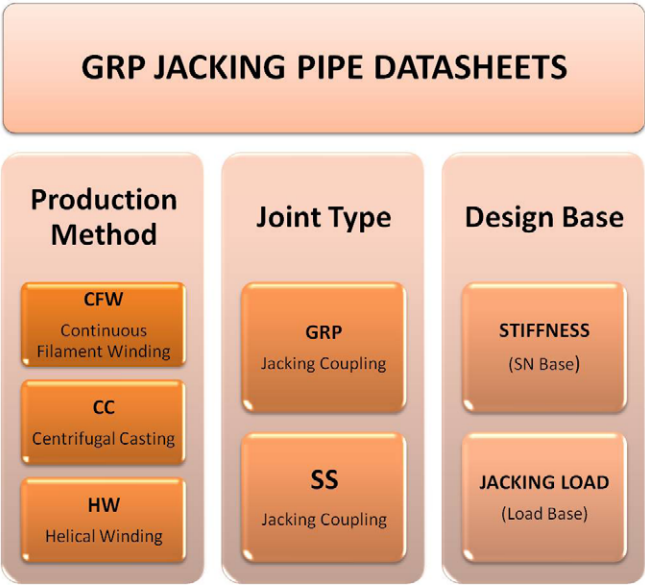
The inside diameter of the finished pipe is defined by mandrel outside diameter and designed wall thickness is achieved by repeated winding passes and the outside diameter of the pipe is determined by the wall thickness. Following the completion of the curing, mold is separated from the cured pipe by using extraction equipment.



2.3 Superlit Jacking Pipes Product Range

Thanks to Superlit Production Technologies that, it is possible to manufacture FRP jacking pipes both on Continuous Filament Winding, Centrifugal Casting and Helical Winding Machines. Pipe joints can be designed with FRP coupling and or either SS coupling. Pipe properties can be read from several pages of datasheets given on the tables at Appendix. A depending on the SN based or load based classification.

Within datasheets Pipe OD, t, ID, Mass, Fmax, Pipe Stiffness, Production Method and Joint Type, information can be read in order to make an accurate design for the project. For special diameters or pipe classes it is advised to contact Superlit for availability.



GRP JACKING DATASHEET

CONTINUOUS FILAMENT WINDING (CFW)
GLASS REINFORCED POLYESTER (GRP) ISO 25780
JOINT TYPE : FULLFACE GRP JACKING COUPLING



GRP JACKING PIPE TABLE : SN 100 000 – 1 000 000

OD (mm)	PIPE STIFFNESS SN (N/m ²)																							
	100 000				128 000				160 000				200 000				320 000				640 000			
	ID	e	Mass	Fmax	ID	e	Mass	Fmax	ID	e	Mass	Fmax	ID	e	Mass	Fmax	ID	e	Mass	Fmax	ID	e	Mass	Fmax
	mm	mm	kg/m	kN	mm	mm	kg/m	kN	mm	mm	kg/m	kN	mm	mm	kg/m	kN	mm	mm	kg/m	kN	mm	mm	kg/m	kN
345	312,6	16,2	33	124	310,0	17,5	36	152	306,8	19,1	39	186	304,0	20,5	42	215	296,8	24,1	49	289	311,0	32,5	70	491
376	340,8	17,6	40	157	338,0	19,0	43	190	334,4	20,8	46	232	331,0	22,5	50	270	323,4	26,3	58	356	311,0	32,5	70	491
427	397,0	20,0	51	243	384,0	21,5	55	283	379,8	23,6	60	338	376,0	25,5	64	387	367,4	29,8	74	497	353,2	36,9	90	672
478	433,2	22,4	64	348	429,6	24,2	69	401	425,0	26,5	75	469	421,0	28,5	80	527	411,2	33,4	93	667	395,4	41,3	113	885
515	466,6	24,2	75	435	462,8	26,1	80	495	457,4	28,8	88	581	453,6	30,7	93	640	443,0	36,0	108	803	426,0	44,5	131	1.056
530	480,4	24,8	79	468	476,4	26,8	85	534	471,2	29,4	92	618	467,0	31,5	99	686	456,0	37,0	115	860	438,4	45,8	139	1.130
550	498,4	25,8	85	521	494,2	27,9	91	593	489,0	30,5	100	681	484,8	32,6	106	751	473,0	38,5	124	945	455,0	47,5	150	1.231
618	560,0	29,0	107	763	555,2	31,4	116	855	549,6	34,2	125	961	544,6	36,7	134	1.055	531,6	43,2	156	1.295	511,0	53,5	190	1.664
650	589,0	30,5	119	814	584,0	33,0	128	915	578,0	36,0	139	1.035	572,8	38,6	148	1.137	559,2	45,4	172	1.401	537,6	56,2	210	1.808
718	651,0	33,5	144	1.040	645,2	36,4	156	1.169	638,0	40,0	170	1.328	632,8	42,6	181	1.441	617,6	50,2	211	1.767	594,0	62,0	255	2.258
760	688,8	35,6	162	1.159	682,8	38,6	175	1.300	675,0	42,5	192	1.482	669,6	45,2	203	1.606	653,8	53,1	236	1.965	628,8	65,6	286	2.515
820	743,0	38,5	189	1.345	736,8	41,6	203	1.502	729,2	45,4	221	1.694	722,4	48,8	236	1.863	705,4	57,3	274	2.279	678,0	71,0	334	2.930
860	775,6	40,2	207	1.506	773,0	43,5	223	1.682	764,4	47,8	244	1.909	758,0	51,0	259	2.076	740,0	60,0	301	2.539	711,0	74,5	368	3.261
924	837,2	43,4	240	1.810	830,2	46,9	258	2.010	821,6	51,2	281	2.254	814,0	55,0	300	2.467	795,0	64,5	348	2.992	764,0	80,0	424	3.821
960	869,8	45,1	259	1.987	862,8	48,6	278	2.195	853,6	53,2	303	2.466	845,6	57,2	324	2.699	826,0	67,0	376	3.261	794,0	83,0	457	4.151
1.026	930,0	48,0	295	2.318	922,0	52,0	318	2.572	912,0	57,0	347	2.887	904,0	61,0	370	3.136	882,4	71,8	430	3.798				
1.099	995,8	51,6	339	2.740	988,2	55,4	363	2.999	977,0	61,0	398	3.377	968,6	65,2	423	3.657	945,4	76,8	493	4.419				
1.127	1.021,2	52,9	357	2.906	1.013,0	57,0	383	3.192	1.002,0	62,5	419	3.572	992,6	67,2	447	3.894	969,4	78,8	519	4.675				
1.225	1.114,0	57,5	423	3.538	1.104,6	62,2	456	3.896	1.093,0	68,0	496	4.333	1.082,6	73,2	531	4.722								
1.290	1.169,0	60,5	467	3.966	1.160,0	65,0	500	4.325	1.147,0	71,5	547	4.840	1.136,0	77,0	587	5.271								
1.348	1.221,6	63,2	510	4.382	1.211,0	68,5	550	4.824	1.198,0	75,0	600	5.361	1.187,0	80,5	641	5.812								
1.399	1.267,8	65,6	549	4.767	1.257,0	71,0	592	5.235	1.243,0	78,0	647	5.835	1.232,0	83,5	690	6.302								
1.434	1.299,2	67,4	578	5.054	1.289,0	72,5	620	5.507	1.274,8	79,6	677	6.131	1.264,0	85,0	720	6.602								
1.499	1.359,0	70,0	628	5.539	1.348,0	75,5	675	6.050	1.333,0	83,0	738	6.740	1.321,0	89,0	788	7.287								
1.536	1.392,0	72,0	662	5.811	1.380,0	78,0	714	6.381	1.366,0	85,0	775	6.941												
1.638	1.485,0	76,5	750	6.142	1.472,0	83,0	811	6.802	1.460,0	89,0	866	7.405												
1.720	1.559,0	80,5	829	7.013	1.546,0	87,0	892	7.706																
1.842	1.670,0	86,0	948	8.173																				

Detailed information with product tolerances of an individual pipe is being shared for specific project is given in Jacking Pipe TDS. Consult to Superlit for project-based assistance.

