FARATEC

FARATEC GENERAL CATALOGUE
PIPE SYSTEMS

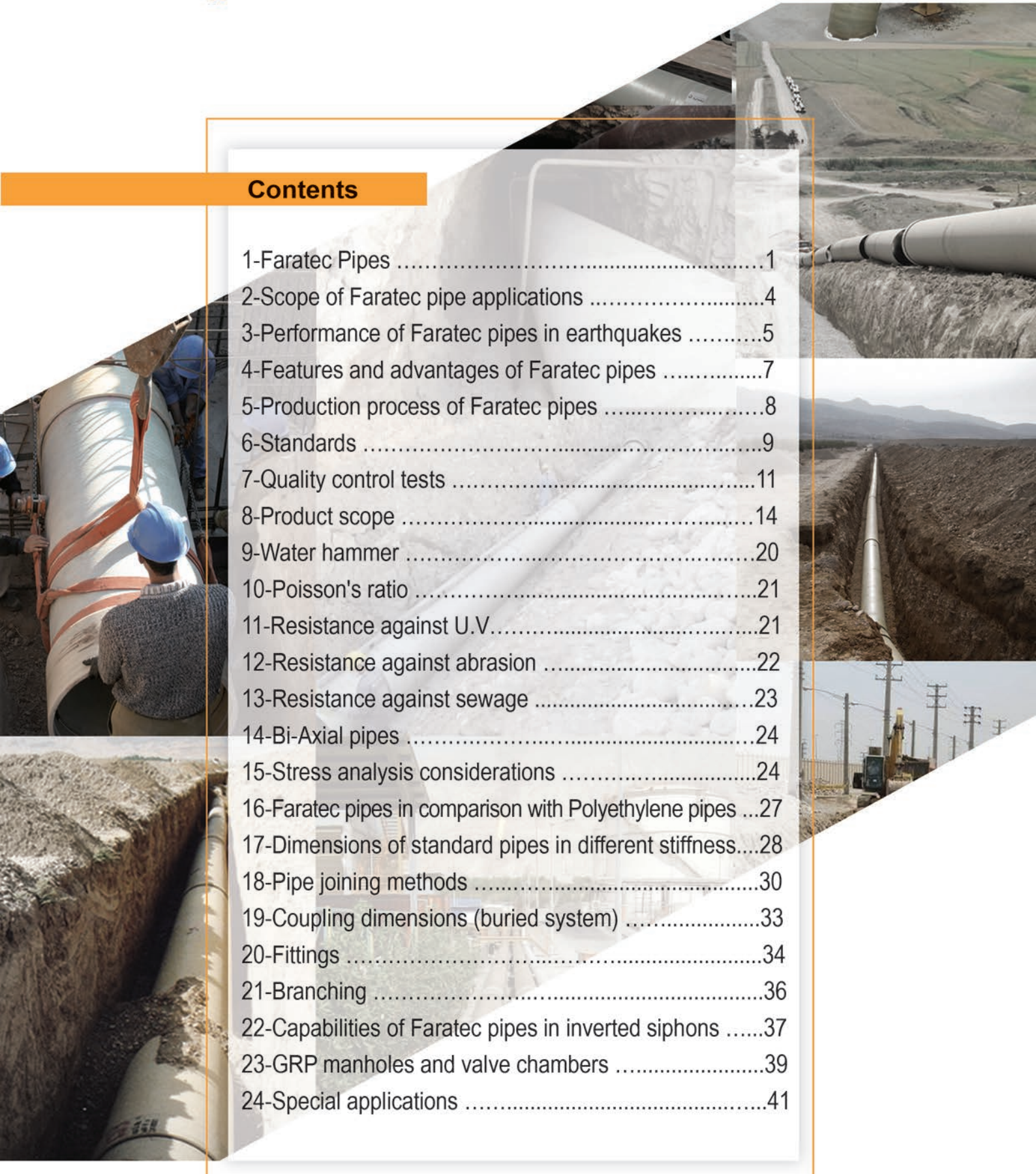








- **FARATEC GRP PIPES AND FITTINGS**
- Diameters 25 to 4000 mm up to 100 bar pressure



Contents

1-Faratec pipes

GRP Faratec pipes are composite pipes known worldwide as GRP (Glass Reinforced Polymer Pipe) or FRP (Fiber Reinforced polymer pipe). Development in composite technology has led to improvements in capabilities and applications of GRP pipes so that these kinds of pipes are used in many infrastructures nowadays.

Because of the fact that GRP Faratec pipes benefit a superior manufacturing technology in comparison with the other GRP pipes, they're chosen as the best alternative in prominent national and international projects.

Faratec composite pipes are suitable alternatives to replace other kinds of pipes such as Polyethylene, PVC-U, Carbon Steel, Titanium Alloy, Cupper Nickel, Ductile Iron and Stainless Steel. GRP Faratec pipes could be the most important and a unique alternative according to their high mechanical resistance as well as considerable chemical resistance against corrosion which almost all kinds of metal pipes have problems with.

In addition, the lower cost of GRP pipes and their simple installation procedure, encourage the users to choose these pipes, especially when they're compared to metal pipes.

Many companies under the license of Faratec such as Farassan Fars, Saba Loole, Farapox, Avisa Parseh Zabol, Farassan in Iran, Grand pipe in Turkey, Romania and Africa provide services to customers in the following fields:

• Supply pipes and different kinds of fittings, manholes and valve chambers with GRP, GRE and GRVE material.

• Engineering services such as detailed studies, providing executable drawings for piping (by PDMS software), stress analysis of the piping, supporting design and etc.

As regards the GRP pipes consist of advanced engineering of fiberglass and resin with specific compositions, the manufacturer could achieve the pipes with desired characteristics choosing correct composition of material and process.

Producible pipe types
1. GRP pipes
2. GRVE pipes
3. GRE pipes
4. Pipe jacking type
5. Abrasion/Erosion resistant pipes
6. Uni-Axial pipes (buried)
7. Bi-Axial or semi-steel pipes: mechanical strength similar or higher than steel pipes
8. Earthquake resistant pipes
9. Pipes appropriate to transfer potable and raw water
10. Pipes appropriate for urban sewerage networks

Please contact Farassan Company for more information about each product.

Product scope is as follows:

- Diameter 25 up to 4000 mm
- Pressure 1 up to 100 bars
- Stiffness 2500 up to 20000 Pascal (higher stiffness is producible on request)

This scope contains all kinds of products according to national and international standards. Any unusual product or the products out of scope of the usual standards will be designed and manufactured if needed, therefor products with different diameters, nominal pressures and stiffness would be manufactured on request. Please contact Farassan Company for more information about these kinds of products.

2-Scope of Faratec pipe applications

Regarding to widespread applications of Faratec composite pipes, several examples on the applications are given as following:

-Water transmission and distribution
(potable and raw water)
- Sanitary collection systems
- Storm sewers
- Sea water transmission systems
- Irrigation and drainage networks
- Cooling water systems
- Pipe jacking systems
- Hydropower plant projects

If constructing new pipelines or replacing other pipe materials, Faratec pipes deliver long, effective service lifespan with low operating and maintenance costs. Faratec pipes are usually the lowest cost option.

3-Performance of Faratec pipes in earthquakes

The effect of earthquake on buried pipelines is divided into two main categories of temporary land deformation due to the release of earthquake waves and permanent land deformation such as liquefaction, lateral extension and landslide. During design and routing of pipelines, geotechnical studies should identify the geological hazards associated with earthquakes, in order to select the most suitable route for pipelines.
The experience of extreme earthquakes in different parts of the world has indicated that composite pipes have the ability to function properly.

This appropriate behavior in the earthquake is due to the following three factors:

1- The considerable flexibility of the fiberglass pipes and the matching of the pipeline with temporary and permanent deformation of the earth during and after the earthquake.

2- High mechanical strength of the fiberglass pipes allows the pipes to tolerate stresses from the surrounding soil.

3- Joints of fiberglass pipes have a good functionality against earthquakes. The common REKA coupling joints with an axial tolerance of at least 0.3% length and a suitable deflection angle, can depreciate a significant portion of the deformations on the pipe. On the other hand, rigid joints such as glued coupling or lamination joints have the ability to attach pipes to create continuous operation in the pipeline and stress is tolerated by the pipe body.

Therefore, Faratec pipes could be designed for a variety of specific conditions.

Country	Name of earthquake	Time	Earthquake magnitude
Iran	Fars-Lar	1996 - 2007	3.0-7.0
Iran	Kermanshah - Sarpol-e-Zahab	Nov. 2017	7.0-7.5
New Zealand	Christchurch	Jun. 2011	6.3
New Zealand	Christchurch	Sep. 2010	7.1
Chili	Conception	Feb. 2010	8.8
Colombia	Armenia	Jan. 1999	6.2
Turkey	Izmir	Oct. 2005	5.9
Turkey	Erzurum	Mar. 2004	5.6
Turkey	Sultandagi-Afyon	Dec. 2000	6.0
Turkey	Izmit (Kocaeli)	Aug. 1999	7.6

Examples of successful performance of composite pipes in large earthquakes in Iran and other parts of the world

In the Iran-Kermanshah earthquake (2017) in Sarpol-e-Zahab County, the second largest earthquake recorded in Iran, Faratec pipelines were not only damaged in the vicinity of the earthquake, but they were able to provide part of the vital needs of the region by supplying the district's drinking water.

