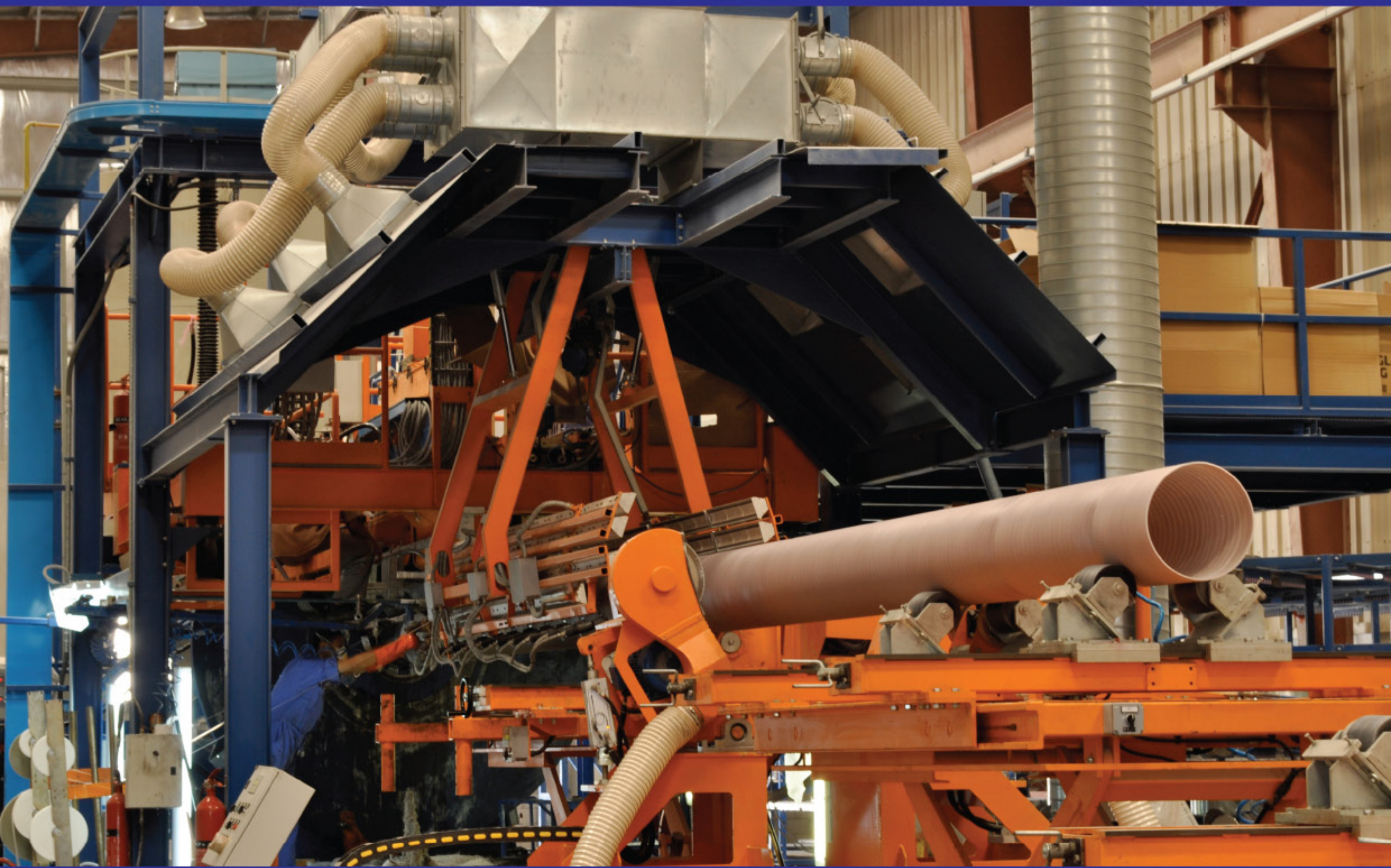
FIBER REINFORCED PLASTICS

GLASS REINFORCED POLYESTER (GRP)



شركة مصنع أنظمة الأنابيب السعودي المحدودة

SAUDI PIPES SYSTEMS CO. LTD.®

INDEX

ABOUT US

Saudi Pipes Systems Co. Ltd. (SPS), founded in 1995, designs and manufactures Ductile Iron Valves and Fittings, Fire Hydrants, HDPE, GRP and Pre-insulated pipes, and Manhole covers and gratings for water distribution, water transmission, irrigation and water treatment. The company is well poised to support and develop each project worldwide with a full range of water solutions.

SPS is an ISO 9001-2015 certified company and offers the most comprehensive range of products for the use of both potable and sewage applications in the Middle East. Being at the forefront of innovation means that its customers constantly receive state of the art products and top class services.

SPS Products are approved with major government authorities such as: The Ministry of Water and Electricity, Saline Water Conversion Corporation (SWCC), Royal Commission for Jubail & Yanbu and Saudi Electricity Company.

SPS also has Aramco approval for HDPE and SASO Quality Mark approval.

MANUFACTURING FACILITIES AND SUSTAINABILITY

SPS has four manufacturing facilities in Saudi Arabia, which are all located in phase 4 in Jeddah's industrial zone area. In order to sustain and lengthen the company's growth, SPS acquired the kingdom's first foundry, formerly known as "Quality Casting" that started its operations over 40 years ago, taking its expertise, SPS decided to enlarge the foundry's size and upgrade its machines over the past decades with fully automated production lines, resulting in outstanding casting quality that can keep up with the markets high volume demands. At the same time all products and facilities are subject to strict quality controls in accordance with BS, EN, DIN, SASO, Aramco and ISO standards.

SPS Goals are to provide high quality products and cost-effective advanced solutions. We also aim to provide our customers with the best product specifications and the highest international standards by using and investing in innovative engineering techniques and specialized expertise.

FOUNDRY CASTING FACTORY

Saudi Pipe Systems Co. Ltd. (SPS) offers the most comprehensive range of ductile Iron Valves, Fittings, Manhole covers and Gratings in both potable and sewage applications in the Middle East. Being at the forefront of the innovation means that its customers constantly receive state of the art products and top class services.

SPS has a wide range of fittings designed and developed according to the related international standards (BS, EN and ISO).

The foundry has high capacity

Head Office: Jeddah - Industrial Zone Phase (4) Building 4534 - Zip 22426 - Additional 7634 - Unit 1 - Saudi Arabia
Tel.: +966 -12 -637 0999 / 608 1100, Fax: +966 -12 -636 5925 / 637 9439 Email: sps@pipes.sa - Website: www.pipes.sa

facilities with precise CNC machines operated by highly qualified staff alongside a specialized team that keeps all our testing equipment readily calibrated in order to maintain accurate positive results and efficiency.

VALVES PLANT

SPS was founded in 1995 to produce valves for potable and treatment water. It had become one of the leading establishments of its sector in a short time. As manufacturers, SPS has a wide range of valves in the water and waste-water matters sector. Individually manufactured special valves and complete solutions are also part of our range of products. Our products have been subjected to pressure and performance tests before sales by the quality control department, and technical support services have been given at the installation operation and maintenance stages, after sales, by our experienced engineers. Our customers' satisfaction has top priority for us and has been confirmed by certification in accordance with ISO 9001:2015. Our valves are certified in accordance with the regulations required by the WRAS, UL/FM, SASO and ISO 9001:2015.

Production: The factory relies on the production capacity of the other two units and the participation of selected third-party partners. The complete manufacturing process includes the following steps: Casting, Machining, Coating, Assembly and Quality Control.

MANHOLE COVERS & GRATINGS

SPS with its experience of nearly twenty-five years produces, as per order, a range of cast iron and grey ductile iron. Mainly drainage manhole covers, gas, telecom, sewerage, electricity lids and gratings.

SPS manages the whole production process: from product design to manufacturing to distribution and sales. Improving itself by continuous Research and Design activities, and by being the leader in its sector, SPS provides high performance solutions particularly in the field of manhole covers & gratings. On top of our intense R&D activities, is the design and development of quality and high performance ductile iron manhole covers and gratings with automatic locking systems.

These provide protection against unauthorized use and theft, and with gasket system noise pollution suppression, depending on the needs of water and gas features, which are in compliance with EN 124 Standard.