3. JOINTS



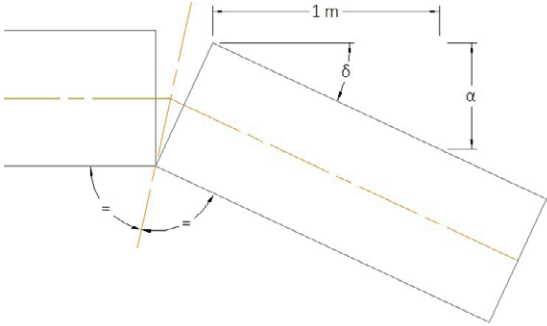
3.1 Jacking Pipe Joints

Superlit Jacking pipes has flexible coupling joints, provides leak tightness during construction and operation periods. This leak tightness refers to both internal and external water pressures, and also for pressures caused by lubricants.

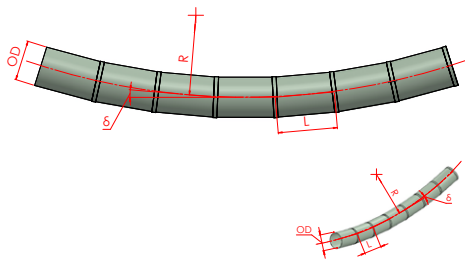
The outside diameter of Jacking pipe joint/ coupling does not exceed the external diameter of pipe body. This joints system is also called as “flush joint”.

Flexible joint design allows to angular deviation in accordance with the requirement of ISO25780 standard as given in below table. With this joint capability, pipe string can follow a radius in pipe jacking projects with curved line.

External Diameter	Max. Allowable Installed Deflection	
OD (inch)	a (inch/ft)	δ (°)
OD ≤ 8"	0,24	1,15
8" < OD ≤ 20"	0,18	0,86
20" < OD ≤ 39"	0,12	0,57
39" < OD	$a=0,12 \times (39,37/OD)$	$\text{atan}(a/12)$



Minimum radius (R) of the curved line can be calculated by using above table depending on the OD, max allowable angular deflection at joint and jacking pipe length. Minimum R values can be found as a reference in below table calculated for selected pipe diameters.



OD (inch)	a (inch/ft)	δ (°)	*Rmin (ft)
18,8	0,18	0,86	666
33,9	0,12	0,57	1000
43,3	0,11	0,52	1100
56,5	0,08	0,40	1435
72,5	0,06	0,31	1842
96,6	0,05	0,23	2454
112,5	0,04	0,20	2858
* Rmin = Permissible minimum radius for selected diameters			
* Considering a jacking pipe length of 10 ft.			

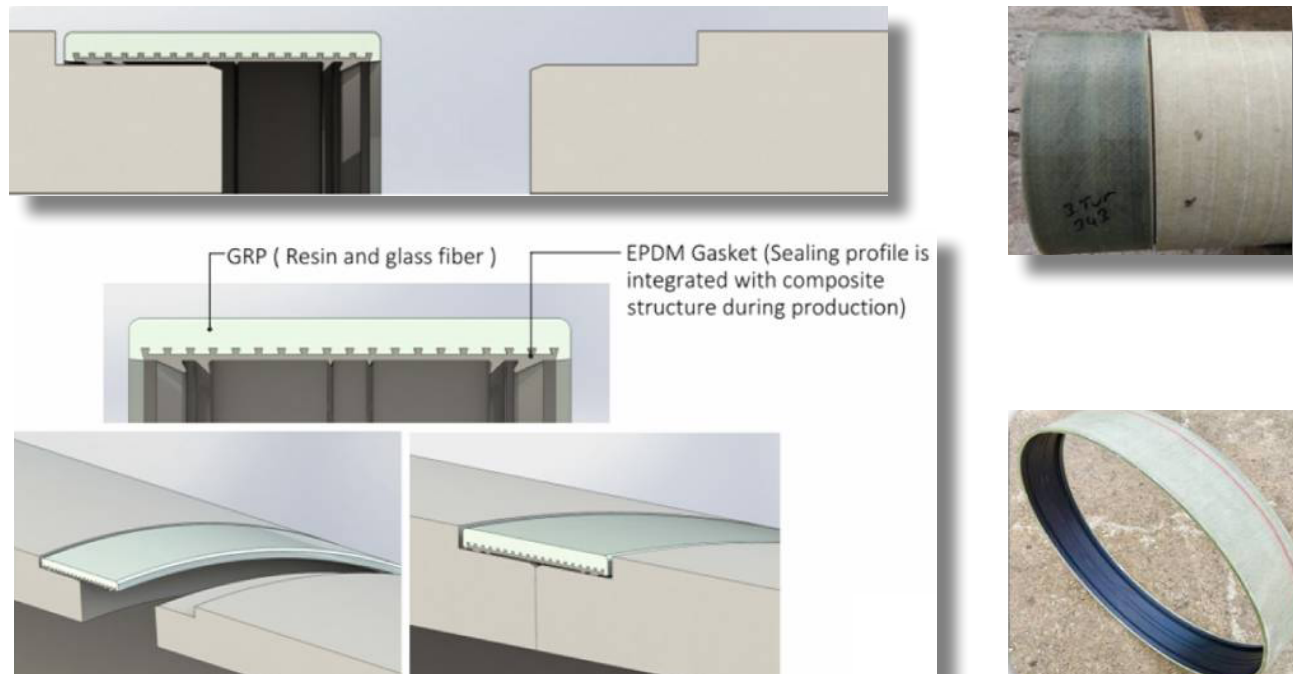
Material of the coupling can be selected as FRP, Coated Steel, Stainless Steel with SS304, SS316, or SS 316Ti depending on the pressure and chemical requirement.

During installation, applied jacking load transferred from one pipe to the next generates axial compression forces acting on the cross section of the pipe. In practice, a perfect contact of the jacking faces is not common and, in most cases, jacking loads are transferred with an eccentricity. This eccentric loading is an expected result when pipeline is intentionally designed with curves. This reduced contact area has already been considered in design of Superlit Jacking pipes and declared jacking loads are calculated by including an additional factor of safety of 2 as a stress eccentricity ratio.

Sealing material is generally chosen from EPDM which has very good chemical resistance and meets the requirements of ASTM F477 and EN 681-1 standards. Sealing element with different material can be manufactured in accordance with project specific requirements.

3.1.1 FRP Jacking Coupling

FRP jacking coupling is a flush joint taking place as an alternative to steel joints which are used in trenchless applications. It provides unique solutions to corrosion issue of aggressive soil environment where metal couplings have limit of service life under corrosion attack.



New composite jacking coupling has minimum 50 years of service life in similar and even aggressive conditions. Special designed full face rubber profile integrated with the coupling during production, ensures leak tightness by help of its FRP structure of body and fully comply with the performance requirements of ISO 25780 standard.



3.1.2 Stainless Steel Jacking Coupling

Most of the Jacking pipe suppliers use Steel or Stainless Steel at the connections of pipe spigots. Stainless Steel Jacking Couplings were very popular due to corrosion resistance property before FRP composite Jacking couplings introduced in the market.



EPDM Sealing Rubber is bonded to SS Sleeve firmly and can provide leak tightness up to 200 psi internal pressures. The grade of SS material is SS304 preferably and other grades such as SS316, SS316Ti are available upon request for special project conditions.

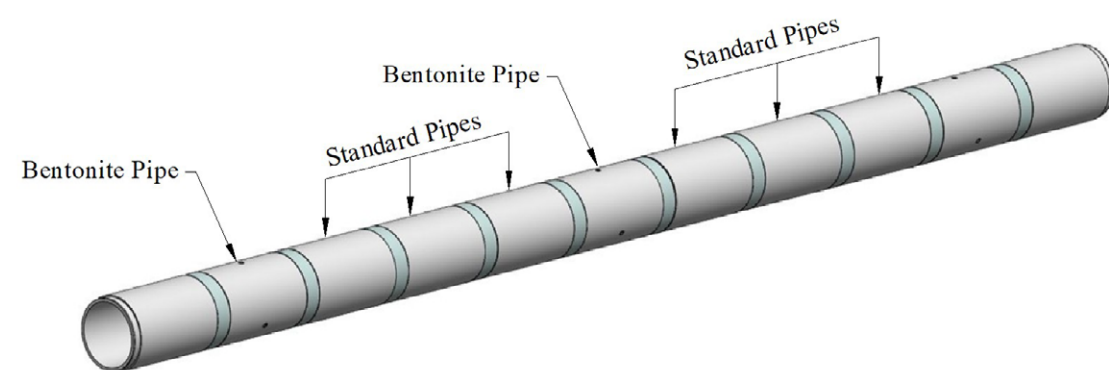
In concrete jacking pipes and vitrified clay jacking pipes, jacking forces are usually distributed from one pipe to the other with pressure transfer rings in order to distribute jacking load evenly between the pipe faces. Solid wood or OSB boards are being used for this purpose.