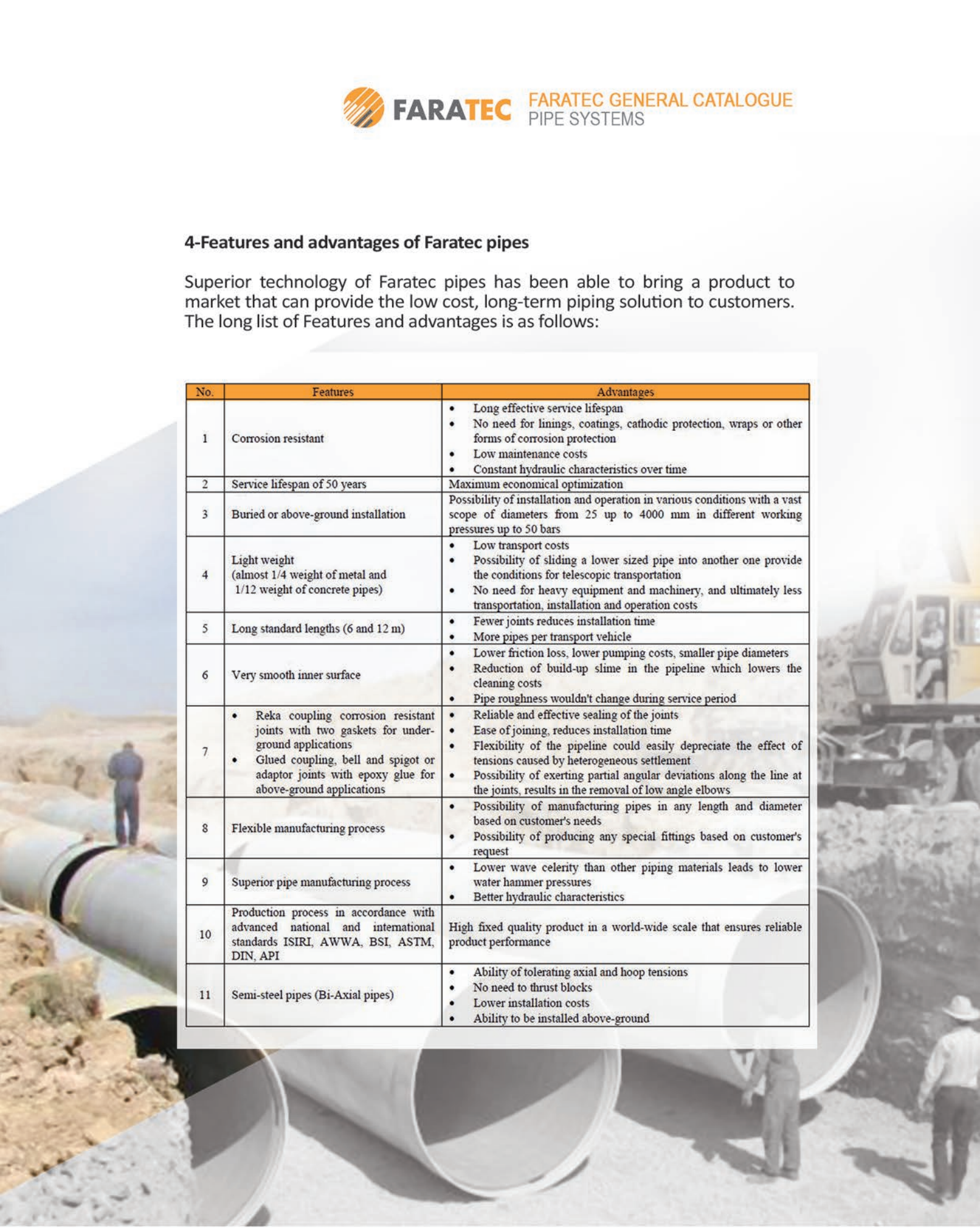
Qualification for the transfer of drinking water

Faratec composite pipes have been tested and approved for drinking water transmission by
Ministry of Health and Medical Education of Iran and the WRAS Institute of England.

4-Features and advantages of Faratec pipes

Superior technology of Faratec pipes has been able to bring a product to market that can provide the low cost, long-term piping solution to customers. The long list of Features and advantages is as follows:

No.	Features	Advantages
1	Corrosion resistant	• Long effective service lifespan • No need for linings, coatings, cathodic protection, wraps or other forms of corrosion protection • Low maintenance costs • Constant hydraulic characteristics over time
2	Service lifespan of 50 years	Maximum economical optimization
3	Buried or above-ground installation	Possibility of installation and operation in various conditions with a vast scope of diameters from 25 up to 4000 mm in different working pressures up to 50 bars
4	Light weight (almost 1/4 weight of metal and 1/12 weight of concrete pipes)	• Low transport costs • Possibility of sliding a lower sized pipe into another one provide the conditions for telescopic transportation • No need for heavy equipment and machinery, and ultimately less transportation, installation and operation costs
5	Long standard lengths (6 and 12 m)	• Fewer joints reduces installation time • More pipes per transport vehicle
6	Very smooth inner surface	• Lower friction loss, lower pumping costs, smaller pipe diameters • Reduction of build-up slime in the pipeline which lowers the cleaning costs • Pipe roughness wouldn't change during service period
7	• Reka coupling corrosion resistant joints with two gaskets for under-ground applications • Glued coupling, bell and spigot or adaptor joints with epoxy glue for above-ground applications	• Reliable and effective sealing of the joints • Ease of joining, reduces installation time • Flexibility of the pipeline could easily depreciate the effect of tensions caused by heterogeneous settlement • Possibility of exerting partial angular deviations along the line at the joints, results in the removal of low angle elbows
8	Flexible manufacturing process	• Possibility of manufacturing pipes in any length and diameter based on customer's needs • Possibility of producing any special fittings based on customer's request
9	Superior pipe manufacturing process	• Lower wave celerity than other piping materials leads to lower water hammer pressures • Better hydraulic characteristics
10	Production process in accordance with advanced national and international standards ISIRI, AWWA, BSI, ASTM, DIN, API	High fixed quality product in a world-wide scale that ensures reliable product performance
11	Semi-steel pipes (Bi-Axial pipes)	• Ability of tolerating axial and hoop tensions • No need to thrust blocks • Lower installation costs • Ability to be installed above-ground



5-Production process of Faratec pipes

Faratec pipes' diameter range from 300 to 4000 mm which is manufactured based on the advanced Continuous Filament Winding method.

This process allows the use of continuous glass fiber reinforcements in the circumferential direction which is mixed by Chopped glass fiber to reinforce the pipe in axial and hoop directions. Incorporating continuous reinforcements in circumferential direction increases strength of the pipes and is costly efficient thus the pressurized under-ground pipes could resist well in hoop direction.

In this process which is based on an advanced manufacturing technology, three main categories of raw materials are used to make a compressed layer with maximum efficiency.

In addition to resin and continuous-chopped glass fibers to make necessary axial and hoop strength, silica sand may be added to increase pipe's stiffness.

In diameters of 300 mm and less, the raw materials are likewise, but the production method is discontinuous.

6-Standards

Standards developed by Norsak, DIN, ISO, API, ASTM, AWWA and ISIRI are applied to a variety of Faratec pipes applications including drinking water transmission, sanitary systems, and etc. The principal communality of different standards is the definition of the efficiency of pipes for specific uses based on useful lifespan.

6-1-Iranian standards

Pipe type	Code	Standard
Pressure pipes - water supply systems	10729	ISIRI
Non-pressure pipes - gravity sewerage systems	10730	ISIRI
Joints of GRP pipes	11432	ISIRI
Pressure pipes - sewerage and industrial systems	11433	ISIRI
Petroleum and gas industries	IPS-E-PI-221/1	

6-2-ASTM standard

Currently, there are several ASTM product standards in use which apply to a variety of fiber glass pipe applications. These standards include many tough qualification and quality control tests. Faratec pipes are designed to meet all of these standards.

Pipe type	Code	Standard
Gravity sewer	D3262	ASTM
Pressure pipe	D3517	ASTM
Pressure sewer	D3754	ASTM

6-3-TSE and ISO standards (CEN and TSEN)

Pipe type	Standard
Pressurized or gravity water conveyance systems	TSEN 1796
Pressurized or gravity sewerage and drainage systems	TSEN 14364
Pressurized or gravity water conveyance systems	TSEN 10639
Pressurized or gravity sewerage and drainage systems	TSEN 10467

Standards DIN 16868 and BS 5480 have been updated by new EN standards that are mentioned above.

6-4-AWWA and ASME standards

AWWA C950 is one of the most comprehensive product standards for GRP pipes. This standard applies to the use of pressurized water pipelines with full specifications for pipes and fittings, which are based on quality control and qualification tests according to the appropriate pattern.
AWWA has developed a standard design guide named M45, several parts of which are devoted to the design of GRP pipes for buried and above-ground installation methods.

Pipe type	Standard
Fiberglass pressurized pipe	AWWA C950
Fiberglass pipes design manual	AWWA M45
Pipes and pipelines	ASME B31.4
Flange drilling	ASME B16.5 (up to 24")
	ASME B16.47 (up to 60")
	AWWA C207 (above 60")
Process piping	ASME B31.3

7-Quality control tests

Since the quality of raw materials has a major impact on the quality of the manufacturer's products, these materials are purchased carefully from reliable resources, and all of the necessary tests are carried out before they are consumed. Purchase of raw materials is done from the approved sources of the Faratec Technology Center, thus the quality of the products will be guaranteed in accordance with the company's standards and technical specifications of the pipes.

In addition, appropriate quality control tests are carried out on raw materials purchased, in accordance with the company's quality control program. Taking into account the quality considerations in purchasing raw materials, the company ensures the quality of the superior products. In the quality control unit, the following controls are implemented in three stages:

a. Pre-production tests on input materials

b. Tests and controls during production

c. Post-production tests on the final product

The main raw materials in the production of GRP pipes are as follows:

- **Glass fiber**
- **Resin**
- **Catalyst**
- **Filer (silica sand)**
- **Chemical additives and accelerators**
- **Surface mat**

7-1-Final product and related tests

The final product shall be subjected to following control checks:

- Visual inspection
- **Hardness (Barcol)**
- **Wall thickness**
- **Length and diameter**
- **Hydrostatic test (twice the nominal pressure)**
- **Structural analysis of the Pipes and design verification (Loss On Ignition or L.O.I test)**
- **Tensile test in axial and hoop directions**
- **And etc.**

7-2-Qualification tests

Qualification tests are required in accordance with international standards as well as national standard of Iran. These tests are said to be long-term because their duration lasts around 10,000 hours (approximately 1.5 years). Qualification tests are carried out for three main objectives:

a. Determination of the long-term mechanical properties of the raw materials used in the pipe structure. It should be taken in account that long-term mechanical strength of 50 years is determined by qualification tests.

b. Gaining results for designing GRP pipes with a useful lifespan of 50 years
c. Performing re-qualification tests to confirm that the raw materials have a consistent formulation and quality (once every 1.5 years)

The most important qualification tests are as follows:

- *Hydrostatic design basis*
- *Long term ring bending , "Strain bending test "*
- *Long term specific ring stiffness*

In addition to long-term tests, the following tests are also carried out:

- Resistance to UV rays
- Resistance to abrasion
- Test of fittings (short-term and long-term)

8-Product scope

8-1-Diameter

Faratec pipes can be supplied in the following nominal diameters (mm). Smaller and other diameters are available on request. Please contact Farassan Company for more information.