GLASS REINFORCED PLASTIC (GRP) PIPES:

GRP pipes are manufactured using the process of Continuous Filament Winding (CFW).

Head Office: Jeddah - Industrial Zone Phase (4) Building 4534 - Zip 22426 - Additional 7634 - Unit 1 - Saudi Arabia
Tel.: +966 -12 -637 0999 / 608 1100, Fax: +966 -12 -636 5925 / 637 9439 Email: sps@pipes.sa - Website: www.pipes.sa

Famous for being light weight, easy to install and deterioration resistant, our GRP pipes are rust proof and hence do not require periodic maintenance. Their resistance to water and sewage systems' acidic environment are another advantage.

Our GRP pipes are mainly used for transporting drinking water, sewage drainage and seawater, in addition to desalination water, chemical and industrial residues, fire-fighting's systems cooling systems and irrigation.

GRP pipes and fittings are produced in diameters ranging from 80mm to 2600mm.

PRE-INSULATED PIPES AND FITTINGS

SPS manufactures pre-insulated pipes for district cooling, oil and gas and other industrial applications using both insulation methods of injected foam or sprayed foam depending on customer requirements.

The core pipe can be supplied in either Polyethylene (PE) Cross-linked polyethylene (PEX), steel or Glass Reinforced plastic (GRP) pipe, or the jacket pipe which are made of either high density polyethylene or GRP pipe. While the core pipes can range in sizes from 20mm up to 1500mm, the jackets can be made up to the size of 2750mm in diameter.

SPS pre-insulated pipes can also be supplied with leak detection system for district cooling applications depending on customer requirements.

The different types of jacket core pipe configurations include:

* Steel - HDPE
* Steel - GRP
* HDPE-HDPE
* HDPE- GRP
* GRP- HDPE
* GRP- GRP

HIGH DENSITY POLYETHYLENE PIPES PLANT (HDPE)

In January 2004 SPS established the most advanced plant with fully automated extrusion machines producing high density polyethylene pipes (HDPE) with a minimum production output of 8,500 tons per year ranging of 16mm up to 630mm and with pressure rating 5 bars to 16bars.

This plant is measured at 11,250 square meters, and it is located at Jeddah industrial Zone – Phase 5. The above factory specializes in producing of HDPE pipes from very small to big sizes.

The factory uses most advanced machinery and equipment which are operated by well qualified engineers and technicians. The SPS plant was certified by Aramco as an approved Aramco Supplier and manufacturer in May 2017, with the approved Vendor Code Number. 10025856, and Plant No. 30003130.

Head Office: Jeddah - Industrial Zone Phase (4) Building 4534 - Zip 22426 - Additional 7634 - Unit 1 - Saudi Arabia
Tel.: +966 -12 -637 0999 / 608 1100, Fax: +966 -12 -636 5925 / 637 9439 Email: sps@pipes.sa - Website: www.pipes.sa

PRODUCT DESCRIPTION

PRODUCTION PROCESS

Continuous Filament Winding Process

NOMINAL DIAMETERS

DN 300 mm DN2600 mm.

PIPE LENGTHS

GRP pipes are manufactured in length between 6m-12m, and may also be manufactured between 0.5m-15m length depending on the desired length according to the project needs.

PRESSURE CATEGORIES

PN I bar to PN 32 bar

STIFFNESS CATEGORIES

GRP pipes are manufactured in SN 2500 N/m², SN 5000 N/m², SN 10.000 N/m², and may also be manufactured in the desired values of stiffness according to the project needs (up to 12500 N/m²).

AREAS OF USE

- Drinking water networks and water distribution pipelines.
- Irrigation networks and drainage applications.
- Sewerage projects network, collector lines.
- Sewerage projects force mains.
- Pressure Pipelines for hydroelectric power stations.
- Storm water drainage.
- Cooling water supply & discharge in power stations.
- Pipelines to carry the chemical wastes.
- Relining Applications.
- Pipelines to remove the industrial wastes.
- Pipelines to carry the geothermal water.
- Reservoir for chemical plants and drinking water.
- Discharge lines of the sea.

RAW MATERIALS

Isophtalic, orthophtalic polyester resin, E/ECR fibreglass quartz sand, catalyst and additives.

Resin: Only qualified resin for the winding process. Usually it is delivered in drums or bulk. The resin is prepared in day tanks at the winder. Normal application temperature is 25°C.

Glass: It is specified by tex which is the weight in grams / 1000 meters length.

Quartz sand: Sand is added to the core of the pipe and the inner layer of couplings. High silica sand must be within the specifications for approved raw material.

Catalyst: The right amount of catalyst is added to the resin for curing the mix right before application on the mandrel. Only approved catalysts are used in the manufacturing process of the pipes.

Additives:

Additives are used as accelerator for the resin. and are mixed with it in the day tanks. The additives are available in different concentrations and may

be diluted by the producers in mineral spirit to reach the required concentration needed for the production of the pipes.

QUALITY STANDARDS

GRP pipes are manufactured in accordance with all the national and international standards such as SASO,

Head Office: Jeddah - Industrial Zone Phase (4) Building 4534 - Zip 22426 - Additional 7634 - Unit 1 - Saudi Arabia
Tel.: +966 -12 -637 0999 / 608 1100, Fax: +966 -12 -636 5925 / 637 9439 Email: sps@pipes.sa - Website: www.pipes.sa

ISO, BS, DIN. ASTM AWWA. Other local approvals are also available dependent on country specific requirements.

PRODUCTION PROCESS

SPS GRP pipes are produced by continuous filament winding process. Major raw materials are Isophtalic, orthophtalic resin, E glass, ECR glass, quartz sand, etc. Production process is fully operated with computer controlled machines which provides standard and repeatable quality in GRP pipes and fittings.

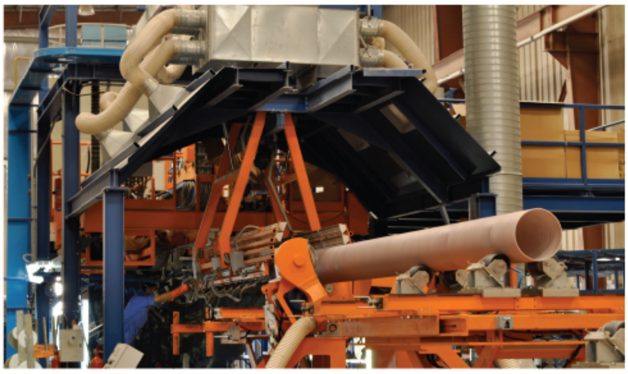
SAUDI	SASO
USA	AWWA M45
	ASTM D 3517
	ASTM D 3754
	ASTM D 3262
GERMANY	DIN 16 869 (1+2)
	DIN 16 565 (1)
ENGLAND	BS 5480 (1+2)
ITALY	UNI 9032
	UNI 9033
JAPAN	JIS A 5350
SWEDEN	SS 3622
	SS 3623
BELGIUM	NBN T 41-101
	NBN T 41-102
AUSTRIA	ÖNORM B 5184
	ÖNORM B 5182

Manufacturing is in accordance with the national, international standards like SASO, ISO, BS, ASTM, DIN, AWWA C 950 , etc.

SUPERIORITIES & ADVANTAGES.

PRODUCTION & METHODS

The production process is fully operated based on computer controlled system to ensure the continuous and repeatable quality. The standards used for the GRP Pipes are, SASO GRP pipes and fittings. AWWA C950 pressure drinking water pipes. ASTM 3517 pressure drinking water pipes. ASTM 3262 gravity sewer pipes, ASTM 3754 pressure sewer pipes, BS 5480 GRP pipes and fittings, DIN 16869 GRP pipes and fittings, ISO/DIS 10467.3 waste water pipes, ISO/DIS 10639.3 drinking water pipes.



APPLICATION AREAS

Underground applications, upper ground applications. Sub water applications and relining.

HANDLING & STORAGE

The ability of telescopic loading provides savings in handling & storage.