For FRP pipes, due to the elastic properties of material itself, jacking loads are transferred to the next pipe through the pipe face without using pressure transfer ring.

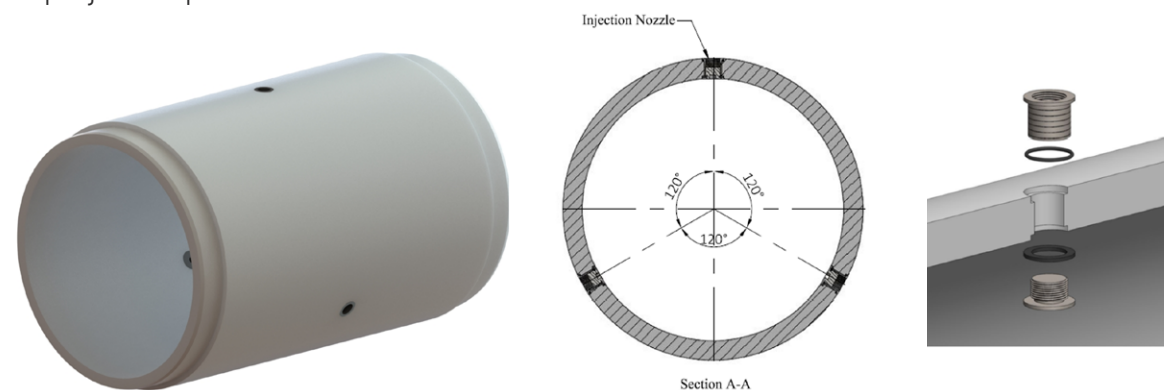
3.2 Bentonite Pipe & Injection Nozzles

For long run jacking applications, in order to reduce friction forces between pipe external surface and soil, annular gap is lubricated with bentonite suspension. The basic functions of bentonite injection are to support excavated area, lubricate the pipe surface for easy sliding, and to provide a buoyant region at the annular gap.

Lubrication medium is distributed to the gap between pipe and soil through the injection nozzles that has been located over pipe. In general injection ports are placed within an interval of 9-15 m depending on the properties of the ground. In such a case, depending on the pipe segment length every 3rd – 5th pipe is prepared with lubrication system consisting of injection nozzles. These pipes specifically instrumented with injection nozzles are generally called **"bentonite pipe"**.



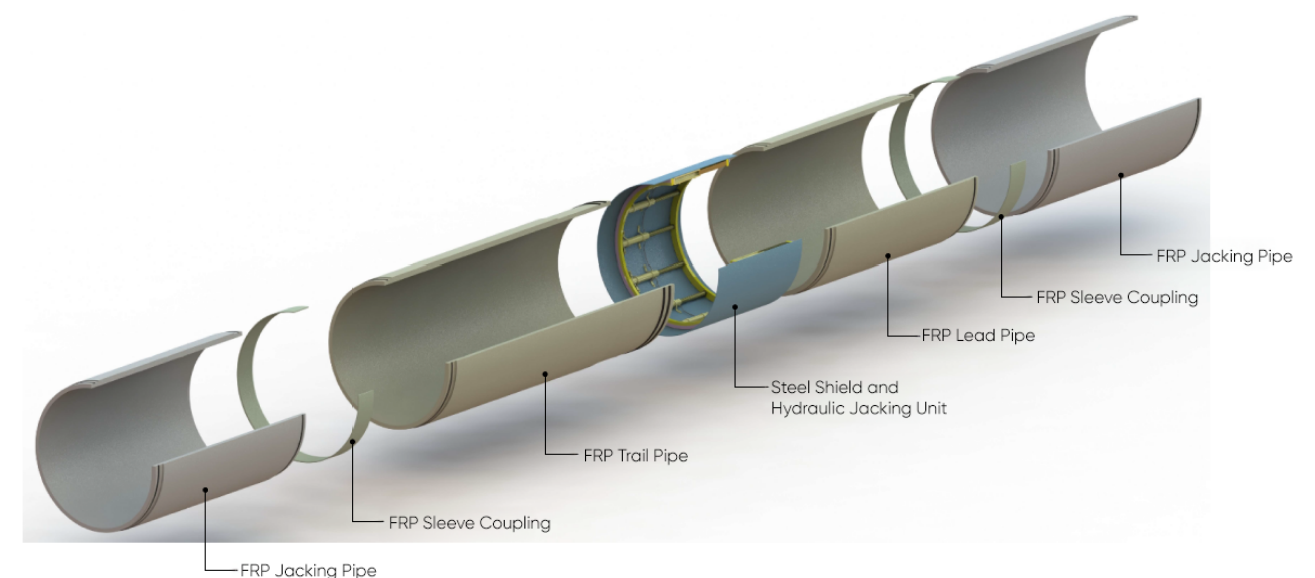
Injection nozzles are generally 1" diameter brass or stainless steel, with a length designed to fit pipe wall thickness. In general, 3 injection port distributed on the circumference of the pipe is the common design. Port quantity and frequency along the pipe string can be reduced depending on the project requirements.



Contact injection will cause an external pressure outside of the pipe. Injection pressure and volume should be measured in order to prevent an accidental return of the injection fluid or damage to the jacking pipe. Where there is water table on the jacking route, injection pressure should be adjusted slightly above the groundwater pressure.

3.3 Intermediate Jacking Station

Intermediate jacking stations (IJS) are jacking units located in the pipe string in order to provide additional thrust; divide and separate pipeline to prevent exceeding the capacity of main jacking station or jacking pipes. IJS consists of steel shield and hydraulic jacking cylinders distributed evenly on the whole circumference. These components are removed after the final stage and jacking string is being completed. Special designed jacking pipes are installed in front and behind the steel shield. These specifically designed FRP pipes have different sealing elements, additional lubrication ports and special calibration lengths in order to adapt frequent longitudinal movements during application.