Continuous Filament Winding					
300	350	400	450	500	600
700	800	900	1000	1100	1200
1400	1600	1800	2000	2200	2400
2600	2800	3000	3200	3400	3600
3800	4000				

Discontinuous Filament Winding						
25	50	100	150	200	250	300

8-2-Length

The standard length of Faratec pipes for diameters over 300 mm is 12 meters, for diameters 100 to 300 mm is 6 meters and for diameters less than 100 mm is 3 meters. Any other length could also be supplied for special orders.

8-3-Pressure

Typical pressure classes of Faratec pipes are listed in the following table. Contact the manufacturer if you are requesting a higher working pressure. Faratec pipes can be produced up to 100 bars working pressure at lower diameters.

Pressure Class(bar)	6	9	10	12	15	16	20	25	32	50	100
Diameter Upper Limit (mm)	4000	4000	4000	4000	4000	4000	1600	1600	1600	300	200

The working pressure of the pipes has been calculated according to AWWA M45 standard. Pressure classification is determined based on the maximum pressure at operation time and does not depend on the depth of the pipe burial.

Faratec pipes are manufactured in a wide range of diameters up to 4000 mm (157 inches) and maximum working pressure of 100 bars (1450 PSI).
Some of the mechanical properties of Faratec Uni-Axial and Bi-Axial pipes are shown in the table below compared to steel and GRE pipes.

	Pipe Type				
Term	Unit	Uni-Axial	Bi-Axial	GRE	Steel***
Max axial tensile	MPa	55.9	115	107.8	207
Max hoop tensile	MPa	342.6	394	264.7	207
Axial modulus of elasticity	GPa	9.4-11.7	10.7	12.7	207
Hoop modulus of elasticity	GPa	9.2-32.9	19.4*	17.6	207
Poisson's ratio	---	0.25	0.3	0.26	0.26
Specific gravity	---	2.0	2.0	1.8	7.8
Hazen-William's C	---	150	150	150	130**

* Average quantity
** New pipe with cement lining. Roughness increases exponentially over time.
*** The range of mechanical strength value is based on AWWA M11. Referring to the API 5L, value of 207 for the metal pipe is the minimum resistance for the pipe made at Grade A.
The values in the table are merely for comparison purposes. Please contact Farassan Company for precise values if required.

In order to ensure long lifespan service of the pipeline, the following tips should be noted:

8-4-Hydrotest

Maximum test pressure in the factory based on pressure classification (AWWA C950, ASTM D3517)	2.0 × PN
Maximum field test pressure	1.5 × (P_w)

8-5-Water hammer

$P_s + P_w < 1.4 \times PN$	Maximum pressure

8-6-Stiffness

Faratec pipes are manufactured in following standard stiffness:

Reference	Unit	Nominal Pipe Stiffness (SN)					
ISO	Pa	1250	2500	5000	10000	15000	20000
AWWA	kN/m^2	62	124	248	494	744	992

8-7-Flow velocity

The permitted flow velocity in Faratec pipes is 3 m/s which could be increased in the absenceof abrasive materials in the fluid up to 9 m/s. Please contact Farassan Company for more information.

8-8-Load capacity

Faratec pipes use the following values for hoop tensile strength and axial tensile .strength according to common standards

Hoop (Circumferential) Load Capacity (Strength), in N/mm of Circumference								
DN	4	6	10	12,5	16	20	25	32
100	80	120	200	250	319	400	500	640
150	121	180	300	375	478	600	750	960
200	160	240	400	500	639	800	1000	1280
250	201	300	500	625	798	1000	1250	1601
300	240	360	600	750	957	1200	1500	1920
350	281	420	700	875	1117	1400	1750	2240
375	300	450	750	937	1197	1500	1876	2400
400	320	480	800	1000	1276	1600	2000	2560
450	361	540	900	1125	1436	1800	2250	2880
500	400	600	1000	1250	1595	2000	2500	3200
550	441	660	1100	1375	1755	2200	2750	3520
600	480	720	1200	1500	1915	2400	3000	3840
700	560	840	1400	1750	2234	2800	3500	4480
750	601	900	1500	1875	2393	3000	3750	4801
800	641	960	1600	2000	2553	3200	4000	5120
850	681	1020	1700	2125	2712	3400	4250	5440
900	720	1080	1800	2250	2871	3600	4500	5760
1000	800	1200	2000	2500	3191	4000	5000	6400
1100	880	1320	2200	2750	3510	4400	5500	7040
1150	921	1380	2300	2875	3669	4600	5750	7360
1200	960	1440	2400	3000	3829	4800	6000	7680
1300	1040	1560	2600	3250	4148	5200	6500	8320
1400	1120	1680	2800	3500	4467	5600	7000	8960
1500	1200	1800	3000	3750	4786	6000	7500	9600
1600	1280	1920	3200	4000	5105	6400	8000	10240
1700	1360	2040	3400	4250	5425	6800	8500	10880
1800	1440	2160	3600	4500	5743	7200	9000	11520
1900	1520	2280	3800	4750	6062	7600	9500	12160
2000	1600	2400	4000	5000	6381	8000	10000	12800
2100	1680	2520	4200	5250	6701	8400	10500	13440
2200	1760	2640	4400	5500	7020	8800	11000	14080
2300	1840	2760	4600	5750	7338	9200	11500	14720
2400	1920	2880	4800	6000	7658	9600	12000	15360
2500	2000	3000	5000	6250	7977	10000	12500	16000
2600	2080	3120	5200	6500	8296	10400	13000	16640
2700	2160	3240	5400	6750	8615	10800	13500	17280
2800	2240	3360	5600	7000	8934	11200	14000	17920
2900	2320	3480	5800	7250	9253	11600	14500	18560
3000	2400	3608	6000	7500	9572	12000	15000	19200
3100	2480	3726	6200	7750	9891	12400	15500	19840
3200	2560	3844	6400	8000	10210	12800	16000	20480
3300	2640	3962	6600	8250	10529	13200	16500	21120
3400	2720	4080	6800	8500	10848	13600	17000	21760
3500	2800	4200	7000	8750	11168	14000	17500	22400
3600	2880	4320	7200	9000	11487	14400	18000	23040
3700	2960	4440	7400	9250	11806	14800	18500	23680
3800	3040	4560	7600	9500	12125	15200	19000	24320
3900	3120	4680	7800	9750	12444	15600	19500	24960
4000	3200	4800	8000	10000	12763	16000	20000	25600

Axial (Longitudinal) Load Capacity (Strength), in N/mm of Length								
DN	4	6	10	12,5	16	20	25	32
100	70	75	80	85	90	100	110	125
125	75	80	90	95	100	110	120	135
150	80	85	100	105	110	120	130	145
200	85	95	110	115	120	135	150	155
250	90	105	125	130	135	155	170	190
300	95	110	140	145	155	175	200	220
400	105	130	165	175	190	215	250	285
500	115	145	190	205	225	255	300	345
600	130	160	220	235	255	295	350	415
700	140	175	250	265	290	335	400	475
800	155	190	280	300	325	380	450	545
900	165	205	310	330	360	420	505	620
1000	180	225	340	365	395	465	555	685
1200	205	255	380	415	465	540	645	790
1400	230	290	420	460	530	620	745	915
1600	255	320	460	520	600	700	845	1040
1800	280	350	500	570	670	785	940	1160
2000	305	385	540	625	740	865	1040	1285
2200	335	415	575	675	810	945	1140	1410
2400	360	450	620	730	880	1025	1240	1530
2600	385	480	665	785	945	1110	1335	1655
2800	410	515	710	840	1015	1190	1435	1780
3000	435	545	755	890	1080	1270	1535	1900
3200	460	575	805	950	1150	1350	1630	2025
3400	490	610	850	1005	1220	1430	1730	2150
3600	520	645	895	1060	1290	1515	1830	2250
3800	550	680	940	1115	1355	1595	1930	2400
4000	580	715	985	1170	1425	1675	2025	2520

8-9-Operating temperature

Faratec pipes have the ability to be designed for fluid transfer temperatures up to 160 ºC. Maximum allowable fluid temperature in standard pipes produced with commonly used polyester resins is 45 °C. For continuous operation at a temperature between 50 °C and 60 °C it is recommended to consider one higher pressure class; e.g.: use a 10 bar pipe for 6 bars. At higher temperatures other resins with higher thermal resistance and special design are used. Please contact Farassan Company for more information.

8-10-Thermal expansion coefficient

The thermal coefficient of axial expansion and contraction for Faratec pipes is as follows:

$$21 \times 10^{-6} cm/cm/^{oC} \quad \text{ت} \quad 28 \times 10^{-6} cm/cm/^{oC}$$

This coefficient in the longitudinal direction is 1.5 to 2 times the one for steel.
However, for under-ground pipes the thermal expansion is eliminated by using couplings. In case of above-ground installation which solid pipe joints should be implemented, the pipes' longitudinal changes would not be neglected. Hence the stress analyze of piping should be carried out to investigate if using expansion joints or expansion loops are required.