LIGHTNESS

GRP pipes are in the 1/4 weight of ductile iron, steel pipes and 1/10 weight of concrete pipes. SPS, GRP pipes eliminates

Head Office: Jeddah - Industrial Zone Phase (4) Building 4534 - Zip 22426 - Additional 7634 - Unit 1 - Saudi Arabia
Tel.: +966 -12 -637 0999 / 608 1100, Fax: +966 -12 -636 5925 / 637 9439 Email: sps@pipes.sa - Website: www.pipes.sa

the need for expensive pipe handling equipment.

PIPE LENGTHS
GRP pipes are manufactured between 6m - 12m and may be manufactured between 0.5m - 16m according to the project needs.

COUPLING
Sleeve coupling combined with two gaskets provides 100% tightness. (Mechanic Couplings, Flanged couplings, with other type of pipes and couplings with parts like valves etc.)

FAST MOUNTING
Mounting is fast and reliable with EPDM gaskets. SPS GRP pipes make handling and mounting easier than any other types.

CUTTING & FINISHING
Adjustments of pipes on site with easy cutting and finishing according to the desired lengths.

DESIGN
Design alternatives are made on the basis of chemical materials to be carried, stiffness values, temperature of fluids and fitting types.

EXTREME PRESSURES
Elastic pipe walls substantially absorb the peak pressures which is known as water hammer.

CORROSION RESISTANT
SPS, GRP pipes do not require linings, coatings, cathodic protection, wraps or other forms of corrosion protection. Maintenance cost is low. Hydraulic characteristics are essentially constant over time.

HYDRAULIC CONDUCTION
Smooth inside walls of GRP pipes provides savings from pipe diameters and from electrical energy consumptions in pumping lines. (Cole brook White k=0,001, Hazen-Williams c=155, Manning n=0,008).

QUALITY OF FITTINGS
Fittings have the same characteristics of GRP pipes as they are produced from the same materials.

RESISTIVITY
GRP pipes do not conduct electricity and are not affected from induction flows.

ELASTICITY
The elastic characteristic of GRP pipes enables the accommodation of earth movements. For this reason GRP Pipes

Head Office: Jeddah - Industrial Zone Phase (4) Building 4534 - Zip 22426 - Additional 7634 - Unit 1 - Saudi Arabia
Tel.: +966 -12 -637 0999 / 608 1100, Fax: +966 -12 -636 5925 / 637 9439 Email: sps@pipes.sa - Website: www.pipes.sa

are preferred in seismic zones. Elasticity also reduces the quantities of bends used in the projects.

DEVIATION IN FITTINGS

The tolerance of deviation in the fittings decreases the bends required in the projects. The tolerable degrees are;
3° for DN300-500mm,
2° for DN 600-900 mm,
1° for DN1000 -1800 mm and
0.5° for DN >1800 mm.

EXTREMELY SMOOTH BORE

Low friction loss means less pumping energy needed and lower operating costs.

ENGINEERING FORMULAS

1. HEAD LOSS

The Hazen-Williams Manning and Darcy-Weisbach methods are prevalently used to determine the local & continuous pressure loss.

1.1 Hazen-Williams equation.

The Hazen-Wiliams equation is applicable to water pipes under conditions of full turbulent flow.
Although not as technically correct as other methods for all velocities the Hazen-Williams equation has gained wide acceptance in the water and wastewater applications. Many engineers prefer a simplified version of the Hazen-Williams equation.

$h_f = [3.35\times10^6\ Q/(Cd^{2.63})]^{1.852}$

h_f: Friction factor,m of water/100m
Q: Flow rate (L/Sec)
C: Hazen-Williams roughness coefficient, (dimensionless) Typical value for fibreglass pipe=150
d: Pipe inside diameter, mm.

Head Loss converted to Pressure Loss;

p= [(h/100) L (SG)]
p: Pressure loss, ton/m^2 (1 ton/m^2 = 9,81 kPA)
L: Line length (m)
SG: Specific gravity, dimensionless, (1 for water)

1.2 Manning equation;

The manning equation typically solves gravity flow problems where the pipe is only partially full and is under the influence of an elevation head only.

$Q = (K/n)\ (S)^{0.5}\ (R_H)^{2/3}\ A$

n : Roughness coefficient (0.009 for typical fibreglass pipe)
K : Coefficient (K=1,0m)
S : Hydraulic, slope.
H_1 : S=(H1 - H2)/L Upstream
H_2 : elevation (m) Downstream

Head Office: Jeddah - Industrial Zone Phase (4) Building 4534 - Zip 22426 - Additional 7634 - Unit 1 - Saudi Arabia
Tel.: +966 -12 -637 0999 / 608 1100, Fax: +966 -12 -636 5925 / 637 9439 Email: sps@pipes.sa - Website: www.pipes.sa

L : elevation (m) Length of pipe
A : section (m) Cross sectional
R_H : area (m^2) hydraulic radius
W_P: wetted perimeter of pipe (m)
(m), (A/W_p)

1.3 Darcy - Weisbach equation;

The primary advantage of this equation is that it is valid for all fluids in both laminar and turbulent flow. 'f' coefficient in this equation is characterized with the Reynolds number.

If Re ≤ 2000 flow type is 'Laminar'
If 2000 < Re <4000 flow type is 'Transition flow zone'
If Re≥4000 flow type is 'Turbulent'

$h_f = (f/D)\ (V^2 / 2g)\ L$

f: Darcy-weisbach friction factor, (dimensionless).
D: Pipe inside diameter (m)
h_f: Friction factor (m)
g: Gravitational constant (9.81 m/s^2)
L: Length of pipe section (m)
V: Fluid velocity (m/sec)
If Re≤2000 f=64/Re
If Re≥4000 f coefficient is,
$f_t = [1,8x\text{Log}\ (Re/7)]^{-2}$ (%1 imperfection)

1.4 Local Head Loss in Fittings;

Head loss in fittings is expressed as the equivalent length of pipe that is added to the straight run of pipe. When tabular data are not available or when additional accuracy is necessary. Head loss in fittings can be determined using loss coefficients 'K' for each type to fitting.

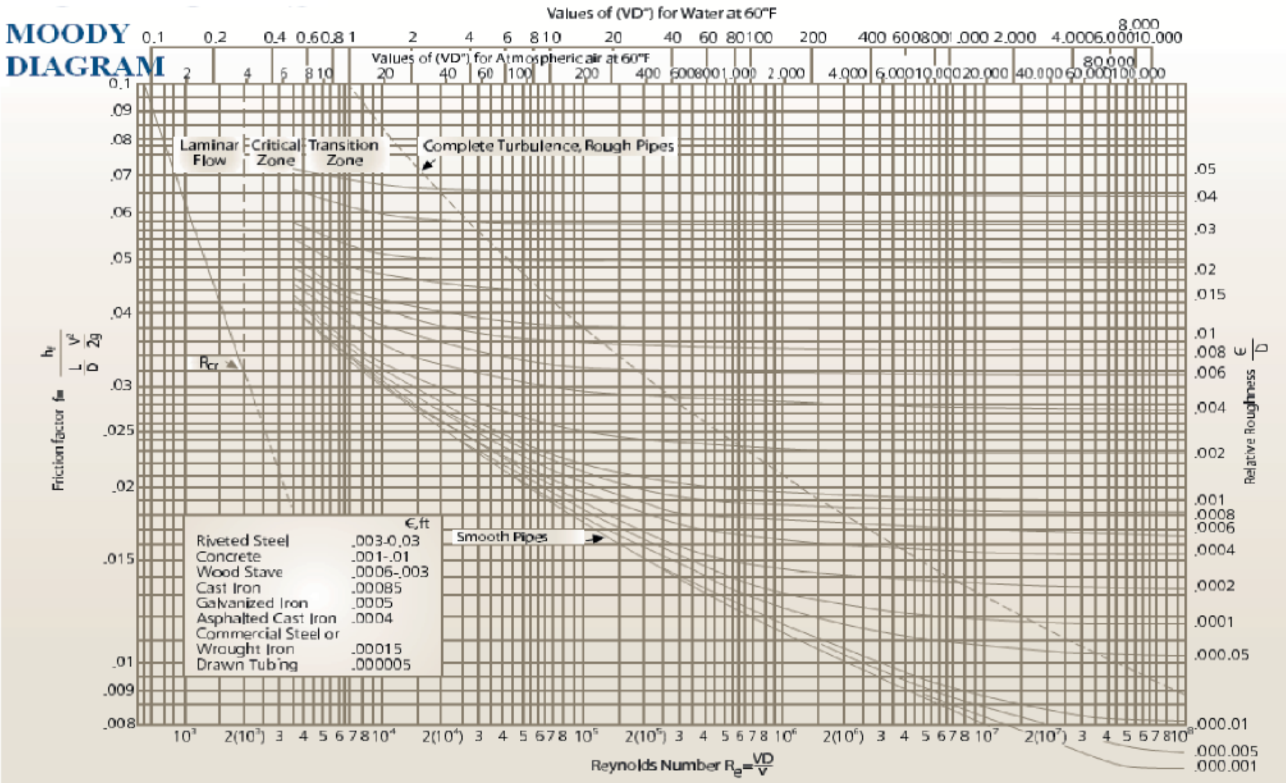
$h_{ff} = K\ (V^2 /2g)$

h_{ff}: Head loss (m)