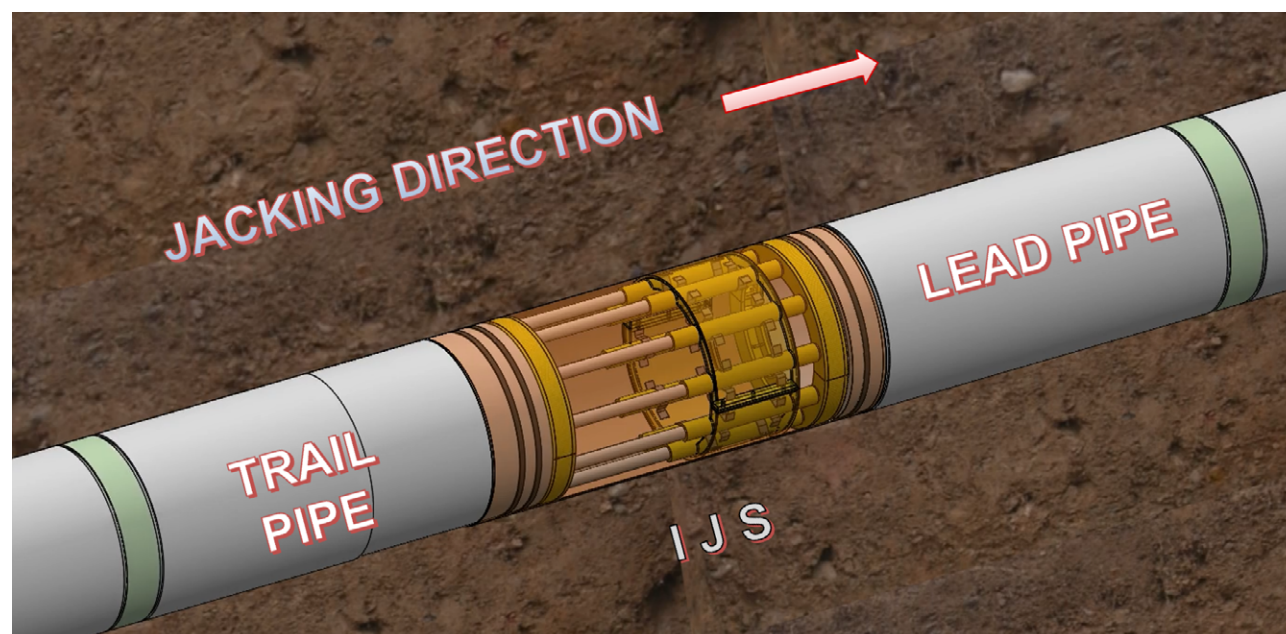
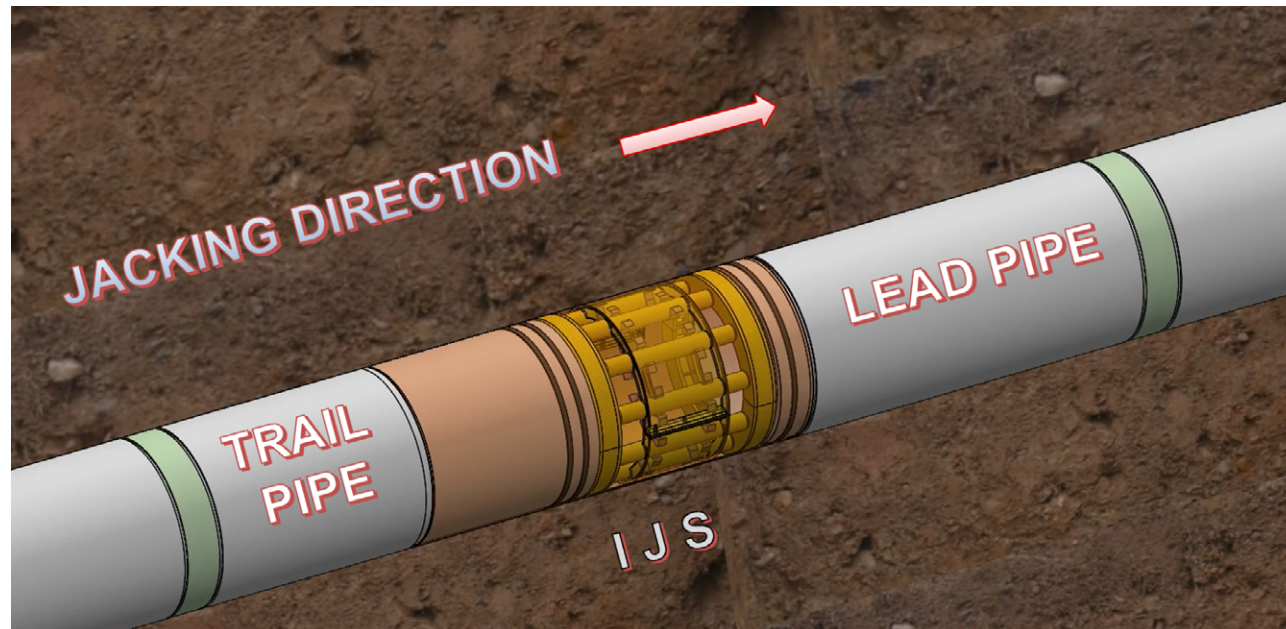


Inside of the steel shield has to be smooth, free from any grooves and bulges that can damage sealing gasket during longitudinal bi-directional movements.

Special pipe located between steel shield and receiving shaft is called "Lead pipe" that is in front of the steel shield; while the pipe located between starting pit and steel shield is called "Trail pipe" that is behind the steel shield. Trail pipe has two sealing element, lubrication ports to lubricate gaskets and a long pipe body calibration to allow steel shield slide over along the length of jacking cylinders stroke. The other side of the trail pipe is machined for integration with regular FRP jacking pipes. Lead pipe sealing element is different than trail pipe seals, since there will be not be a continuous and both directional movement at this joint side.

It is recommended to use wooden rings between steel and FRP pipe faces to allow even distribution of jacking forces. Wooden rings are not necessary between FRP to FRP joints.

Depending on the theoretical jacking force calculations based on geological conditions and drive length; quantity and the distance between IJS can be estimated. During installation phase, with the aid of automatic data recording system maximum jacking force at the shaft should be checked. As a general practice IJS is added to the pipe string where the applied jacking force exceeds 80% of the maximum allowable jacking force of the pipes or any other components in the system.



4. INSTALLATION GUIDE



This chapter gives brief information as a reference to contractors and field engineers, regarding the installation steps of jacking pipes. There may be other national or local construction codes; project specifications documented for the project, or jacking method related special conditions may arise on site. Therefore, client has to consult manufacturer when there is a conflict between parties or where there are unclear conditions.

4.1 Handling & Storage

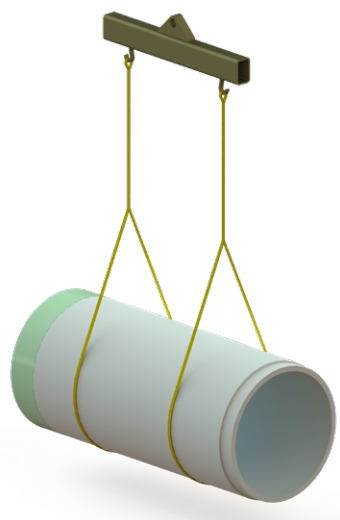
4.1.1 Handling of Jacking Pipes

When pipes received to site, goods have to be visually checked if there are any transportation related damages. This section can be followed through FRP pipe installation manual for detailed sketches and explanations



During the offloading of jacking pipes, or lowering pipes to the launch shaft, textile straps must be used. All lifting slings, and connection elements must be free from damages and has to be adequate in handling the jacking pipe weight. It is not allowed to use steel cables or chains directly in contact with FRP material which can cause a damage in FRP material surface or jacking coupling. Other important points to be followed as below during handling operations.

- ④ Identify proper lifting points and methods.
- ④ Visually control each product for damages or cracks and report any damage. Damaged goods should not be used unless inspected and repaired by Superlit personnel.
- ④ While loading, unloading or placing jacking pipes on the ground, prevent any impact with rigid objects to avoid structural damage.
- ④ Based on jacking pipe diameters, lengths and weights, as well as jobsite conditions, crane-lifting strap method or forklift can be used for these operations.
- ④ Use at least two lifting straps when lifting the pipe in horizontal position. Take care about the accessories which can change the centre of gravity. Guide ropes can help to control pipe manually.
- ④ Jacking pipe should not be dropped or rolled, which can cause serious damages.



4.1.2 Storage of Jacking Pipes

If the jacking pipes will be unloaded to stock area before installation it is recommended to store goods with original packages. General requirements for storage area and related considerations are listed below.



- ④ The storage area should be flat, levelled and clear of objects such as rocks, stones, sharp edges, etc.
- ④ Pipes can be stored in piles to minimize the storage area within the allowed limits. Maximum stack height is recommended as 8,12 ft and it is not recommended to stack pipes greater than DN 47".
- ④ Precautions have to be considered to prevent goods, from rolling or falling due to wind effects.
- ④ If jacking couplings are delivered separately as bundles, couplings should be stored at horizontal position to prevent radial deflection.
- ④ Vegetable based lubricants used for pipe and coupling installation should always be stored in their original packaging.

4.2 Installation of Jacking Pipes

4.2.1 Dimensional Controls

Jacking pipe diameter, pipe lengths, injection nozzles, lead pipe, trail pipe and all necessary elements in the whole string has been designed and confirmed by the client prior to installation. During the installation, before lowering the pipes inside the launch shaft; field technicians should control if there is any critical deviation on the goods, and report if any.

FRP Jacking pipe nominal outside diameter is declared in product datasheets and pipe spigot diameter is calibrated according to joint design and suitability between machinery and jacking frame connectors of the pipe spigots

agreed before production. Due to the nature of the Filament Winding and Helical Winding production processes; actual outside of the pipe barrel at all cross sections can be variable from the declared nominal diameter.

Jacking machine boring head diameter is generally 0,6" - 1,6" larger than the nominal outside diameter of pipe, therefore max OD of pipe is always less than the bored gap in practice. ISO25780 standard recommends that; the maximum OD of pipe shall be agreed between purchaser and manufacturer; for specific project conditions.