8-11-Hydraulic coefficients

Head loss of pipeline is due to elevation change, flow turbulence (due to a sudden change in cross-sectional direction) and fluid friction with the wall of the pipe. Different methods are used to measure the frictional loss of pressure in Faratec pipes.
Common methods include the equations Manning, Darcy-Weisbach and Hazen-Williams. Following coefficients are used in the corresponding equations for design.

a. In Hazen-Williams equation: the C coefficient is approximately 150 to 165
b. In Manning equation: the roughness coefficient is n=0.009
c. In Darcy-Weisbach equation: the surface roughness value is e=0.00518mm
d. In Colebrook White equation: the coefficient value is k=0.029 mm

One of the advantages of Faratec pipes in comparison to metal pipes is their low internal roughness. The effects of this advantage on pressurized fluid transfer systems will be as follows:

a. *Reducing head loss (HF)*
b. *Reducing pumping station's electricity costs (CP)*
c. *Increasing fluid discharge capacity (QF)*
d. *Decreasing pipe diameter (D)*

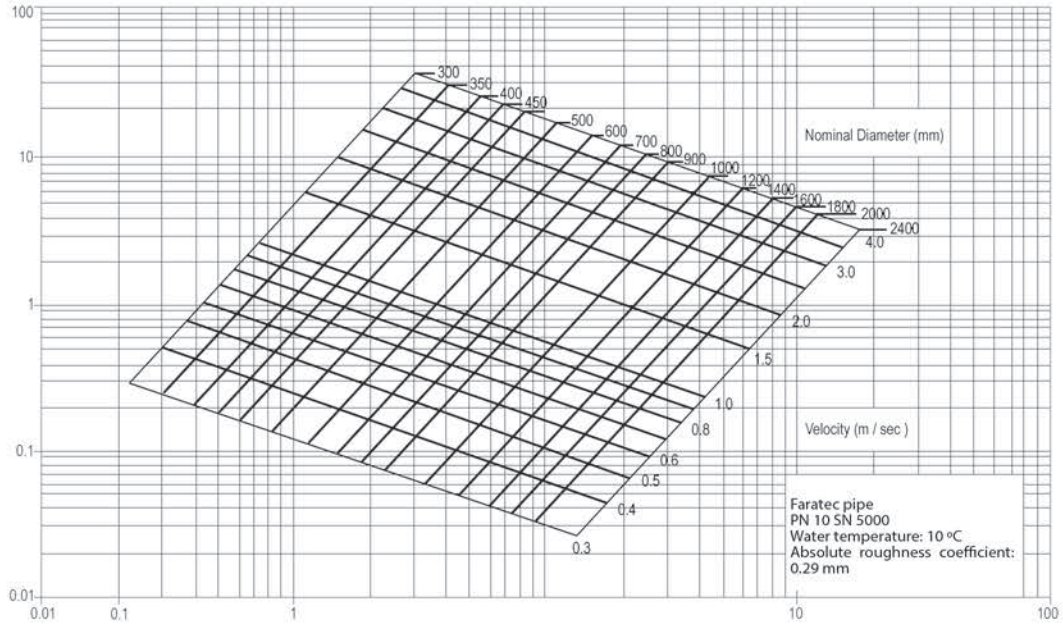
The mentioned advantages could be verified using hydraulic equations (such as Hazen-Williams). In this regard, the following example is presented about decreasing diameter.
In a pressurized system with a constant length and flow conditions (flow and head loss), if the diameter of the steel pipe is 2000 mm, the equivalent diameter is 1800 mm for Faratec pipe as detailed in following calculations:

$$HF_{STEEL}=HF_{GRP} \rightarrow \text{(Hazen-Williams equation)}\ HF=\frac{10.68\,Q^{1.852}.L}{C^{1.852}.D^{4.87}} \rightarrow$$

$$\rightarrow (110/150)^{1.852}=(D_{GRP}/D_{STEEL})^{4.87} \rightarrow D_{GRP}=1777mm$$

In which:
HF (head loss in mH2O)
L (length of the pipeline in m)
Q (discharge in m3/s)
D (pipe diameter in m)
C (Hazen-Williams coefficient)

Due to the fact that the closest diameter of Faratec pipes to 1777mm is 1800 mm, a pipe with this diameter will be used. While the internal roughness of the metal pipes increases with time, the roughness of Faratec pipes is constant over time.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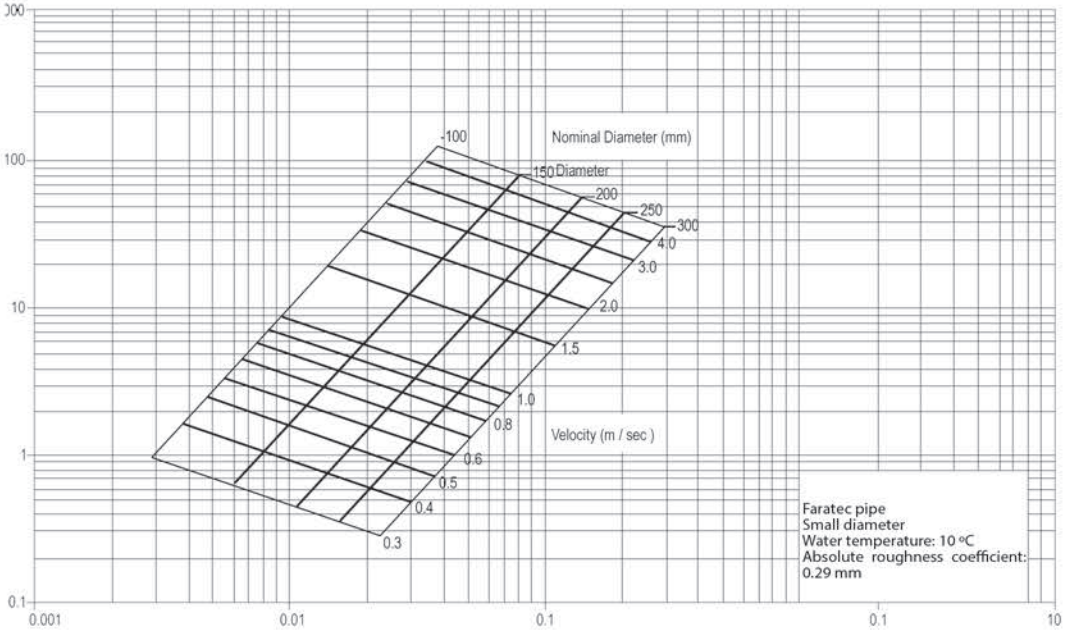
1000
1200
1400
1600
1800
2000
2400
Nominal Diameter (mm)
4.0
3.0
2.0
1.5
1.0
0.8
0.6
0.5
0.4
0.3
Velocity (m / sec)
Faratec pipe
PN 10 SN 5000
Water temperature: 10 °C
Absolute roughness coefficient:
0.29 mm
Discharge (m3/s)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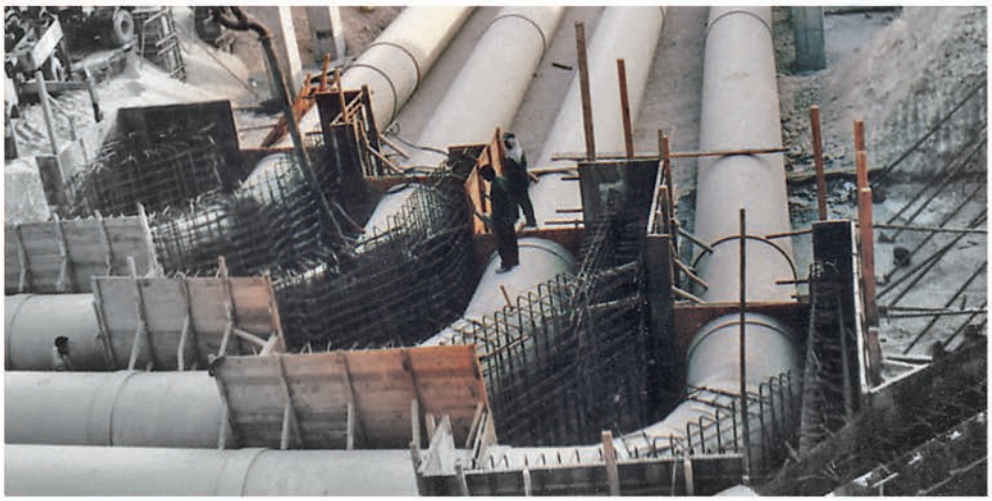
Nominal Diameter (mm)
Diameter
150
200
250
300
4.0
3.0
2.0
1.5
1.0
0.8
0.6
0.5
0.4
0.3
Velocity (m / sec)
Faratec pipe
Small diameter
Water temperature: 10 °C
Absolute roughness coefficient:
0.29 mm
Discharge (m3/s)

9-Water hammer

Internal shocks, most notably water hammer effect, are due to a sudden change in fluid velocity inside the system which is usually caused by rapid closing or opening the valves, or the sudden start-stop of the pumps. Low modulus of elasticity of GRP pipes in comparison with metal pipes makes it possible to reduce water hammer effect in the system. Faratec pipes are able to withstand water hammer at various pressure levels according to the following formula. This approximate formula is used to determine the pressure changes at certain points in a direct pipeline, ne-

$$\frac{P_W + P_S}{1.4} < P_N$$



$$\Delta H = (W.\Delta V)/g$$

In which:

ΔH: *pressure change (m)*

W: *pressure wave celerity (m/s)*

g: *gravity acceleration (m/s2)*

ΔV: *change in fluid velocity (m/s)*

Pressure wave celerity in Faratec pipes could be extracted from following table:

Surge Wave Celerity for Pipes (m/sn)

SN 2500			
DN	300-400	450-800	900-2500
PN6	365	350	340
PN10	435	420	405
PN16	500	490	480

SN 10000			
DN	300-400	450-800	900-2500
PN6	420	415	410
PN10	435	425	415
PN16	500	495	485
PN25	580	570	560
PN32	620	615	615

SN 5000			
DN	300-400	450-800	900-2500
PN6	405	380	370
PN10	435	420	410
PN16	505	495	485
PN25	575	570	560

SN 10000					
DN	100	125	150	200	250
PN6	580	560	540	520	500
PN10	590	570	560	540	520
PN16	640	620	610	600	590

10-Poisson's ratio

This coefficient depends on the structure of the pipe. Poisson's ratio in Faratec pipes for hoop stress and axial strain is between 0.22 and 0.29 and for axial stress and hoop strain is slightly lower than the above.

11-Resistance against U.V.