"K" values for some fitting types;

Fitting Type		K- Value
$11{,}25^0$	bend-single meter	0.09
15^0	bend-single meter	0.20
$22{,}50^0$	bend-single meter	0.12
30^0	bend-single meter	0.29
45^0	bend-single meter	0.50
90^0	bend-single meter	1.40
180^0	bend-single meter	1.30
Tee, flow from branch		1.70
Reducer, single size reduction		0.70
Reducer, double size reduction		3.30

MOODY DIAGRAM



Head Office: Jeddah - Industrial Zone Phase (4) Building 4534 - Zip 22426 - Additional 7634 - Unit 1 - Saudi Arabia
Tel.: +966 -12 -637 0999 / 608 1100, Fax: +966 -12 -636 5925 / 637 9439 Email: sps@pipes.sa - Website: www.pipes.sa

2. PRESSURE SURGE

Pressure surge, also known commonly as water hammer results from an abrupt change of fluid velocity within the system. The magnitude of pressure surge is a function of the fluid properties and velocity, the modulus of elasticity and wall thickness of the pipe material, the length of the of the line, and the speed at which the momentum of the fluid changes The relatively high compliance of fibreglass pipe contributes to a self-damping effect as the pressure wave travels trough the piping system.

Ps= a (SG) AV

Ps: Pressure surge deviation from normal (kPa)

SG: Fluid specific gravity. (Dimension less). (I for

AV: water) Change in flow velocity (mlsec)

a: Wave velocity. (m/sec)

a= 1/ [(P/g)(1/10^9k + d/10^9 E(t)]$^{0.5}$

P: Fluid density (kglm^3)

g: Gravitational constant (9.81 mlsec^2)

k: Bulk modulus of compressibility of liquid (Gpa)

d: Pipe inside diameter (mm)

E: Modulus of elasticity (GPa)

t: Pipe wall thickness (mm)

The pressure class Pc must be greater than or equal to the sum of the working pressure Pw and surge pressure Ps divided by 1.4

Pc ≥ (Pw+Ps) /1,4 (AWWA M45)

Pw : Working pressure

Ps : Surge pressure

3. RING BENDING

The maximum allowable long-term vertical pipe deflection should not result in a ring-bending strain or stress that exceeds the long terming bending capability of the pipe reduced by an appropriate design factor.

For stress basis

$$\sigma_b = 10^3 D_f E \left(\frac{\Delta y_a}{D}\right)\left(\frac{t_t}{D}\right) \leq 10^3 \frac{S_b E}{FS}$$

For strain basis:

$$\varepsilon_b = D_f \left(\frac{\Delta y_a}{D}\right)\left(\frac{t_t}{D}\right) \leq \frac{S_b}{FS}$$

σ_b: maximum ring bending stress due to deflection (MPa)

D_f: Shape factor (dimensionless)

The shape factor relates pipe deflection to bending stress or strain and is a function of pipe stiffness, pipe zone embedment material and compaction hunching native soil conditions and level of deflections. Df has a table of values.

E : Modulus of elasticity (GPa)

Δy_a: Maximum allowable long term vertical pipe deflection (mm).

S_b : Long term, ring-bending strain for the pipe (mmlmm)

D : Mean pipe diameter (mm)

FS: Design factor (1.5)

ε_b: maximum ring-bending strain due to deflection (mmlmm)

t_t : Total wall thickness (mm)

$t_t = t + t_L$

Shape factors table

Pipe-zone embedmentmaterial and compaction

	Gravel		Sand	
Stiffness	Dumbed to Slight	Moderate to High	Dumbed to Slight	Moderate to High
kPa	Shape factor D_f (dimension less)			
62	5.5	7.0	6.0	8.0
124	4.5	5.5	5.0	6.5
248	3.8	4.5	4.0	5.5
496	3.3	3.8	3.5	4.5

Head Office: Jeddah - Industrial Zone Phase (4) Building 4534 - Zip 22426 - Additional 7634 - Unit 1 - Saudi Arabia
Tel.: +966 -12 -637 0999 / 608 1100, Fax: +966 -12 -636 5925 / 637 9439 Email: sps@pipes.sa - Website: www.pipes.sa

4. WEARING RESISTANCE

The inside surface of GRP pipes are resistant to the corrosive liquids inside, which prevents the increase of friction losses.
There is no increase of friction losses in GRP pipes, depending on the ageing of materials along the 50 years lifetime of design and 100 years lifetime of service. SPS/GRP pipes provides energy conservation due to sensitivity of 1/100 slickness of pipe walls.

5. DEFLECTION

Buried pipes should be installed in a manner that will ensure that external loads will not cause a long term decrease in the vertical diameter of the pipe exceeding the maximum allowable deflection.

$$\Delta y/D \leq \delta d/D \leq \Delta y_a/D$$

$\Delta y/D$: Predicted vertical pipe deflection
$\delta d/D$: Permitted vertical pipe deflection
$\Delta y_a/D$: Maximum allowable vertical pipe deflection

$$\frac{\Delta y}{D} = \frac{(D_L W_c + W_L) K_x}{149\,PS + 61000\,M_s}$$

D_L:Deflection lag factor to compensate for time-consoldiation rate of the soil (dimension less) DL > 1,00 is appropriate for long term deflection approximation.
W_c: vertical soil load on pipe (N/m²)
$W_c = Y_s H$
Y_s: Unit weight of overburden, (N/m³)
H : Burial depth to top of pipe (m)
W_L: Live load on pipe (N/m²)

AASHTO HS-20 ve COOPER E-80

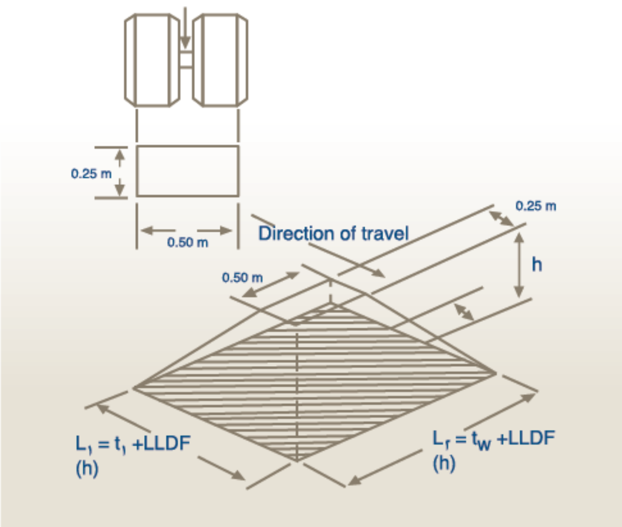
LIVE LOADS

HS - 20		Cooper E - 80	
Depth (m)	W_L (kPa)	Depth (m)	W_L (kPa)
0.6	92	0.9	110
0.8	67	1.2	97
0.9	51	1.5	84
1.2	32	1.8	72
1.5	23	2.1	62
1.8	18	2.4	53
2.4	11	3.0	39
3.0	7.6	3.7	32
3.7	5.5	4.6	23
4.6	4.1	6.1	15
6.1	2.8	7.6	10
8.5	1.4	9.1	7.6
12.2	0.7	12.2	4.1

$$W_L = \frac{M_p\,P\,I_f}{(L_1)(L_2)}$$

M_p: Multiple presence factor (1,2)
P : wheel load magnitude (71300 N for HS-20, 89000 N for HS- 25)
I_f : impact factor
$I_f = 1 + 0,33\,[(2,44-h)/2,44] \geq 1,0$
h : Depth of cover (m)
L_1 : Load width parallel to direction of travel (m)
$L_1 = t_1 + LLDF(h)$
t_1 : Length of tire footprint (0,25 m)
LLDF:factor to account for live load distribution with depth of fill, (1.15 for backfills SCI and SC2, 1.0 for all other backfills).
L_2 : Load width perpendicular to direction of travel (m) $h \leq h_{int}$
$L_2 = t_W + LLDF(h)$
t_w : Width of tire footprint (0,5 m)
h_{int}: Depth at which load from wheels interacts.
h_{int}: $[1,83m - t_W]$ / LLDF h > hint
L = [t + 1,83m+LLDF(h)] / 2
K_x: bedding coefficient, dimensionless,0,l for nonuniform pipe beddings 0,083 for uniform pipe beddings.