4.2.2 Pipe Assembly

Below steps and controls should be followed during the installation of jacking pipes;

- Ⓢ Pipes should be lowered into the launching pit by means of textile straps, as described in handling section. Extra care should be taken not to damage FRP/SS jacking coupling and spigot end.
- Ⓢ Depending on the jacking frame and TBM machine shield design, jacking coupling can be on the front end or back end. It has to be controlled that pipe is placed in correct position.
- Ⓢ It has to be checked that pipe spigot, coupling and injection nozzles are free from dirt, and to be cleaned if any.
- Ⓢ EPDM gasket of the joint should be lubricated with vegetable-based lube before assembly.
- Ⓢ Pipe should be kept in straight horizontal alignment during pushing pipe end inside the joint.
- Ⓢ During the stock condition, pipe may be pre-deflected due to self-weight/stocked pipes weight. Therefore, it is recommended to turn pipe that will be installed 90° at least 4-6 hours prior to installation. In general, the clearance between pipe and coupling is enough for alignment and jointing, this method can be followed if found necessary by site practices.
- Ⓢ It has to be checked through the machine records that applied jacking loads are not exceeding the allowable jacking load of the pipe.
- Ⓢ Allowable angular deflection values given in Section 3.1 of this manual should not be exceeded.
- Ⓢ When jacking string is designed with intermediate jacking stations, trailer pipe sealings has to be lubricated frequently from the nozzles over the pipe in order to ensure functionality of the gasket performance.
- Ⓢ If the jacking line is a section of a standard open cut project, use necessary adaptors for the connection between jacking pipe and regular pipes. If the jacking pipe is a continuous system consisting from several jacking drives, manholes or special connectors can be used to finalize and close gaps inside shaft.



5. APPENDIX

Jacking Pipe Datasheets

CONTINUOUS FILAMENT WINDING (CFW)
FIBERGLASS REINFORCED PLASTIC (FRP) ISO 25780
JOINT TYPE : FULLFACE STAINLESS STEEL JACKING COUPLING



Stiffness = 144 psi							Stiffness = 230 psi						
OD	ID	e	Mass	Allowable Jacking Load			OD	ID	e	Mass	Allowable Jacking Load		
				FS = 3,5	FS = 3,0	FS = 2,5					FS = 3,5	FS = 3,0	FS = 2,5
in	in	in	lb/ft	U.S. Tons	U.S. Tons	U.S. Tons	in	in	in	lb/ft	U.S. Tons	U.S. Tons	U.S. Tons
13,6	12,9	0,37	13	2,0	2,4	2,8	13,6	12,7	0,42	15	5,7	6,6	7,9
14,8	14,0	0,40	16	4,4	5,1	6,2	14,8	13,9	0,46	18	8,8	10,2	12,3
16,8	15,9	0,45	20	9,4	11,0	13,2	16,8	15,8	0,52	23	15,0	17,5	21,0
18,8	17,8	0,51	25	15,5	18,1	21,7	18,8	17,6	0,59	29	22,8	26,6	31,9
20,3	19,2	0,55	29	20,5	23,9	28,7	20,3	19,0	0,63	34	28,7	33,5	40,2
20,9	19,7	0,56	31	22,3	26,0	31,2	20,9	19,6	0,65	36	31,2	36,4	43,6
21,7	20,5	0,58	33	25,6	29,9	35,8	21,7	20,3	0,68	39	35,0	40,8	49,0
24,3	23,0	0,65	42	37,0	43,2	51,9	24,3	22,8	0,76	49	48,9	57,1	68,5
25,6	24,2	0,69	47	43,3	50,5	60,6	25,6	24,0	0,81	54	57,5	67,1	80,5
28,3	26,8	0,76	57	51,6	60,2	72,2	28,3	26,5	0,89	66	68,8	80,3	96,3
29,9	28,3	0,83	65	64,7	75,5	90,6	29,9	28,1	0,93	74	79,6	92,9	111,4
32,3	30,6	0,87	74	76,0	88,7	106,4	32,3	30,3	1,00	85	96,9	113,0	135,6
33,9	32,0	0,91	81	86,2	100,5	120,6	33,9	31,7	1,06	95	111,2	129,7	155,6
36,4	34,4	0,98	95	95,9	111,9	134,2	36,4	34,1	1,14	110	122,7	143,2	171,8
37,8	35,7	1,02	102	106,8	124,6	149,5	37,8	35,4	1,18	118	134,7	157,1	188,6
40,4	38,2	1,08	116	125,7	146,6	175,9	40,4	37,9	1,26	134	159,2	185,8	222,9
43,3	40,9	1,16	133	151,0	176,2	211,5	43,3	40,6	1,36	155	191,0	222,8	267,3
44,4	42,0	1,19	140	160,8	187,6	225,1	44,4	41,6	1,39	163	203,4	237,3	284,7
48,4	45,8	1,30	167	201,1	234,6	281,5	48,4	45,4	1,50	191	245,7	286,7	344,0
50,8	48,0	1,38	185	230,3	268,7	322,4	50,8	47,6	1,59	214	281,8	328,8	394,5
53,1	50,2	1,44	202	255,8	298,4	358,1	53,1	49,8	1,65	231	309,6	361,3	433,5
55,1	52,1	1,49	217	279,1	325,6	390,7	55,1	51,6	1,72	250	340,1	396,8	476,1
56,5	53,4	1,52	227	293,7	342,6	411,1	56,5	52,9	1,77	264	361,4	421,6	505,9
59,0	55,9	1,58	247	326,1	380,4	456,5	59,0	55,3	1,85	288	400,1	466,8	560,2
60,5	57,2	1,63	261	335,1	390,9	469,1	60,5	56,7	1,90	303	412,1	480,7	576,9
64,5	61,0	1,73	296	390,5	455,6	546,7	64,5	60,5	2,01	342	473,8	552,7	663,3
67,7	64,1	1,81	325	435,9	508,5	610,2	67,7	63,5	2,13	380	535,8	625,1	750,1
72,5	68,6	1,95	374	515,0	600,8	721,0	72,5	68,0	2,28	437	628,7	733,5	880,2
76,5	72,4	2,06	418	584,3	681,7	818,0	76,5	71,7	2,40	485	707,1	825,0	990,0
80,6	76,2	2,17	462	656,4	765,8	918,9	80,6	75,5	2,52	535	790,1	921,8	1.106,2
85,0	80,5	2,28	514	708,6	826,7	992,1	85,0	79,8	2,64	592	849,9	991,5	1.189,8
88,6	83,8	2,38	559	780,3	910,3	1.092,4	88,6	83,1	2,76	644	935,6	1.091,5	1.309,8
96,6	91,4	2,60	665	951,8	1.110,4	1.332,5	96,6	90,6	3,01	767	1.138,9	1.328,7	1.594,5
100,5	95,1	2,70	718	1.038,5	1.211,6	1.453,9	100,5	94,2	3,15	835	1.251,8	1.460,4	1.752,5
104,6	99,0	2,81	780	1.140,7	1.330,8	1.597,0	104,6	98,1	3,25	896	1.353,1	1.578,6	1.894,4
108,6	102,8	2,91	838	1.235,7	1.441,6	1.729,9	108,6	101,8	3,37	966	1.470,1	1.715,2	2.058,2
112,5	106,5	3,03	904	1.344,6	1.568,7	1.882,4	112,5	105,5	3,50	1.038	1.589,6	1.854,5	2.225,4
116,6	110,4	3,13	967	1.449,2	1.690,7	2.028,9							
120,7	114,2	3,23	1.032	1.557,2	1.816,8	2.180,1							

You can contact us at sales@superlit.com for dimensions, jacking forces and other technical data.



CONTINUOUS FILAMENT WINDING (CFW)
FIBERGLASS REINFORCED PLASTIC (FRP)ISO 25780
JOINT TYPE : FULLFACE STAINLESS STEEL JACKING COUPLING



CONTINUOUS FILAMENT WINDING (CFW)
FIBERGLASS REINFORCED PLASTIC (FRP)ISO 25780
JOINT TYPE : FULLFACE STAINLESS STEEL JACKING COUPLING