About 5% of sunlight is U.V. ray covering wavelengths of 280 to 400 nm. Solar radiation energy is usually measured with Langley unit (Ly):

$$1\ \text{Ly} = 1\ \frac{Cal}{Cm2}$$

The average solar radiation in kilo-Langley (KLy) for different countries is as following table:

Iran	200	Germany	80
Malaysia	140	England	70
Saudi Arabia	200	Austria	80
Ethiopia	150	Norway	70
France	120	Brazil	120
South Africa	160	Japan	100

Research and experiments show that if the pipes have been selected correctly, the U.V. rays do not have any effect on Faratec pipes.

In general, based on their installation method, pipes are classified into two types of buried and above-ground. In above-ground pipes, chemical U.V. absorber or mechanical U.V. reflective materials are used to prevent damages of U.V. rays. It is recommended to use U.V.-resistant additives if burial pipes are going to be exposed to the sun for more than one year.

12-Resistance against abrasion

Faratec pipes are abrasion resistant. The abrasion resistance coefficient can predict the effect of sand or other particles on the inner surface of the pipe. Faratec pipe resistance has been investigated by the Darmstodt rocker method. According to the experiments, the average abrasion loss of Faratec pipes against silica sand is 0.34 mm at 100,000 full cycles.

13-Resistance against sewage

13-1-Resistance against sewage

The contents of urban and industrial sewage are not predictable. A wide range of corrosive fluids with different pH (base or acid) such as detergents, disinfectants, drain openers, anti-vermin toxins, along with suspended particles and even sharp objects are also found in sewage. Thus, a pipe used for a sewerage system should not only be resistant to chemicals, but also have a good mechanical strength.
The constant and low roughness of Faratec pipes makes it possible to have milder slopes in gravity sewerage systems and the pipes function optimally over time. Special sewerage Faratec pipes are completely resistant to a variety of chemicals and have constant mechanical properties over their 50-year useful lifespan. Buried metal pipes corrode from the outer side of their wall due to the free electrical charges and corrosive soil around. Unprotected metal pipes are also gradually corroded from inside because of the fluid flow through them.
Unprotected concrete pipelines corrode quickly from the inside due to the presence of acidic environments and corrosive gases from sewage.
It should be noted that because of the chemical properties and quality of the fluid, the type of the GRP product suitable for the users will be recommended and produced by Farassan Company.

14-Bi-Axial pipes

Bi-Axial pipes can be used in various projects of water supply (drinking or raw water), etc.
Then this generation of pipe is capable of being designed for various industrial applications.

14-1-Mechanical characteristics

The design of the Bi-Axial pipes resulted in pipes with extremely high axial and hoop strengths, therefore these pipes are much more resistant than standard burial pipes. Installing these pipes could be done using different installation methods such as butt-wrap or glued couplings. Some of the mechanical characteristics of the above pipes as well as Butt-Wrap joints are given in the following table:

Faratec Biaxial Pipes				Butt-wrap Joints
Physical Prperties	Hoop	Axial	Hoop	Axial
E_T,Tensile modulus (GPa)	20.0	13.1	-	10.3
E_T,Flexural modulus(GPa)	18.6	12	-	10.3
$\sigma_{T_{ULT}}$ Ultimate tensil stress(Mpa)	380	158	-	138
ν Poisson 's ratio	0.2	0.25	-	0.3
α Termal coeff liner(cm/cm/C)	9.0	12.6	-	27
G,Shear modulus(GPa)	3.3	3.3	-	3.1
τ_{ULT}, Ultimate shear stress(Mpa)	46.9	19	-	138
Tensile allowable stress(Mpa)	62.0	26.4	23	23
Flexural allowable stress(MPa)	62.0	26.4	23	23
Shear allowable stress(MPa)	7.8	7.8	5.7	5.7

15-Stress analysis considerations

In order to make enough resistance against axial and hoop stresses in above-ground piping, the rigid joint system (like Butt-Wrap or Glued Coupling) is used.
The thermal expansion coefficient of GRP is approximately 2 times the steel but the modulus of elasticity in GRP is less than that of steel, so the stresses decrease to some extent. Expansion Joint or Expansion Loop systems may be used to eliminate the effect of these destroying stresses. Thrust Blocks or Anchor Blocks are used at elbows in buried pipelines depending on the pipe and project type.

16-Faratec pipes in comparison with Polyethylene pipes

a. The strength of Faratec composite pipes is designed to withstand temperatures up to 160°C, while polyethylene pipes are sensitive to high temperatures, especially in tropical areas.

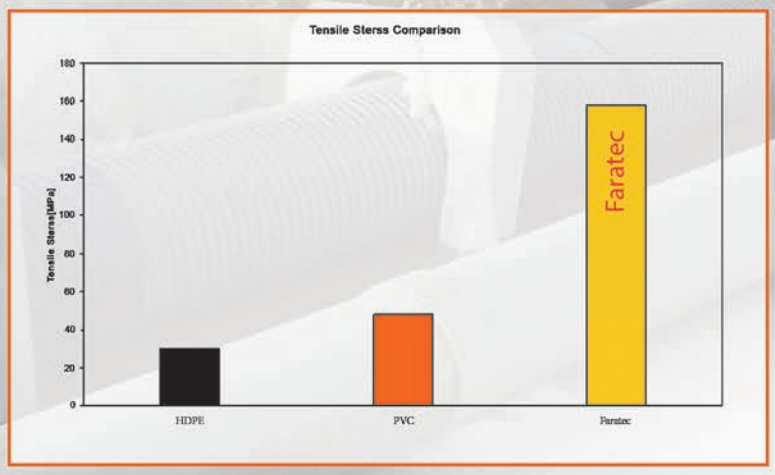
b. GRP pipes have a useful 50-year lifespan, working properly at different depths and also against heavy traffic loads.

c. The high hardness of Faratec pipes (it's 7 in Mohs hardness scale) prevents them to be damaged by vermin like mouse.

d. The high thermal expansion coefficient in polyethylene pipes causes the pipe to be separated at the joints in some cases.

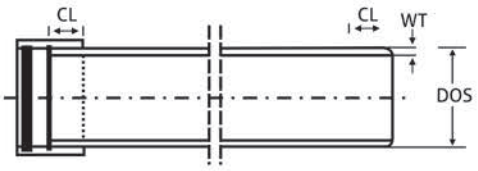
e. GRP pipes could be manufactured to pressures up to 100 bars which it is limited in the case of polyethylene pipes.

f. The installation of GRP pipes is less costly than polyethylene pipes.



The important quantities of the GRP pipes including stiffness are verified by long-term tests. The purpose of these tests is to assure the consumers that the main structural characteristics of the pipes have a reliable coefficient of certainty after 50 years. Considering the ISO definition based on the catalogs of polyethylene pipe manufacturers, the maximum stiffness produced in these types of pipes is about 2000 Pascal (approximately 123 in ASTM standard), which is significantly less than the stiffness of Faratec pipes. It should be noted that this stiffness decreases with the increase in the diameter of the polyethylene pipes, to the extent that for a diameter of 1000 mm, the stiffness of the polyethylene pipe hardly reaches 200 Pascal. The mechanical strength of Faratec pipes is much higher than that of all sewage plastic pipes. The above graph compares the maximum stresses of different types of plastic pipes.

17-Dimensions of standard pipes in different stiffness



SN 2500						
DN	DOS max	WT (Wall Thickness) (mm)				Weight kg/m
		PN6	PN10	PN16	PN20	
300	311	4,1	3,9	3,8	3,8	8
350	362	4,7	4,6	4,4	4,4	10,6
400	413	5,1	4,9	4,8	4,7	12,5
450	464	5,8	5,4	5,3	5,2	15,7
500	515	6,4	5,9	5,8	5,7	19,2
600	617	7,8	7	6,7	6,7	27
700	719	8,9	8	7,7	7,6	37
800	821	10,1	9,1	8,6	8,6	48
900	923	11,3	10,1	9,6	9,5	60
1000	1025	12,5	11,1	10,5	10,5	74
1100	1127	13,7	12,2	11,5	11,4	89
1200	1229	14,8	13,2	12,5	12,3	106
1300	1331	16	14,2	13,4	13,3	124
1400	1433	17,1	15,2	14,4	14,2	144
1500	1535	18,2	16,2	15,3	15,1	164
1600	1637	19,4	17,3	16,3	15,9	187
1700	1739	20,8	18,3	17,2		210
1800	1841	21,9	19,3	18,2		235
1900	1943	23	20,3	19,1		261
2000	2045	24,2	21,4	20,1		290
2100	2147	25,4	22,4	21		319
2200	2249	26,5	23,4	22		349
2300	2351	27,7	24,4	22,9		382
2400	2453	28,9	25,4	23,9		415
2500	2555	30	26,5	24,9		450
2600	2657	31,2	27,5	25,9		486
2700	2759	32,5	28,5	26,8		523
2800	2861	33,7	29,5	27,6		553
2900	2963	35	30,5	28,6		604
3000	3065	35,9	31,5	29,7		654
3100	3167	36	31,7	29,9		665
3200	3269	37,1	32,6	30,8		710
3300	3371	38,3	33,6	31,8		790
3400	3473	39,4	34,6	32,7		800
3500	3575	40,5	35,5	33,6		845
3600	3677	41,6	36,6	34,6		895
3700	3779	42,8	37,5	35,5		945
3800	3881	43,9	38,5	36,5		995
3900	3983	45,1	39,5	37,4		1045
4000	4085	46,2	40,5	38,3		1100