Head Office: Jeddah - Industrial Zone Phase (4) Building 4534 - Zip 22426 - Additional 7634 - Unit 1 - Saudi Arabia
Tel.: +966 -12 -637 0999 / 608 1100, Fax: +966 -12 -636 5925 / 637 9439 Email: sps@pipes.sa - Website: www.pipes.sa



PS: Pipe stiffness (kPa)

The pipe stiffness can be determined by conducting parallel-plate loading tests in accordance with ASTM D2412. During the parallel-plate loading test, deflection due to loads on the top and bottom of the pipe is measured.

If DN < 1600 mm, L = 300 mm

If DN ≥ 1600 mm. L = 1.20 X DN.

$PS = 1000F / Ay_t$

F : Load per unit length (N/mm)

Ay_t: Vertical pipe deflection, mm, when tested by ASTM D2412 with a vertical diameter reduction of 5 % Pipe stiffness may also be determined by the pipe dimensions and material properties.

$$PS = \frac{EIx10^6}{0,149\ (r + Ay_{t,}12)^3}$$

E : Ring flexural modulus (GPa)

I : Moment of inertia of unit length (mm^4 Imm) ($I = t^3 / 12$)

t_L: Total wall thickness

r : Mean pipe radius (mm)

GRP PIPE STIFFNESS CATEGORIES ASTM ISO

9psi-62kPa	1250 pa
18psi-124kPa	2500 Pa
36psi - 248kpa	5000 Pa
72psi-496 kPa	10000 Pa

M_s : Composite constrained soil modulus (MPa)

$M_s = S_C M_{sb}$

S_c : Soil support combining factor (dimension less)

M_{sb}: Constrained soil modulus of the pipe zone embedment (MPa). To use the Sc table, the following values are required.

M_{sn} : Constrained soil modulus of the native soil at pipe elevation (MPa).

B_d : Trench width at pipe spring line (mm).

Head Office: Jeddah - Industrial Zone Phase (4) Building 4534 - Zip 22426 - Additional 7634 - Unit 1 - Saudi Arabia
Tel.: +966 -12 -637 0999 / 608 1100, Fax: +966 -12 -636 5925 / 637 9439 Email: sps@pipes.sa - Website: www.pipes.sa

VALUES FOR THE SOIL SUPPORT COMBINING FACTOR

M_{sa}/M_{sb}	B_d/D 1.25	B_d/D 1.5	B_d/D 1.75	d B2/D	B_d/D 2.5	B_d/D 3	B_d/D 4	B_d/D 5
0.005	0.02	0.05	0.08	0.12	0.23	0.43	0.72	1.00
0.01	0.03	0.07	0.11	0.15	0.27	0.47	0.74	1.00
0.02	0.05	0.10	0.15	0.20	0.32	0.52	0.77	1.00
0.05	0.10	0.15	0.20	0.27	0.38	0.58	0.80	1.00
0.1	0.15	0.20	0.27	0.35	0.46	0.65	0.84	1.00
0.2	0.25	0.30	0.38	0.47	0.58	0.75	0.88	1.00
0.4	0.45	0.50	0.56	0.64	0.75	0.85	0.93	1.00
0.6	0.65	0.70	0.75	0.81	0.87	0.94	0.98	1.00
0.8	0.84	0.87	0.90	0.93	0.96	0.98	1.00	1.00
1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1.5	1.40	1.30	1.20	1.12	1.06	1.03	1.00	1.00
2	1.70	1.50	1.40	1.30	1.20	1.10	1.05	1.00
3	2.20	1.80	1.65	1.50	1.35	1.20	1.10	1.00
≥ 5	3.00	2.20	1.90	1.70	1.50	1.30	1.15	1.00

M_{sb} BASED ON SOIL TYPE & COMPACTION CONDITION.

Vertical Stress Level kPa	Depth for soil density 18.8 kN/m³ m1	SPD100 MPa	SPD95 MPa	SPD9O MPa	SPD85 MPa
Stiffness Categories 1 and 2 (sc1,sc21)					
6.9	0.4	16.2	13.8	8.8	3.2
34.5	1.8	23.8	17.9	10.3	3.6
69	3.7	29	20.7	11.2	3.9
138	7.3	37.9	23.8	12.4	4.5
276	14.6	51.7	29.3	14.5	5.7
414	22	64.1	34.5	17.2	6.9
Stiffness Categories 3 (SC3)					
6.9	0.4		9.6	4.6	2.5
34.5	1.8		11.5	5.1	2.7
69	3.7		12.2	5.2	2.8
138	7.3		13	5.4	3
276	14.6		14.4	6.2	3.5
414	22		15.9	7.1	4.1
Stiffness Categories3 (SC4)					
6.9	0.4		3.7	1.8	0.9
34.5	1.8		4.3	2.2	1.2
69	3.7		4.8	2.5	1.4
138	7.3		5.1	2.7	1.6
276	14.6		5.6	3.2	2
414	22		6.2	3.6	2.4

SPD : Standard proctor density (%)

VALUES FOR THE CONSTRAINED MODULUS OF THE NATIVE SOIL AT PIPE ZONE ELEVATION

Native In Situ Soils

Granular: Blows 0,3m1)	Granular: Description	Cohesive: q (kPa1	Cohesive: Description	M (MPa1
> 0-1	Very,Very loose	0-13	Very,Very Soft	0,34
1-2	Very loose	13-25	Very soft	1,4
2-4		25-50	soft	4,8
4-8	loose	50-100	Medium	10,3
8-15	slightly compact	100-200	Stiff	20,7
15-30	compact dense	13-25	Very soft	1,4
30-50	Very dense	400-600	Very soft	1,4
>50		> 600	Very hard	138,0

SOIL STIFFNESS CATEGORIES

Soil Stiffness Category	Unified Soil Classification System Soil Group
SC1	**Crushed rock:** 15% sand, maximum 25% passing the 3/8-in. sieve and maximum 5% passing No. 200 sieve
SC2	**Clean, coarse-grained soils:** SW,SP, GW, GP or any soil beginning with one of these symbols with 12% or less passing No.200 sieve.
SC3	**Coarse-grained soils with fines:** GM,GC,SM,SC or any soil beginning with one of these symbols with more than 12% or fines. **Sandy or gravelly fine-grained soils:** CL,ML (or CL-ML, CL/ML, ML/CL) with more than 30% retained on a No. 200 sieve.
SC4	**Fine-grained soils:** CL,ML (or CL-ML, CL/ML, ML/CL) with 30% or less retained on a No. 200 sieve.
SC5	**Highly plastic and organic soils:** MH, CH, OL, OH, PT.