Stiffness = 288 psi						
OD	ID	e	Mass	Allowable Jacking Load		
				FS = 3,5	FS = 3,0	FS = 2,5
in	in	in	lb/ft	U.S. Tons	U.S. Tons	U.S. Tons
13,6	12,7	0,46	16	7,8	9,1	10,9
14,8	13,8	0,50	19	11,5	13,4	16,1
16,8	15,7	0,57	25	18,7	21,8	26,2
18,8	17,5	0,64	32	26,9	31,4	37,7
20,3	18,9	0,69	37	33,9	39,6	47,5
20,9	19,4	0,71	39	36,9	43,0	51,7
21,7	20,2	0,73	41	40,3	47,1	56,5
24,3	22,7	0,83	53	56,7	66,2	79,4
25,6	23,9	0,87	58	64,5	75,3	90,3
28,3	26,4	0,95	71	77,6	90,5	108,6
29,9	27,9	1,01	79	90,0	105,0	126,0
32,3	30,1	1,09	93	109,9	128,2	153,8
33,9	31,6	1,14	102	123,6	144,2	173,0
36,4	33,9	1,22	117	136,1	158,7	190,5
37,8	35,2	1,28	127	152,0	177,3	212,8
40,4	37,7	1,36	144	177,7	207,3	248,8
43,3	40,4	1,46	166	210,8	245,9	295,1
44,4	41,4	1,50	175	224,5	261,9	314,3
48,4	45,1	1,63	208	276,8	322,9	387,5
50,8	47,3	1,72	230	312,5	364,6	437,5
53,1	49,5	1,79	250	343,7	401,0	481,1
55,1	51,3	1,87	270	376,4	439,1	526,9
56,5	52,6	1,91	284	397,6	463,8	556,6
59,0	55,0	1,99	309	438,0	511,0	613,1
60,5	56,4	2,05	326	454,2	529,8	635,8
64,5	60,1	2,19	371	526,9	614,8	737,7
67,7	63,1	2,30	409	590,4	688,8	826,5
72,5	67,6	2,46	469	688,5	803,2	963,9
76,5	71,3	2,60	523	777,2	906,7	1.088,1
80,6	75,1	2,74	580	871,3	1.016,5	1.219,8
85,0	79,3	2,87	643	943,4	1.100,6	1.320,7
88,6	82,6	3,01	702	1.041,0	1.214,5	1.457,5
96,6	90,0	3,29	835	1.262,7	1.473,2	1.767,8
100,5	93,7	3,43	905	1.380,6	1.610,7	1.932,9
104,6	97,5	3,54	975	1.496,9	1.746,3	2.095,6

Stiffness = 360 psi						
OD	ID	e	Mass	Allowable Jacking Load		
				FS = 3,5	FS = 3,0	FS = 2,5
in	in	in	lb/ft	U.S. Tons	U.S. Tons	U.S. Tons
13,6	12,6	0,50	18	10,7	12,5	15,0
14,8	13,7	0,55	21	15,0	17,5	21,0
16,8	15,6	0,62	27	22,7	26,5	31,7
18,8	17,4	0,70	34	32,1	37,4	44,9
20,3	18,8	0,75	40	39,8	46,5	55,8
20,9	19,3	0,77	42	43,0	50,1	60,2
21,7	20,0	0,80	46	47,8	55,8	67,0
24,3	22,5	0,90	58	65,2	76,0	91,2
25,6	23,7	0,95	64	74,3	86,7	104,0
28,3	26,2	1,05	78	89,9	104,9	125,9
29,9	27,7	1,11	87	104,2	121,5	145,9
32,3	29,9	1,20	101	125,8	146,7	176,1
33,9	31,4	1,25	111	140,8	164,3	197,1
36,4	33,7	1,35	128	157,3	183,5	220,2
37,8	35,0	1,40	138	172,6	201,4	241,7
40,4	37,4	1,50	158	203,5	237,4	284,9
43,3	40,1	1,60	182	239,9	279,9	335,9
44,4	41,1	1,65	192	256,8	299,6	359,5
48,4	44,8	1,79	227	312,0	364,0	436,8
50,8	47,0	1,88	251	349,5	407,7	489,3
53,1	49,1	1,97	274	387,1	451,7	542,0
55,1	51,0	2,05	296	422,5	492,9	591,5
56,5	52,3	2,09	310	445,9	520,2	624,2
59,0	54,6	2,19	338	491,7	573,6	688,4
60,5	56,0	2,24	356	509,2	594,0	712,9
64,5	59,7	2,40	406	591,5	690,1	828,1
67,7	62,7	2,52	447	659,4	769,3	923,1
72,5	67,1	2,70	513	767,7	895,6	1.074,7
76,5	70,9	2,83	569	860,8	1.004,3	1.205,1
80,6	74,6	2,99	632	966,6	1.127,6	1.353,2
85,0	78,7	3,15	702	1.051,7	1.227,0	1.472,4
88,6	82,0	3,29	763	1.153,9	1.346,2	1.615,4
96,6	89,5	3,54	897	1.377,0	1.606,5	1.927,8
100,5	93,3	3,62	955	1.472,2	1.717,5	2.061,1

Stiffness = 920 psi						
OD	ID	e	Mass	Allowable Jacking Load		
				FS = 3,5	FS = 3,0	FS = 2,5
in	in	in	lb/ft	U.S. Tons	U.S. Tons	U.S. Tons
13,6	12,2	0,69	24	22,1	25,9	31,0
14,8	13,3	0,75	29	28,2	32,9	39,5
16,8	15,1	0,85	37	39,8	46,4	55,7
18,8	16,9	0,95	46	53,9	62,9	75,5
20,3	18,2	1,03	54	65,2	76,1	91,3
20,9	18,8	1,06	57	69,8	81,5	97,8
21,7	19,5	1,10	61	76,9	89,7	107,6
24,3	21,9	1,24	78	102,1	119,1	143,0
25,6	23,0	1,30	86	115,0	134,2	161,0
28,3	25,4	1,43	105	139,5	162,7	195,2
29,9	26,9	1,52	118	159,8	186,4	223,7
32,3	29,0	1,64	137	190,4	222,1	266,5
33,9	30,4	1,71	150	211,6	246,9	296,3
36,4	32,7	1,85	174	239,8	279,8	335,8
37,8	34,0	1,91	187	261,1	304,7	365,6
40,4	36,3	2,05	214	304,5	355,3	426,4
43,3	38,9	2,18	244	353,6	412,6	495,1
44,4	39,9	2,24	257	375,7	438,4	526,0
48,4	43,5	2,45	306	456,4	532,5	639,0
50,8	45,7	2,56	336	506,6	589,9	707,9
53,1	47,7	2,70	370	562,6	656,4	787,6
55,1	49,5	2,80	398	609,5	711,1	853,3
56,5	50,7	2,85	417	640,6	747,4	896,9
59,0	53,1	2,97	454	702,7	819,8	983,8
60,5	54,3	3,07	480	736,1	858,8	1.030,0
64,5	58,0	3,27	545	846,0	985,8	1.183,9
67,7	60,9	3,43	600	937,7	1.094,0	1.312,8

Stiffness = 1150 psi						
OD	ID	e	Mass	Allowable Jacking Load		
				FS = 3,5	FS = 3,0	FS = 2,5
in	in	in	lb/ft	U.S. Tons	U.S. Tons	U.S. Tons
13,6	12,1	0,75	25	23,5	27,3	33,3
14,8	13,2	0,82	31	32,9	38,4	46,0
16,8	15,0	0,93	40	46,0	53,7	64,4
18,8	16,7	1,04	50	62,5	73,8	89,1
20,3	18,0	1,13	59	74,8	87,3	104,7
20,9	18,6	1,16	62	79,3	92,6	111,1
21,7	19,3	1,20	67	86,7	101,2	121,4
24,3	21,6	1,35	84	114,0	133,0	159,7
25,6	22,8	1,42	93	128,4	149,8	179,8
28,3	25,1	1,57	114	157,3	183,5	220,2
29,9	26,6	1,67	129	180,2	210,2	252,3
32,3	28,7	1,79	148	211,9	247,2	296,6
33,9	30,1	1,88	164	237,1	276,7	332,0
36,4	32,3	2,02	189	267,2	311,8	374,1
37,8	33,6	2,09	204	291,6	340,2	408,2
40,4	35,9	2,24	233	339,9	396,6	475,9
43,3	38,5	2,40	267	396,1	462,1	554,5
44,4	39,4	2,46	281	418,5	488,2	585,9
48,4	43,0	2,68	333	505,6	589,9	707,8
50,8	45,2	2,81	368	563,5	657,4	788,9
53,1	47,2	2,95	403	623,0	726,8	872,2
55,1	49,5	3,07	435	677,0	789,8	947,8
56,5	50,2	3,13	455	710,8	829,3	995,2
59,0	52,5	3,27	496	780,3	910,3	1.092,4
60,5	53,8	3,35	520	810,2	945,3	1.134,3
64,5	57,5	3,50	582	912,8	1.065,0	1.278,0