SN 5000							
DN	DOS max	WT (Wall Thickness) (mm)					Weight kg/m
		PN6	PN10	PN16	PN20	PN25	
300	311	5,1	5,1	4,8	4,7	4,7	10,3
350	362	5,9	5,8	5,4	5,4	5,4	13,8
400	413	6,6	6,2	5,8	5,8	5,8	16,2
450	464	7,3	6,9	5,8	5,8	5,8	21
500	515	8,1	7,6	7,1	7	7	25
600	617	9,6	8,9	8,4	8,2	8,2	36
700	719	11,1	10,3	9,6	9,3	9,3	49
800	821	12,5	11,6	10,9	10,5	10,5	63
900	923	14	13,2	12,1	11,8	11,8	80
1000	1025	15,4	14,5	13,3	12,9	12,9	99
1100	1127	16,9	15,9	14,6	14,2	14,2	119
1200	1229	18,3	17,3	15,8	15,3	15,3	141
1300	1331	19,9	18,6	17	16,5	16,5	165
1400	1433	21,4	20	18,3	17,8	17,8	191
1500	1535	22,9	21,3	19,5	19	18,5	219
1600	1637	24,3	22,7	20,7	19,9	19,7	249
1700	1739	25,8	24,1	22			281
1800	1841	27,3	25,4	23,2			314
1900	1943	28,7	26,8	24,4			350
2000	2045	30,1	28,2	25,6			388
2100	2147	31,6	29,5	26,9			427
2200	2249	33,1	32,9	28,1			468
2300	2351	34,5	32,3	29,3			512
2400	2453	36	33,7	30,6			557
2500	2555	37,5	35	31,8			604
2600	2657	38,7	36,5	33			657
2700	2759	41,2	38	34,5			708
2800	2861	41,9	39	35,5			760
2900	2963	44,1	40,5	37			814
3000	3065	44,8	41,5	38			871
3100	3167	45,1	41,6	38,2			885
3200	3269	46,5	42,9	39,4			940
3300	3371	47,9	44,3	40,6			1000
3400	3473	49,3	45,6	41,8			1065
3500	3575	50,8	46,9	43,0			1125
3600	3677	52,2	48,2	44,2			1190
3700	3779	53,7	49,6	45,4			1260
3800	3881	55,1	50,9	46,6			1325
3900	3983	56,5	52,2	47,8			1400
4000	4085	57,9	53,5	49,0			1470

* Weight and thickness may vary slightly depending on the type of resin, glass fiber or construction conditions.

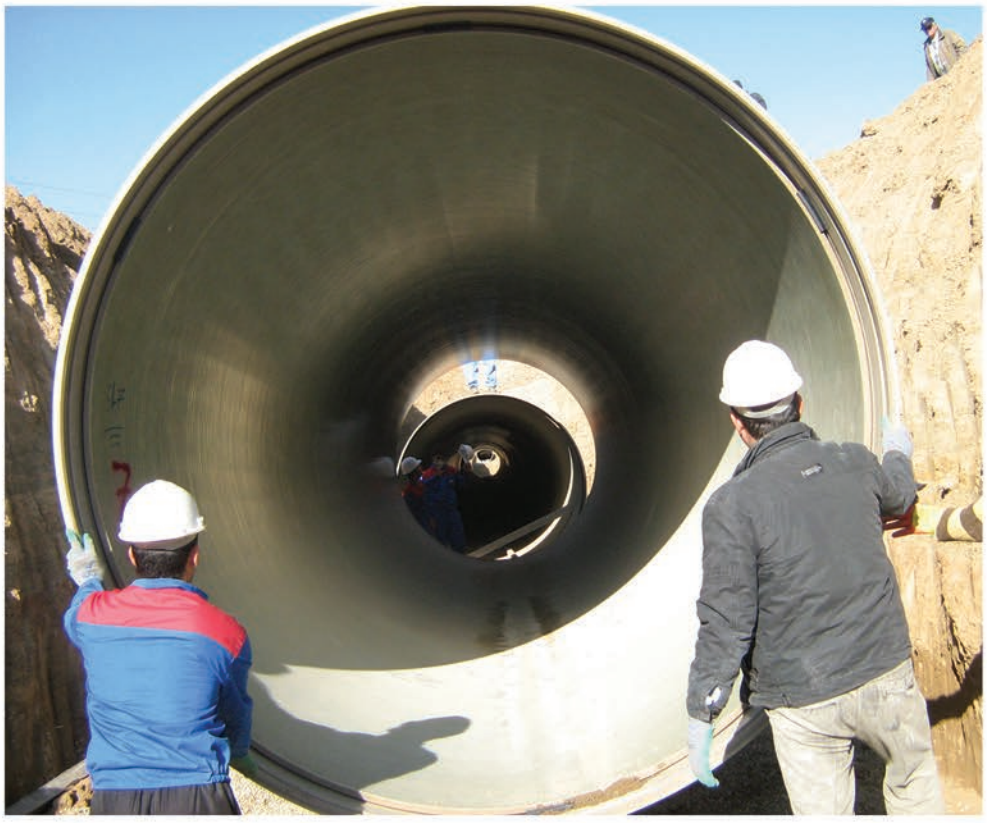
* The maximum DN and OD for Faratec pipes are always constant.

SN 10000								
DN	DOS max	WT (Wall Thickness) (mm)						Weight kg/m
		PN6	PN10	PN16	PN20	PN25	PN32	
100	107	3,5	3,5	3,5	3,5			2,0
150	157,6	3,8	3,8	3,8	3,8			3,3
200	209,8	4,9	4,9	4,9	4,9			5,8
250	262	6,0	6,0	6,0	6,0			8,9
300	311	6,2	6,2	6	5,8	5,7	5,7	12,7
350	362	7,2	7,2	6,8	6,7	6,6	6,5	17,4
400	413	7,8	7,8	7,4	7,2	7,1	7	21
450	464	8,8	8,8	8,2	8	7,9	7,8	26
500	515	9,8	9,8	9	8,8	8,6	8,5	33
600	617	11,7	11,7	10,7	10,4	10,2	10	48
700	719	13,7	13,7	12,3	11,9	11,7	11,5	65
800	821	15,5	15,5	14	13,5	13,2	13	85
900	923	17,3	17,3	15,6	15,1	14,7	14,5	107
1000	1025	19,2	19,2	17,2	16,6	16,2	16	132
1100	1127	21,2	21,2	18,9	18,2	17,7	17,5	160
1200	1229	23	23	20,5	19,7	19,3	19	190
1300	1331	24,8	24,8	22,1	21,3	21,8	20,4	223
1400	1433	26,7	26,7	23,7	22,9	22,3	21,9	258
1500	1535	28,4	28,4	25,4	23,9	23,8	23,1	295
1600	1637	30,3	30,3	27	25,4	24,8	24,5	336
1700	1739	31	32,1	28,6				378
1800	1841	34	34	30,3				423

DN	DOS max	WT (Wall Thickness) (mm)						Weight kg/m
		PN6	PN10	PN16	PN20	PN25	PN32	
1900	1943	35,8	35,8	31,9				472
2000	2045	37,6	37,6	33,5				521
2100	2147	39,5	39,5	35,1				574
2200	2249	42,7	42,7	38				630
2300	2351	44,6	44,6	39,7				688
2400	2453	46,5	46,5	41,4				748
2500	2555	47,2	47,7	41,7				822
2600	2657	47,9	49,5	43,3				888
2700	2759	50,8	51,3	44,9				955
2800	2861	51,3	53,1	46,5				1025
2900	2963	54,5	55	48,2				1102
3000	3065	55,1	55,8	49,7				1176
3100	3167	56,4	56,0	49,8				1200
3200	3269	58,2	57,7	51,4				1275
3300	3371	60,0	59,5	53,0				1355
3400	3473	61,8	61,3	54,5				1440
3500	3575	63,6	63,1	56,1				1525
3600	3677	65,4	64,9	57,7				1615
3700	3779	67,2	66,7	59,3				1705
3800	3881	69,0	68,4	60,9				1800
3900	3983	70,7	70,2	62,4				1895
4000	4085	72,5	72,0	64,0				1995

* Weight and thickness may vary slightly depending on the type of resin, glass fiber or construction conditions.

* The maximum DN and OD for Faratec pipes are always constant.



18-Pipe joining methods

18-1-Bell and Spigot joint

This joining method is typically used for pipe diameters less than 300 mm (12 inches).
The pipes in this method have an enlarged diameter part (bell) at one end. After the application of resin around the spigot end (the thinner part of the pipe) of a pipe, it is slid into the bell end of the other pipe. This joint will be rigid as soon as the resin dries.

18-2-Adhesive bonded double bell coupling

This type is a rigid joint made with the help of an intermediate piece called the adapter. This joining method is usually used in above-ground piping, especially in oil platforms.

18-3-Butt-Wrap or Lay-Up joint

This joint is made using different types of fiberglass and resin layers. The length and thickness of the joint are determined based on the diameter and working pressure of the pipe. This type of connection requires trained personnel and appropriate conditions. The manufacturer will provide relevant services as needed.

18-4-Adhesive bonded coupling (four-gasket glued coupling)

Rigid couplings with epoxy glue are provided in this method to be used in buried or above-ground pipelines. This type of joint is used when it is necessary to provide resistance in the axial direction of the pipe. Sealing with two gaskets and epoxy adhesives is performed in these couplings for each end of a pipe. In addition, the epoxy adhesive between the pipe and the coupling causes the coupling to be rigid, and as a result the joint is quite resistant to the stresses along the pipeline.

18-5-Reka coupling

Reka couplings are the most common joints, especially for buried pipelines. The pipes are generally connected by a two-gasket GRP coupler. Pipes and couplings can be provided separately, but usually a coupling is installed at one end of the pipe in the factory. The couplings are sealed with two gaskets, and a gasket or separate pieces of gaskets in the middle of the coupling prevents the head-to-head collisions, called Stopper. Gaskets are placed in the grooves that are carefully cut and are resistant to more than 75 years application. All dimensions of the couplings of this company are specified in the table below.