Head Office: Jeddah - Industrial Zone Phase (4) Building 4534 - Zip 22426 - Additional 7634 - Unit 1 - Saudi Arabia
Tel.: +966 -12 -637 0999 / 608 1100, Fax: +966 -12 -636 5925 / 637 9439 Email: sps@pipes.sa - Website: www.pipes.sa

6. COMBINED LOADING

The maximum stress or strain resulting from the combined effects of the internal pressure and deflection should meet the equations as follows:

For stress basis:

$$\frac{\sigma_{pr}}{HDB} \leq \frac{1-\left(\frac{\sigma_b r_c}{S_b E x10^3}\right)}{FS_{pr}}$$

$$\frac{\sigma_b r_c}{S_b E x10^3} \leq \frac{1-\left(\frac{\sigma_{pr}}{HDB}\right)}{FS_b}$$

For strain basis:

$$\frac{\varepsilon_{pr}}{HDB} \leq \frac{1-\left(\frac{\varepsilon_b r_c}{S_b}\right)}{FS_{pr}}$$

$$\frac{\varepsilon_b r_c}{S_b} \leq \frac{1-\left(\frac{\varepsilon_{pr}}{HDB}\right)}{FS_b}$$

FS_{pr}: Pressure design factor (1.8)
FS_b : Bending design factor (1.5)
σ_{pr} : Working stress due to internal pressure (MPa)
$\sigma_{pr} = P_w D/2t$
Pw : Warking pressure (kPa)
D : Diameter (mm)
t : Thickness (mm)
σ_b : Bending stress due to the maximum permitted deflection (MPa)
$\sigma_b =$ D, E (od/D) (t_t/D)
r : Re-rounding coefficient. (dimension less)
Pw≤3000kpa ⟶ r_c=1-Pw/3000
ε_{pr} : Working strain due to internal pressure (mm/mm)
$\varepsilon_{pr} = P_w D/2 tE_H$
ε_b : Bending strain due to maximum permitted deflection (mm/mm)
ε_b : Df (δd/D) (t_t/D)
δd : maximum permitted long-term installed defection (mm)

7. BUCKLING

The summation of appropriate external loads should be equal to or less than the allowable buckling pressure.

$$q_a = \frac{(1{,}2\,C_n)\,(EI)^{0.33}\,(\varphi_s M_s K_u)^{0.67} R_h}{(FS)r}$$

q_a : Allowable buckling pressure (kPa)
FS: Design factor (2.5)
C_n: Scalar calibration factor to account for some nonlinear effects (0,55)
Q_s : factor to account for variability in stiffness of compacted soil; suggested value is 0,9
K_u: Modulus correction factor for Poission's ratio, v, of the soil.
K_u: (1+v) (1-2v) / (1-v); in the absence of specific information. (it is common to assume v=0.3 giving k_u = 0.74)
R_h: Correction factor for depth of fill 11,4/ (11+D/1000h)
h: Height of ground surface above top of pipe (m)

An alternate form of buckling:

$$q_a = \left(\frac{I}{FS}\right) [1{,}2\,C_n\,(0{,}149\,PS)^{0.33}]\,(\varphi_s 10^6 M_s K_V)^{0.67} R_h$$

Satisfaction of the buckling requirement is assured for typical pipe installations by using the following equation:

$$[\,Y_w h_w + R_w(W_c)\,] \times 10^{-3} + P_v \leq q_a$$

Y_w: Specific weight of water (9800N/m³)
P_v : Internal vacuum pressure, (kPa)
R_w: Water buoyancy factor.
R_w = 1-0,33 (h_w/ h) f10 ≤ h_w ≤ h]
If live loads are considered, satisfaction of the buckling requirement is ensured by:

$$(Y_w h_w + R_w (W_C) + W_L) \times 10^{-3} \leq q_a$$

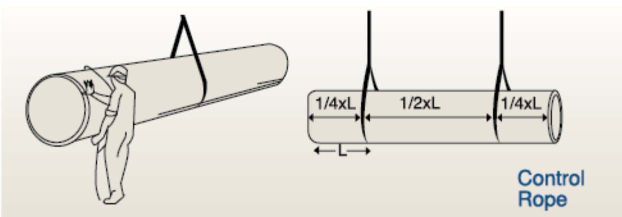
Head Office: Jeddah - Industrial Zone Phase (4) Building 4534 - Zip 22426 - Additional 7634 - Unit 1 - Saudi Arabia
Tel.: +966 -12 -637 0999 / 608 1100, Fax: +966 -12 -636 5925 / 637 9439 Email: sps@pipes.sa - Website: www.pipes.sa

HANDLING, STORAGE AND TRANSPORT

- GRP pipes are suitable for telescopic handling.

- Pipes are transported with the fittings attached on them which avoids extra cost of transport and also fastens the mounting process.

- If the pipes are handled by double sling handling method, the distance between the rope and the pipe end should not exceed L' < L/4 ratio.



Single sling method   Double sling method

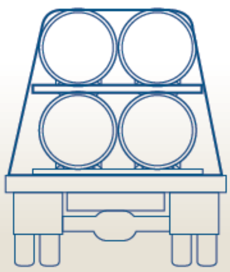
- If the pipes are handled by single sling method, none of the pipe ends should be dragged on, to ensure safety.

- In horizontal and vertical handling if the pipe falls down on a sharp material, the pipe must be controlled against damages.

  If there is an obligation for nesting the pipes, the distance between the planks should not exceed 6 meters.

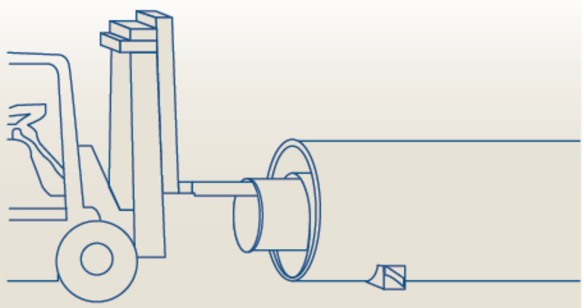
Maximum Storage Deflection:
%2,5 in SN 2500 pipes
%2,0 in SN 5000 pipes
%1,5 in SN 10000 pipes

- All pipes should be supported on flat timbers, spaced at maximum 4 meters (3 meters for diameter DN250), with a maximum overhang of 2 meters and chocked to maintain stability and separation. Abrasion should be avoided.



Transporting Pipe

- Maximum stack height is approximately 2.5 meters. The pipes should be strapped to the vehicle over the support points using pliable straps or rope. Steel cables or chains without adequate padding should never be used to protect the pipe from abrasion. Bulges, flat areas or other abrupt changes of curvature are not permitted. Transport of pipes outside of these limitations may result in damage to the pipes.

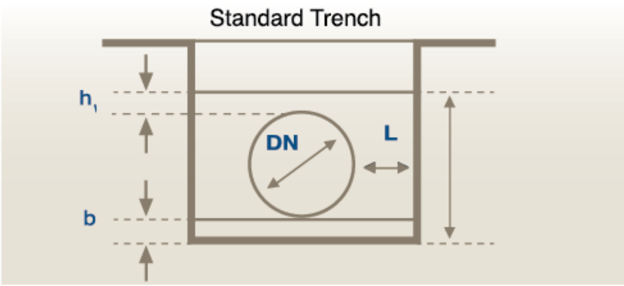


De-nesting with padded boom on forklift truck

Head Office: Jeddah - Industrial Zone Phase (4) Building 4534 - Zip 22426 - Additional 7634 - Unit 1 - Saudi Arabia
Tel.: +966 -12 -637 0999 / 608 1100, Fax: +966 -12 -636 5925 / 637 9439 Email: sps@pipes.sa - Website: www.pipes.sa

PIPE TRENCH

Standard type of trench prepared for mounting the GRP pipes is illustrated schematically below. GRP pipes are manufactured in SN2500, 5000 and 10000 N/m^2 stiffness categories and offer alternative types for mounting depending on the loads. (live loads, backfill loads, etc) In general the bedding material is preferred to be the same material being used for the initial backfill.



h1 = D/2 (max 0.300 mm), b= D/4 (min 0,150 mm)

PARTICLE SIZE	
DN(mm)	a(mm)
< 300	10
300-600	15
700-1000	20
>1000	30

CUSHION LAYER	
DN	b(mm)
300	75
350-500	100
600-2500	150

WORK AREA	
DN (mm)	L(mm)
200-350	150
400-500	200
600-900	300
1000-1600	450
1800-2600	600

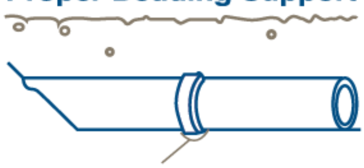
If the soil removed from the trench will be used as backfill material in pipe zone, the particle size allowed should not exceed two times the standard value

PIPE ZONE BACKFILL MATERIAL (ASTM D2487)

GRAVEL	GW, GP, GW, GC GW, GM, GP-GC GP-GM
FINESAND	SW, SP, SW, SC SW, SM, SP-SC SP-SM
SAND	SW, SP, SW-SC SW-SM, SP-SC SP-SM, SM*, SC* GM*, GC*

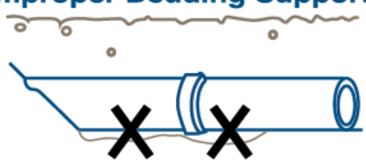
The initial deflection limit of GRP Pipes installed underground is, 3% pressure pipes DN≥300 mm and 6% for gravity pipes DN≥ 300 mm.