Stiffness = 1440 psi						
OD	ID	e	Mass	Allowable Jacking Load		
				FS = 3,5	FS = 3,0	FS = 2,5
in	in	in	lb/ft	U.S. Tons	U.S. Tons	U.S. Tons
13,6	12,2	0,81	26	25,2	29,3	35,3
14,8	13,0	0,89	34	37,3	43,5	52,2
16,8	14,8	1,00	43	51,5	60,1	72,1
18,8	16,0	1,12	54	68,0	79,4	95,2
20,3	17,9	1,21	63	81,5	95,1	114,1
20,9	18,4	1,24	66	86,9	101,4	121,7
21,7	19,1	1,28	71	94,6	110,4	132,4
24,3	21,4	1,44	90	124,6	145,4	174,4
25,6	22,6	1,52	100	140,0	163,3	196,0
28,3	24,9	1,68	121	170,0	198,3	238,0
29,9	26,4	1,78	136	194,2	226,6	271,9
32,3	28,4	1,92	159	230,9	269,4	323,2
33,9	29,8	2,01	174	255,9	298,6	358,3
36,4	32,0	2,17	202	291,2	339,7	407,7
37,8	33,3	2,25	218	317,8	370,8	444,9
40,4	35,6	2,40	248	367,9	429,2	515,1
43,3	38,1	2,57	284	427,6	498,8	598,6
44,4	39,1	2,65	301	454,8	530,4	636,5
48,4	42,6	2,88	357	549,2	640,8	768,9
50,8	44,7	3,03	394	611,9	713,9	856,7
53,1	46,7	3,17	431	673,6	785,8	943,0
55,1	48,5	3,29	464	728,5	851,1	1.012,8
56,5	49,8	3,35	484	763,7	891,0	1.069,2
59,0	52,0	3,50	530	841,7	982,0	1.178,2

Stiffness = 460 psi							
OD	ID	e	In	lb/ft	Allowable Jacking Load		
					U.S. tons	U.S. tons	U.S. tons
13.8	12.5	0.59	59	13.4	15.7	18.0	
14.8	13.6	0.59	23	17.9	20.9	25.1	
16.0	15.5	0.57	30	26.5	30.1	37.7	
17.4	16.4	0.73	36	35.1	41.0	49.2	
20.3	18.7	0.80	42	43.9	51.2	61.4	
21.8	19.2	0.84	46	49.4	57.6	69.1	
21.7	19.7	0.87	47	51.5	59.6	71.3	
23.4	22.4	0.98	62	73.5	85.8	102.9	
25.6	23.5	1.03	69	83.5	97.5	117.0	
28.1	26.0	1.13	80	118.0	137.4	164.7	
29.5	27.5	1.20	94	116.6	136.1	163.1	
32.3	29.7	1.30	110	140.9	164.4	197.3	
33.9	31.1	1.36	121	159.1	184.8	221.1	
36.4	33.8	1.48	137	172.7	202.0	244.7	
37.8	34.8	1.52	150	193.1	225.3	270.4	
40.4	37.8	1.62	171	228.6	266.6	317.6	
43.2	40.7	1.76	177	210.0	210.0	272.0	
45.4	40.1	1.78	206	282.5	329.5	395.5	
48.4	45.1	1.94	246	361.8	408.8	484.6	
50.6	46.7	2.04	270	385.3	449.5	539.4	
53.1	49.5	2.15	295	425.5	490.4	595.7	
56.1	50.7	2.21	318	460.4	547.1	650.0	
58.5	51.9	2.27	335	498.0	572.6	687.1	
59.0	54.8	2.38	386	539.7	627.7	755.6	
60.5	55.6	2.44	386	563.8	675.8	789.4	
64.5	59.3	2.59	437	640.4	755.3	906.8	
67.7	62.3	2.72	465	720.7	840.7	1008.0	
72.5	66.7	2.91	552	830.7	979.7	1175.6	
76.5	70.4	3.09	618	950.7	1109.2	1331.0	
80.6	74.1	3.23	680	1053.9	1227.6	1475.5	
84.0	78.2	3.41	747	1147.6	1316.6	1575.2	
88.6	81.5	3.55	822	1261.2	1471.4	1765.7	

CONTINUOUS FILAMENT WINDING (CFW)

FIBERGLASS REINFORCED PLASTIC (FRP) ISO 25780

JOINT TYPE : FULLFACE GRP JACKING COUPLING



CONTINUOUS FILAMENT WINDING (CFW)

FIBERGLASS REINFORCED PLASTIC (FRP) ISO 25780

JOINT TYPE : FULLFACE GRP JACKING COUPLING



Stiffness = 144 psi						
OD	ID	e	Allowable Jacking Load			
			FS = 3.5	FS = 3.0	FS = 2.5	
in	in	in	lb/ft	U.S. Tons	U.S. Tons	U.S. Tons
13.6	12.7	0.43	16	1.2	1.4	1.7
14.8	13.9	0.46	18	1.9	2.2	2.7
16.8	15.9	0.45	20	1.4	1.6	2.0
18.8	17.8	0.51	25	6.7	7.8	9.3
20.3	19.2	0.55	29	11.0	12.8	15.4
20.9	19.7	0.56	31	12.5	14.5	17.4
21.7	20.5	0.50	33	15.4	17.9	21.5
24.3	23.0	0.65	42	31.0	36.2	43.4
25.6	24.2	0.69	47	31.2	36.4	43.6
28.3	26.8	0.76	57	43.5	50.8	60.9
29.9	28.3	0.83	65	51.0	59.6	71.5
32.3	30.6	0.87	74	54.5	63.6	76.3
33.9	32.0	0.91	81	63.6	74.2	89.0
36.4	34.4	0.98	95	82.0	95.7	114.8
37.8	35.7	1.02	102	92.4	107.8	129.3
40.4	38.2	1.08	116	110.2	128.6	154.3
43.3	40.9	1.16	133	134.5	156.9	188.3
44.4	42.0	1.19	140	143.8	167.8	201.8
48.4	45.8	1.30	167	182.5	212.9	255.5
50.8	48.0	1.38	185	208.0	245.9	295.1
53.1	50.2	1.44	202	235.4	274.6	329.6
55.1	52.1	1.49	217	257.9	300.9	361.1
56.5	53.4	1.52	227	272.0	317.3	380.7
59.0	55.9	1.58	247	303.4	353.9	424.7
60.5	57.2	1.63	261	327.2	381.4	457.9
64.5	61.6	1.70	296	370.9	431.6	519.8
67.7	64.1	1.81	325	364.2	424.9	509.9
72.5	68.6	1.95	374	438.2	511.2	613.5
76.5	72.4	2.06	418	503.2	587.0	704.4
80.6	76.2	2.17	462	570.9	666.1	799.8
85.0	80.5	2.28	514	651.3	759.8	911.8
88.6	83.8	2.38	559	720.5	840.6	1008.7
96.6	91.4	2.60	665	784.2	914.9	1097.9
100.5	95.1	2.70	718	864.0	1008.0	1209.6
104.6	99.0	2.81	780	958.9	1118.8	1342.5
108.6	102.8	2.91	838	1046.9	1221.4	1465.7
112.5	106.5	3.03	904	1148.9	1340.4	1608.5
116.6	110.4	3.13	967	1246.4	1456.1	1744.9
120.7	114.2	3.23	1032	1347.2	1571.8	1886.1

Stiffness = 230 psi						
OD	ID	e	Allowable Jacking Load			
			FS = 3.5	FS = 3.0	FS = 2.5	
in	in	in	lb/ft	U.S. Tons	U.S. Tons	U.S. Tons
13.6	12.7	0.43	16	1.2	1.4	1.7
14.8	13.9	0.46	18	1.9	2.2	2.7
16.8	15.8	0.52	23	7.0	8.2	9.8
18.8	17.6	0.59	29	13.9	16.3	19.5
20.3	19.0	0.63	34	19.2	22.4	26.9
20.9	19.6	0.65	36	21.3	24.9	29.8
21.7	20.3	0.68	39	24.8	28.9	34.7
24.3	22.8	0.76	49	42.9	50.1	60.1
25.6	24.0	0.81	54	45.3	52.9	63.5
28.3	26.5	0.89	66	60.7	70.8	85.0
29.9	28.1	0.93	74	65.9	76.9	92.3
32.3	30.3	1.00	85	75.4	87.9	105.5
33.9	31.7	1.06	95	88.6	103.3	124.0
36.4	34.1	1.14	110	108.9	127.0	153.8
37.8	35.4	1.18	118	120.3	140.3	168.4
40.4	37.9	1.26	134	143.8	167.8	201.3
43.3	40.6	1.36	155	174.4	203.5	244.2
44.4	41.6	1.39	163	186.4	217.4	260.9
48.4	45.4	1.50	191	227.2	265.1	318.1
50.8	47.6	1.59	214	262.3	306.0	367.2
53.1	49.8	1.65	231	289.3	337.5	405.6
55.1	51.6	1.72	250	318.9	372.1	446.5
56.5	52.9	1.77	264	339.7	396.3	479.0
59.0	55.3	1.85	288	377.4	440.3	528.4
60.5	56.7	1.90	303	348.2	406.3	487.5
64.5	60.5	2.01	342	393.3	458.8	550.6
67.7	63.5	2.13	380	444.2	541.5	649.9
72.5	68.0	2.28	437	551.9	643.9	772.7
76.5	71.7	2.40	485	626.0	730.4	876.4
80.6	75.5	2.52	535	704.7	812.2	986.6
85.0	79.8	2.64	592	792.6	914.7	1109.6
88.6	83.1	2.76	644	875.8	1021.8	1226.2
96.6	90.6	3.01	767	971.3	1133.2	1359.9
100.5	94.2	3.15	835	1,077.3	1,256.9	1,508.2
104.6	98.1	3.25	896	1,171.4	1,366.6	1,639.9
108.6	101.8	3.37	966	1,281.5	1,495.0	1,794.0
112.5	105.5	3.50	1,038	1,394.0	1,626.3	1,951.6