18-6-Angular deflection of the joints

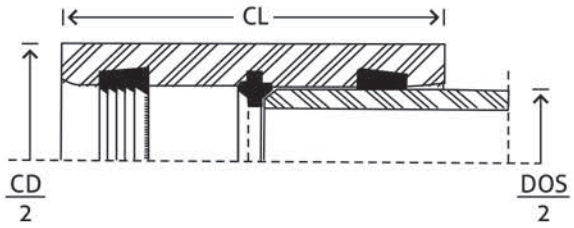
Coupling joints are subject to several tests according to ASTM D 4161 and ISO DIS 8639 standards. Faratec pipes at each joint can have angular deflections up to the values given in the following table:

Nom. Pipe Diameter (mm)	Nom. Angle of Deflection (deg)	Nom. Offset (mm) Pipe length			Nom. Radius of curvature(m) Pipe length		
		3(m)	6(m)	12(m)	3(m)	6(m)	12(m)
DN ≤ 500	3	157	314	628	57	115	229
500< DN ≤ 900	2	107	209	419	86	172	344
900< DN< 1800	1	52	105	209	172	344	688
DN< 1800	0.5	26	52	78	344	688	1376

If the nominal pressure of the pipes is more than 16 bars, the maximum deflection angle is obtained from the following table:

Nom. Pipe Diameter (mm)	Nom. Angle of Deflection(deg)		
	20 (bar)	25 (bar)	32 (bar)
DN < 500	2.5	2.0	1.5
500 < DN< 900	1.5	1.3	1.0
900< DN < 1800	0.8	0.5	0.5

19-Coupling dimensions (buried system)



Underground coupling dimensions									
DN	DOS Max (mm)	Coupling IDMin (mm)	CD (mm)						CL (mm)
			PN6	PN10	PN16	PN20	PN25	PN32	
100	107	107,5	107	107	107	107	107	107	150
150	157,6	158,1	157,6	157,6	157,6	157,6	157,6	157,6	150
200	209,8	210,3	209,8	209,8	209,8	209,8	209,8	209,8	175
250	262	262,5	262	262	262	262	262	262	175
300	311	312,5	351,1	352,7	354,3	356,4	360,7	367,5	270
350	362	363,5	403,3	404,9	406,7	407,6	412,7	447,9	270
400	413	414,5	454,1	456,1	458,1	462,4	463,7	468,7	270
450	464	465,5	504,9	506,5	508,7	513	513,9	519,3	270
500	515	516,5	555,7	557,7	559,3	563,4	564,3	571,1	270
600	617	618,5	664,1	665,9	668,1	673,2	675,9	683,7	330
700	719	720,5	765,9	768,3	772,5	778,2	781,1	792,1	330
800	821	822,5	867,7	871,7	876,7	882,8	883,7	896,9	330
900	923	924,5	970,7	975,1	980,9	984,8	988,7	1001,7	330
1000	1025	1026,5	1073,5	1078,5	1084,7	1089,2	1098,1	1106,5	330
1100	1127	1128,5	1176,3	1181,5	1183	1193,4	1208	1211,7	330
1200	1229	1230,5	1278,9	1284,5	1289,9	1299,4	1315,3	1316,7	330
1300	1331	1332,5	1381,3	1387,3	1393,3	1407,4	1421,1	1422,1	330
1400	1433	1434,5	1483,9	1490,1	1497,5	1515,6	1527,1	1527,1	330
1500	1535	1536,5	1586,3	1592,9	1602,7	1621,2	1632,9	1646	330
1600	1637	1638,5	1688,7	1695,5	1707,3	1722,3	1739,1	1750	330
1700	1739	1740,5	1791,1	1798,3	1812,1				330
1800	1841	1842,5	1893,5	1900,9	1916,1				330
1900	1943	1944,5	1995,9	2003,3	2020				330
2000	2045	2046,5	2098,3	2105,9	2123,5				330
2100	2147	2148,5	2200,5	2208,9	2226,9				330
2200	2249	2250,5	2302,9	2311,9	2330,3				330
2300	2351	2352,5	2405,3	2414,7	2433,3				330
2400	2453	2454,5	2507,5	2517,9	2536,3				330
2500	2555	2556,5	2559,7	2620,9	2639,3				330
2600	2657	2658,5	2690	2695					360
2700	2759	2760,5	2792,5	2797,8					360
2800	2861	2862,5	2895	2900					360
2900	2963	2964,5	2997,5	3002,2					360
3000	3065	3066,5	3099,5	3104,4					360
3100	3167	3168,5	3246,5	3253,5	3274,3				400
3200	3269	3270,5	3348,7	3356,1	3377,7				400
3300	3371	3372,5	3451,1	3458,5	3481,5				400
3400	3473	3474,5	3553,3	3560,9	3589,1				400
3500	3575	3576,5	3655,5	3663,3	3692,7				400
3600	3677	3678,5	3757,9	3765,5	3796,7				400
3700	3779	3780,5	3860,3	3867,9	3900,9				400
3800	3881	3882,5	3962,7	3970,3	4004,7				400
3900	3983	3984,5	4065,1	4072,5	4106,9				400
4000	4085	4086,5	4167,7	4174,7	4213,3				400

DN (mm)	Pipe OD Max (mm)	Coupling ID Min (mm)	CD (Coupling Outside Diameter) Max (mm)						CL (mm)
			PN6	PN10	PN16	PN20	PN25	PN32	
3100	3166	3168.5	3248.1	3258.3	3276.3	-	-	-	400
3200	3268	3270.5	3350.7	3360.9	3379.9	-	-	-	400
3300	3370	3372.5	3453.1	3463.5	3483.5	-	-	-	400
3400	3472	3474.5	3555.7	3565.9	3591.3	-	-	-	400
3500	3574	3576.5	3658.3	3668.7	3694.9	-	-	-	400
3600	3676	3678.5	3760.7	3771.3	3798.9	-	-	-	400
3700	3778	3780.5	3863.3	3873.5	3902.9	-	-	-	400
3800	3880	3882.5	3965.5	3976.7	4006.7	-	-	-	400
3900	3982	3984.5	4068.1	4079.9	4111.1	-	-	-	400
4000	4084	4086.5	4170.7	4182.9	4215.3	-	-	-	400

* Weight and thickness may vary slightly depending on the type of resin, glass fiber or construction conditions.

19-1-GRP Flanges

In certain cases, it is possible to connect the flanges to pipes. When two GRP flanges are connected in diameters above 300 mm, it is suggested that a flange in the face has an O-ring. The common standard drilling is as the following table although other standards for drilling are also available (AWWA, EN, ANSI, ASME, DIN, SSI, etc.).

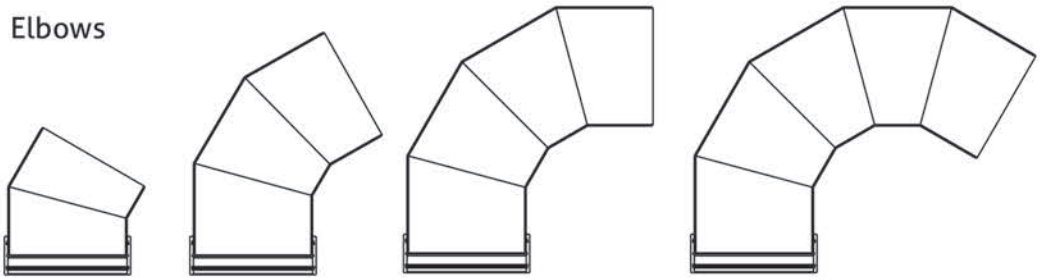
ASME (B 16.5)	Up to 24 inch
ASME (B 16.47)	26 to 60 inch
DIN 2501 / AWWA C207	Above 60 inch

20-Fittings

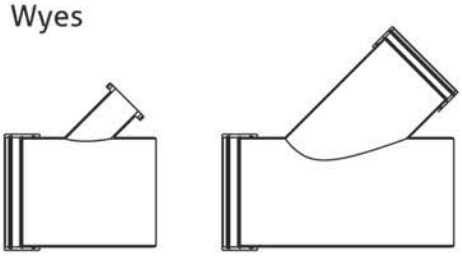
All GRP fittings, such as elbows at various angles, tees, flanges, nozzles, etc. are produced in standard sizes. They could be also produced in sizes other than Faratec standards on request. Samples of the manufacturer's fittings are displayed in the next page. It is possible to provide integrated joints up to a diameter of 900 mm. Please contact the company for more information about integrated or mitered fittings.



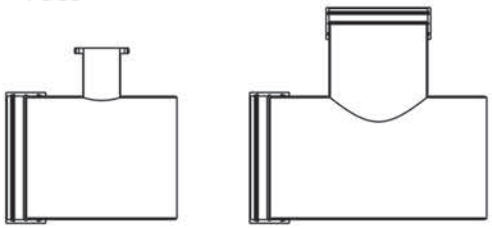
Elbows



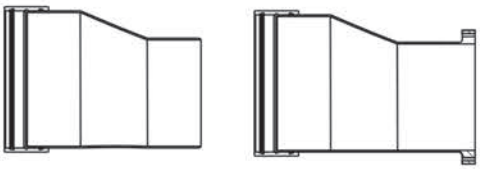
Wyes



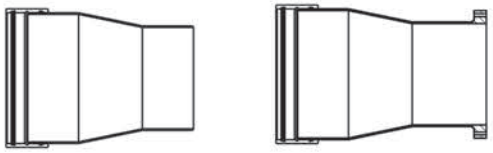
Tees



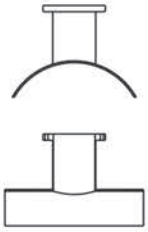
Eccentric Reducer



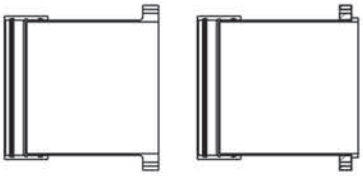
Concentric Reducer



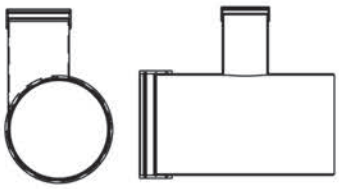
Saddle



Flanges



T Eccentric



21-Branching

The most important issue in installing a pipeline network is the ability to branch out the main pipe.
Branching methods are as follows:

a- Branch saddle

Branching of Faratec pipes is very easy in this method. The gaskets and fittings of this saddle branch are designed to be sealed completely.

b- Mechanical coupling

c- Branching by lay-up joints

(e.g. connecting a flange and a valve to the pipe)

22-Capabilities of Faratec pipes in inverted siphons

22-1-Capabilities

Faratec GRP pipes, due to their various technical and economic advantages, including strong structure, light weight and especially high corrosion resistance, smooth inner surface and very high mechanical strength, long lifespan, easy and fast installation are worthy of consideration as a superior pipe generation in comparison with other pipes. Especially, because of their economical price which makes them considerable options of inverted siphons.