Proper Bedding Support



Bell Hole (fill after completing pipe Joint)

Improper Bedding Support



Head Office: Jeddah - Industrial Zone Phase (4) Building 4534 - Zip 22426 - Additional 7634 - Unit 1 - Saudi Arabia
Tel.: +966 -12 -637 0999 / 608 1100, Fax: +966 -12 -636 5925 / 637 9439 Email: sps@pipes.sa - Website: www.pipes.sa

Water Control:

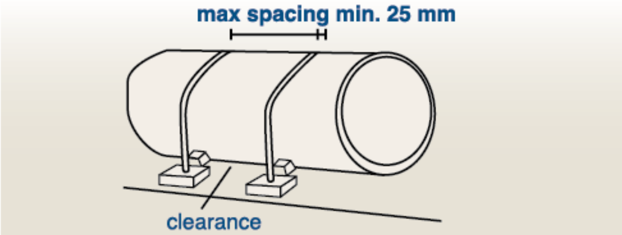
It is always good practice to remove water from a trench before laying and backfilling pipe. Well points, deep wells, geotextiles, perforated under drains or stone blankets of sufficient thickness should be used to remove and control water in trench. Groundwater should be below the bottom of the cut at all times to prevent the washout from behind sheeting or sloughing of exposed trench walls. To preclude loss of soil support, dewatering methods should be employed for minimizing the removal of fines and the creation of voids within in situ materials. Suitable graded materials should be used for foundation layers to transport running water to sump pits or other drains.

Concrete encasement and Floatation

The Concrete must be poured in stages allowing sufficient time between layers for the cement to set and no longer exert buoyant forces. The maximum lift heights are shown in the table below.

SN	MAXIMUM LIFT
2500	Larger of 0.3 m or DN/4
5000	Larger of 0.45 m or DN/3
10000	Larger of 0.6 m or DN/2

During pouring the concrete, or in order to prevent floatation, the pipe must be restrained against movement. This is usually done by strapping over the pipe to a base stab or other anchors. The straps are flat with a minimum of 25 mm width and strong enough to withstand the floatation forces.

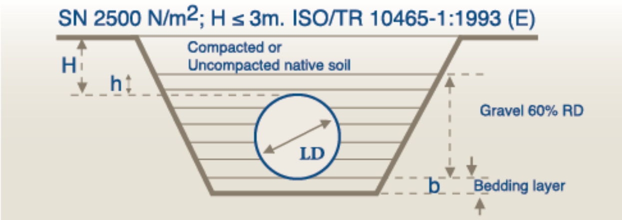


The buoyancy must be checked in cases of low coverage and high groundwater levels or in flood plains.

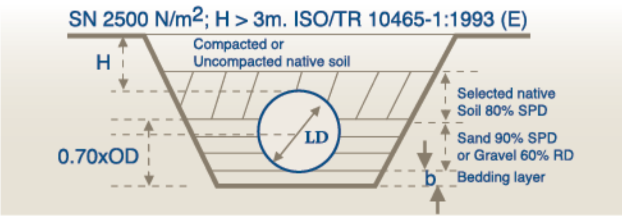
DN	MAXMIUM SPACING(m)
<200	1.5
200-400	2.5
500-600	4.0
700-900	5.0
≥ 1000	6.0

DN	h MIN (m) for Security S-1.1
100	0.07
300	0.20
600	0.37
1000	0.62
2000	1.25
2400	1.5

TRENCH SECTIONS



SPD: Standard Proctor Density
RD: Relative Density
Granular Materials are filled to the 70% of pipe outside diameter.



Granular Materials are filled from the crown up to the h distance. (h) is min. 100 mm, max. 300 mm.

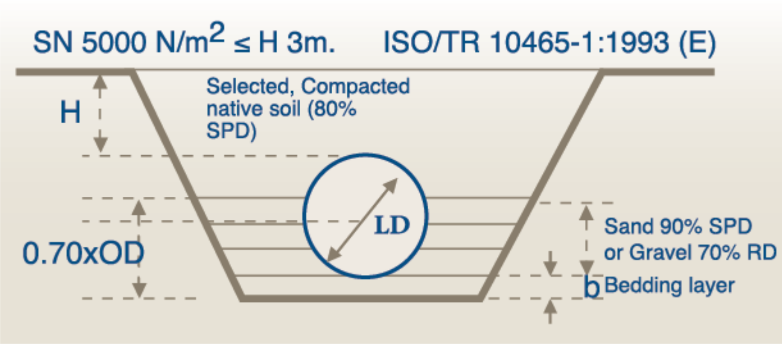
Limits of Deflection in installed GRP Pipes

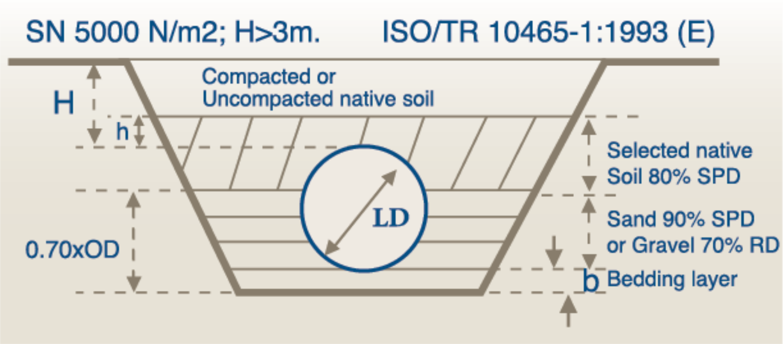
Deflection (%)	Soil Classification				
	1	2	3	4	5
DN ≥ 300 mm (initial)	4	3.5	3	2.5	2
DN < 300 mm (initial)	2.5	2.5	2	1.5	1.5
Long term	6	6	6	6	6

Soil Groups	1	2	3	4	5
Soil-Grained Soils	Very Hard	Hard	medium	soft	very soft
Coarse-Grained Soils	Very dense	dense	medium	loose	very loose

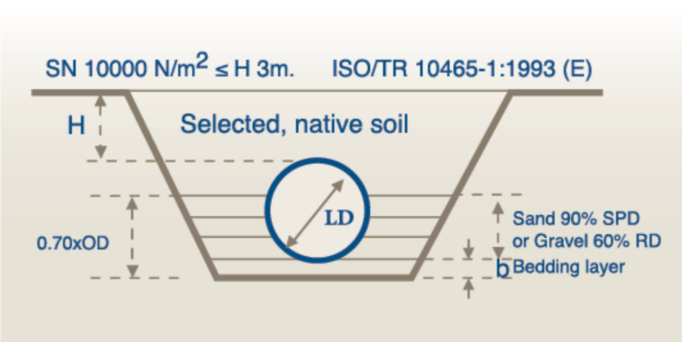
Head Office: Jeddah - Industrial Zone Phase (4) Building 4534 - Zip 22426 - Additional 7634 - Unit 1 - Saudi Arabia
Tel.: +966 -12 -637 0999 / 608 1100, Fax: +966 -12 -636 5925 / 637 9439 Email: sps@pipes.sa - Website: www.pipes.sa

TRENCH SECTIONS

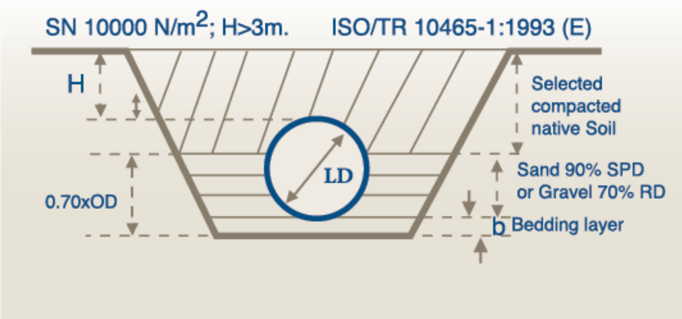




Granular materials are filled upto the 70% of pipe outside diameter then selected, native soil is compacted up to (h) distance (h) distance is min.100 mm max. 300 mm.