Stiffness = 288 psi						
OD	ID	e	Allowable Jacking Load			
			FS = 3.5	FS = 3.0	FS = 2.5	
in	in	in	lb/ft	U.S. Tons	U.S. Tons	U.S. Tons
13.6	12.7	0.46	16	2.7	3.1	3.8
14.8	13.8	0.50	19	4.6	5.4	6.5
16.8	15.7	0.57	25	10.7	12.5	15.0
18.8	17.5	0.64	32	18.1	21.1	25.3
20.3	18.9	0.69	37	24.4	28.5	34.2
20.9	19.4	0.71	39	27.1	31.6	37.9
21.7	20.2	0.73	41	30.1	35.1	42.2
24.3	22.7	0.83	53	50.7	59.2	71.0
25.6	23.9	0.87	58	52.4	61.1	73.3
28.3	26.4	0.95	71	69.5	81.1	97.3
29.9	27.9	1.01	79	76.4	89.1	106.9
32.3	30.1	1.09	93	88.4	103.1	123.7
33.9	31.6	1.14	102	101.0	117.8	141.4
36.4	33.9	1.22	117	122.2	142.6	171.1
37.8	35.2	1.28	127	137.6	160.5	192.6
40.4	37.7	1.36	144	162.3	189.3	227.2
43.3	40.4	1.46	166	194.2	226.6	271.9
44.4	41.4	1.50	175	207.5	242.1	290.5
48.4	45.1	1.63	208	258.2	301.3	361.5
50.8	47.3	1.72	230	293.0	341.8	410.2
53.1	49.5	1.79	250	323.3	377.2	452.6
55.1	51.3	1.87	270	355.2	414.4	497.8
56.5	52.6	1.91	284	375.9	438.5	526.2
59.0	55.0	1.99	309	415.3	484.5	581.4
60.5	56.4	2.05	326	390.3	455.4	546.4
64.5	60.1	2.19	371	446.4	520.8	625.0
67.7	63.1	2.30	409	518.7	605.2	726.2
72.5	67.6	2.46	469	611.7	713.6	856.3
76.5	71.3	2.60	523	696.1	812.1	974.5
80.6	75.1	2.74	580	785.9	916.8	1,100.2
85.0	79.3	2.87	643	886.1	1,033.7	1,240.5
88.6	82.6	3.01	702	981.3	1,144.9	1,373.8
96.6	90.0	3.29	835	1,095.2	1,277.7	1,533.2
100.5	93.7	3.43	905	1,206.2	1,407.2	1,688.6
104.6	97.6	3.54	975	1,315.2	1,534.4	1,841.2

Stiffness = 720 psi						
OD	ID	e	Allowable Jacking Load			
			FS = 3.5	FS = 3.0	FS = 2.5	
in	in	in	lb/ft	U.S. Tons	U.S. Tons	U.S. Tons
13.6	12.3	0.64	22	13.9	16.3	19.5
14.8	13.4	0.69	27	17.7	20.6	24.8
16.8	15.2	0.79	34	27.3	31.9	38.3
18.8	17.1	0.88	43	39.1	45.6	54.7
20.3	18.4	0.95	50	48.9	57.0	68.4
20.9	18.9	0.98	53	52.6	61.4	73.7
21.7	19.6	1.03	57	58.6	68.4	82.0
24.3	22.0	1.14	72	85.8	100.1	120.1
25.6	23.2	1.20	80	91.5	106.8	128.2
28.3	25.6	1.32	97	116.9	136.4	163.7
29.9	27.1	1.40	109	130.3	152.0	182.4
32.3	29.3	1.52	127	151.2	176.4	211.6
33.9	30.7	1.58	139	169.3	197.5	237.0
36.4	33.0	1.71	161	203.5	237.4	284.9
37.8	34.2	1.78	174	223.3	260.6	312.7
40.4	36.6	1.89	198	260.6	304.0	364.8
43.3	39.2	2.03	228	308.0	359.4	431.2
44.4	40.2	2.08	240	326.6	381.0	457.8
48.4	43.9	2.26	284	397.7	464.0	556.8
50.8	46.0	2.38	314	445.8	520.1	624.1
53.1	48.1	2.49	343	492.5	574.6	689.5
55.1	49.9	2.58	369	535.8	625.1	750.1
56.5	51.1	2.65	389	568.1	662.7	795.3
59.0	53.5	2.76	422	622.6	726.4	871.7
60.5	54.8	2.83	445	608.2	709.5	851.4
64.5	58.5	3.05	504	690.4	805.5	966.6
67.7	61.4	3.17	557	788.3	919.7	1,103.6
72.5	65.7	3.39	637	918.7	1,071.8	1,286.2

Stiffness = 920 psi						
OD	ID	e	Mass	Allowable Jacking Load		
				FS = 3.5	FS = 3.0	FS = 2.5
in	in	in	lb/ft	U.S. Tons	U.S. Tons	U.S. Tons
13.6	12.2	0.69	24	17.1	19.9	23.9
14.8	13.3	0.75	29	21.4	24.9	29.9
16.8	15.1	0.85	37	31.8	37.1	44.5
18.8	16.9	0.95	46	45.1	52.6	63.1
20.3	18.2	1.03	54	55.7	64.9	77.9
20.9	18.8	1.06	57	60.0	70.0	84.0
21.7	19.5	1.10	61	66.6	77.7	93.3
24.3	21.9	1.24	78	96.1	112.1	134.6
25.6	23.0	1.30	86	102.8	120.0	144.0
28.3	25.4	1.43	105	131.4	153.3	184.0
29.9	26.9	1.52	118	146.1	170.5	204.6
32.3	29.0	1.64	137	168.9	197.0	238.4
33.9	30.4	1.71	150	188.1	220.9	267.0
36.4	32.7	1.85	174	226.0	263.6	316.4
37.8	34.1	1.91	187	246.7	287.9	345.4
40.3	36.3	2.14	220	289.1	337.7	405.8
44.3	39.8	2.18	244	337.1	393.3	471.9
48.4	43.9	2.24	257	358.8	418.6	502.3
49.5	43.5	2.49	306	424.7	510.9	613.7
50.8	45.7	2.56	330	480.2	567.2	680.7
53.1	47.7	2.70	370	542.3	632.6	759.9
55.1	50.5	2.98	438	636.4	739.3	893.7
56.5	50.7	2.85	417	619.0	722.1	866.6
59.0	53.1	2.97	454	680.1	793.4	952.1
60.5	54.3	3.07	480	723.2	844.4	941.2
62.0	56.7	3.15	515	764.5	892.0	1,070.3
67.7	60.9	3.43	600	866.3	1,010.5	1,212.3



ENVIRONMENTAL
PRODUCT
DECLARATION

TURKEY

EPD®

ENVIRONMENTAL PRODUCT DECLARATIONS

In accordance with ISO 14025 and EN 15804:2012+A2:2019 for

GRP Pipes

from

SUPERLIT Pipe Industries

PIPE INDUSTRIES

Programme:	EPD Turkey, a fully aligned regional programme www.epdturkey.org	The International EPD® System www.environdec.com
Programme operator:	EPD Turkey: SÜRATAM – Turkish Centre for Sustainable Production Research & Design Nef 09 B Blok No:7/15 34415 Kağıthane/Istanbul, TURKEY	EPD International AB
EPD registration number:	S-P-01994	
Publication date:	14.12.2020	
Validity date:	13.12.2025	
Geographical scope:	Global	

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