2-22-GRP inverted siphons

Enough hydraulic head should be supplied in upstream of an inverted siphon to gain suitable efficiency. This upstream head should compensate the losses from inlet and outlet reducers, elbows and the main conduit. Therefore, it is necessary to use pipes with less losses in the design phase. One solution in this condition is to use pipes with smoother and more persistent inner surface so that the roughness of the pipe wouldn't change along service lifespan because of the effects of corrosion or mechanical and chemical factors. The use of GRP pipes and conduits is recommended for this purpose. By applying this change in selecting the type of pipe, the Manning roughness coefficient decreases to 0.009.

The short term advantages of GRP pipes for inverted siphons are:
slight weigh, low price of purchase, transformation and installation.

The long term advantages of GRP pipes for inverted siphons are:
minimum 50-year useful lifespan, constant roughness coefficient along lifespan of the pipes, no need to protection methods like inner and outer coating or cathodic protection. The use of GRP pipes in comparison with other types of pipes minimizes corrosion effects and provides structural health during operation.

GRP pipes reduce the cost of the project significantly and have the following advantages:

- *Reducing hydraulic loss by reducing Manning's roughness coefficient*

- *Minimizing the likelihood of an undesirable hydraulic jump in inlet of the siphon*

- *Reducing cost, risk and duration of installation*

- *Ease of installation of GRP pipes compared to other types of pipes*

- *Ability to use anti-abrasion additives in the structure of the GRP pipes to minimize the effects of abrasion caused by the entry of sediment into the siphon conduit*

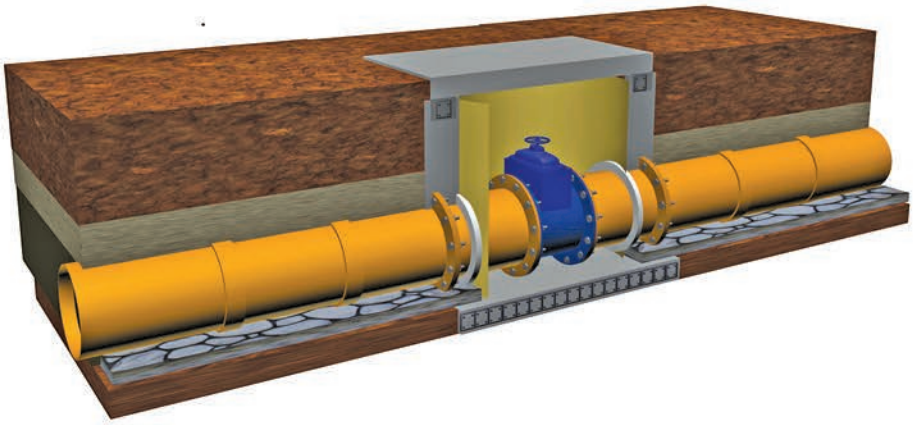
- *Cleaning and draining sediments from the inverted siphon will be facilitated due to easy branching and installing drain valves*

It should be mentioned that the Faratec Technology Center has recommended the use of flexible adhesive mastic (Polyeutex) on couplings in special projects. By injecting this adhesive, in addition to eliminating the possibility of leakage, the flexibility of connection at the couplings remains intact. In other words, the seam between the pipe and the coupling from the inside is filled with elastic mastic and the water leakage is completely ruled out.
Additionally, the injection of this type of adhesive at the junction of the siphon conduit to the inlet and outlet concrete reducers will also fully seal the gaps, so the concern of water leakage at these points will be resolved.

23- GRP manholes and valve chambers

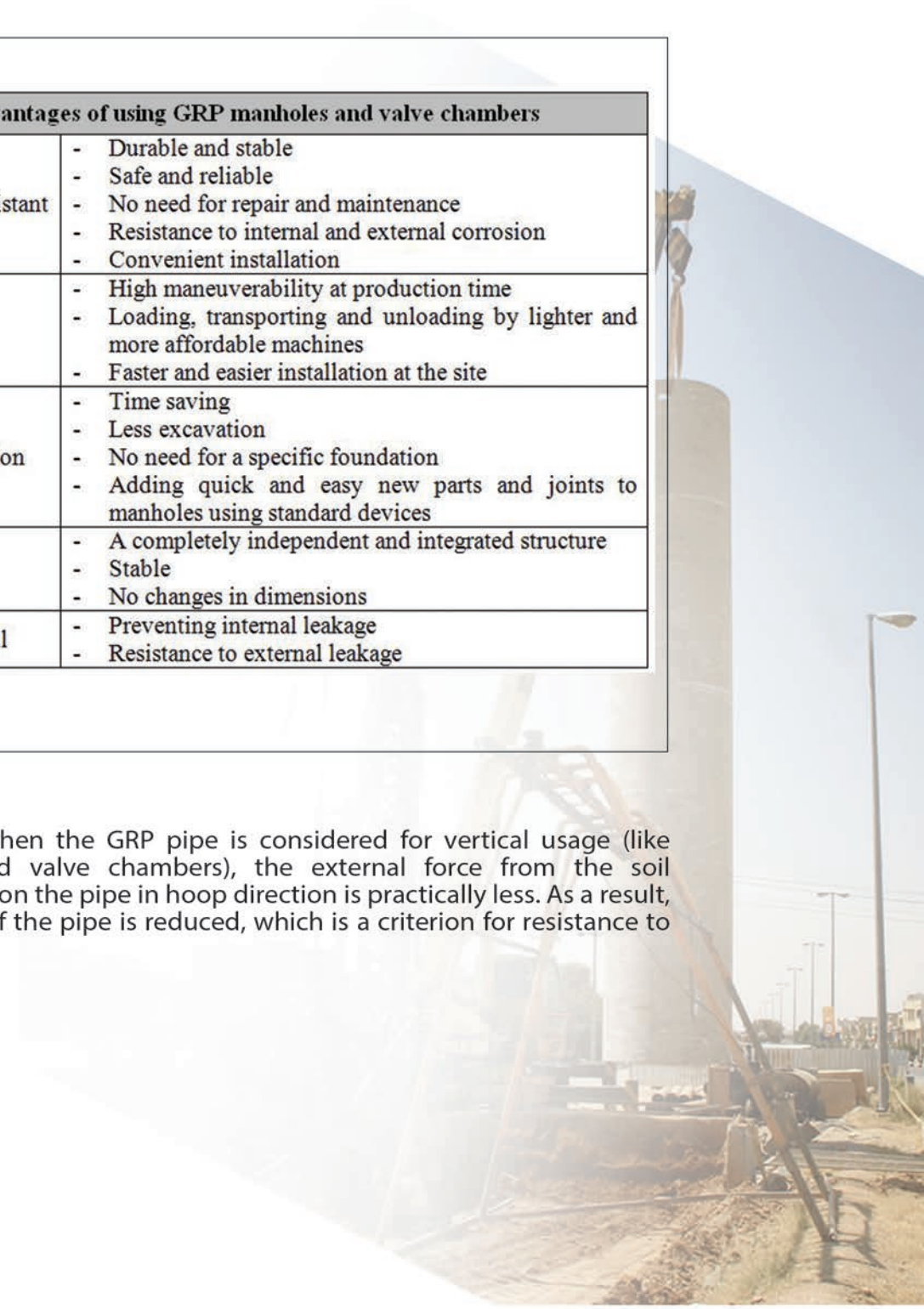
Companies under the license of Faratec have increased the lifespan of the projects as well as decreasing the installation duration and costs by means of producing GRP manholes and valve chambers. This type of product, in combination with GRP pipelines, is an integrated and almost maintenance-free system that can guarantee the quality and life of the pipelines. Valve chambers are designed as parts of pipelines that work either as pressurized or gravity systems for the following purposes:

- Installation and maintenance of the valves
- Accessing and visiting the transmission pipeline, facilities and fittings
- Draining the pipeline
- Cleaning the pipeline
- Changing the conditions of the fluid
- Possibility to inspect inside the pipelines
- The rapid discharge of fluid from the pipeline at certain times
- Ease of installation and repair of valves



Advantages of using GRP manholes and valve chambers	
Corrosion resistant	- Durable and stable - Safe and reliable - No need for repair and maintenance - Resistance to internal and external corrosion - Convenient installation
Light weight	- High maneuverability at production time - Loading, transporting and unloading by lighter and more affordable machines - Faster and easier installation at the site
Easy installation	- Time saving - Less excavation - No need for a specific foundation - Adding quick and easy new parts and joints to manholes using standard devices
Reliable	- A completely independent and integrated structure - Stable - No changes in dimensions
Integrated wall	- Preventing internal leakage - Resistance to external leakage

Technically, when the GRP pipe is considered for vertical usage (like manholes and valve chambers), the external force from the soil implemented on the pipe in hoop direction is practically less. As a result, the stiffness of the pipe is reduced, which is a criterion for resistance to deflection.



24-Special applications

24-1-Pipe Jacking

If the open trench system for installing the pipeline is not applicable, the pipe jacking system could be used. Faratec jacking pipe products can be manufactured to be used in pressurized systems too. According to the customer's requirements and the pipeline system for different projects, a new pipe jacking product is designed. Please contact the company for more complementary information.


NEW HOLLAND KOBELCO
E245B

24-2-Pipe Jacking with Pipe Slip method

The experiences of operators in different parts of the world have shown that the erosion of concrete or metal pipes is unavoidable. In addition, because of their less fluid flow capacity, the overall diameter of these pipes is more than GRP pipes. So, an affordable solution was found to revive old networks by placing new, corrosion-resistant GRP pipes inside the old network. This process is called Rehabilitation of pipeline.
The important issue in jacking pipes is the exact diameter of the pipes and their strength. According to what mentioned above, GRP jacking pipes have been used in Europe for many years as an ideal product. The process of manufacturing Faratec GRP pipes, allows the manufacturer to fully control their internal and external diameter. This is the reason; Faratec pipes are ideal choices for pipe jacking. Faratec jacking pipes have been used in several pipeline projects in Iran.
Another application of GRP is the coating of other pipes with GRP sheets. By applying this coating, the inner surface of the pipe will act as a GRP pipe, which means, a lower roughness and a fully corrosion resistant surface. The implementation of this cover requires its own special tools and technology existing in Farassan Company.

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