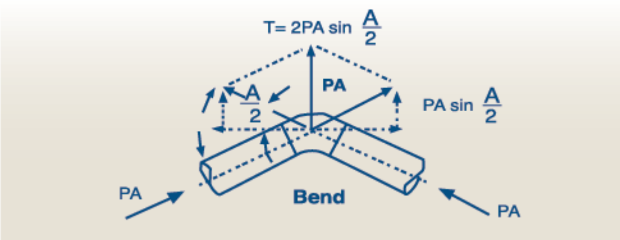


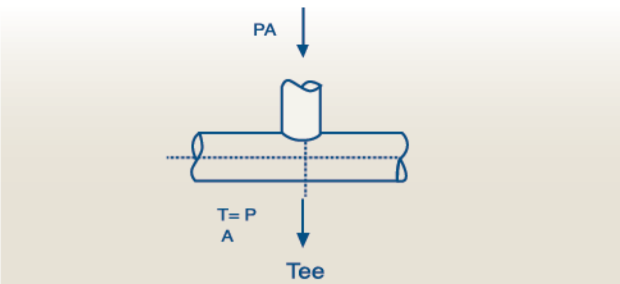
Granular materials are filled to the 70% of pipe outside diameter.

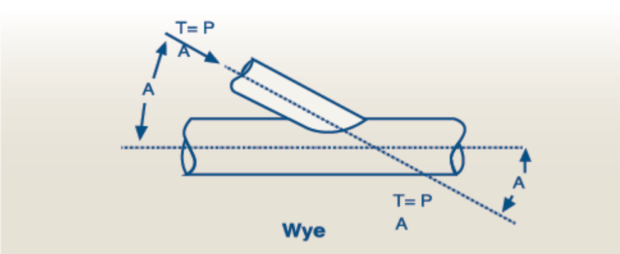


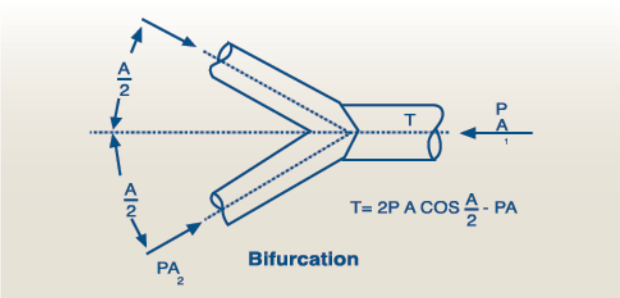
Head Office: Jeddah - Industrial Zone Phase (4) Building 4534 - Zip 22426 - Additional 7634 - Unit 1 - Saudi Arabia
Tel.: +966 -12 -637 0999 / 608 1100, Fax: +966 -12 -636 5925 / 637 9439 Email: sps@pipes.sa - Website: www.pipes.sa

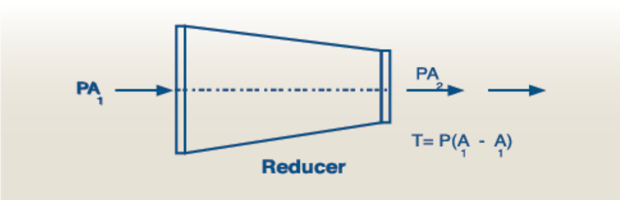
THRUST BLOCK

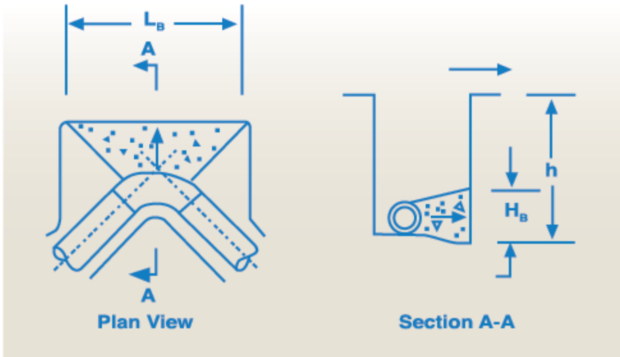


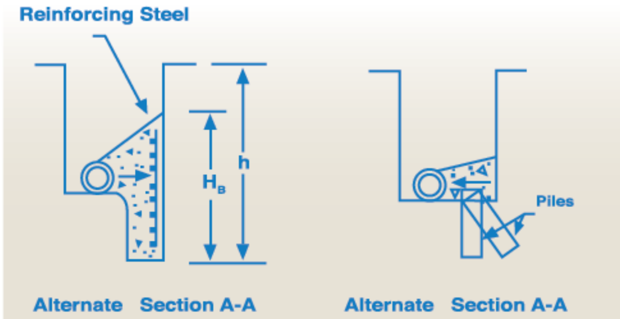












Concrete thrust blocks increase the ability of fittings to resist movement by increasing the bearing area & dead weight of fitting. The block size can be calculated as follows:

$L_b \times H_b$ = (TxFS)/1000 O
T= 2000 P x A x Sin(A/2)

$L_b x H_b$=Area of bearing surface of thurst block (m)²
T= Thurst force (N)
σ δ = Bearing strength of soil (kPa)
FS= Design factor (1,5)
P= Internal pressure (kPa)
A= Crosssectional area of pipe joint (m2)
A= (∏/4) (D/1000)²
D_j= Joint diameter
A = Bend angle, (degrees)

Head Office: Jeddah - Industrial Zone Phase (4) Building 4534 - Zip 22426 - Additional 7634 - Unit 1 - Saudi Arabia
Tel.: +966 -12 -637 0999 / 608 1100, Fax: +966 -12 -636 5925 / 637 9439 Email: sps@pipes.sa - Website: www.pipes.sa

FIELD HYDRO TESTING

It is advised not to exceed pipe testing with installation by more than approximately 750 meters

1.Prior to the test the following should be checked:
- Initial pipe deflection within the acceptable limit.
- Joints assembled correctly.
- System restrained in place.
- Flange bolts are torqued per instructions.
- Backfilling completed.
- Valves and pumps anchored.
- Backfill and compaction near structures and at closure pieces has been properly carried out.

2.The line should be filled with water The valves and vents should be opened, so that all air is expelled from the line during filling and pressure surges should be avoided"

3.The line should be pressurized slowly. Considerable energy is stored in a pipeline under pressure and this pressure should be respected.

4.It should be ensured that the gauge location will read the highest line pressure or adjust accordantly Locations lower in the line will have higher pressure due to additional head

5.It should be ensured that test pressure does not exceed 15 x PIV. Normally the field pressure is either a multiple of the operating pressure or the operating pressure case should the maximum field test pressure exceed I5xPN.

6.If, after a brief period for stabilization the line does not hold constant pressure it should be ensured that thermal effect (a temperature change) system expansion or entrapped air is not the cause If the pipe is determined to be leaking and the location is not readily apparent the following methods may aid discovery of the problem source:
- Checking flange and valve areas.
- Checking line tap location.
- Using sonic detection equipment.
- Testing the lines in smaller segments to isolate the leak.

An alternate test for gravity pipe (PN Ibar) systems may be conducted with air pressure instead of water In addition to routine care, normal precautions and typical procedures used in this work, the following suggestions and criteria should be noted

1.As with the hydro test, the line should be tested in small segments usually the pipe contained between adjacent manholes"

2.It should be ensured that the pipeline and all materials stubs accesses drops, etc. are adequately capped or plugged and braced against the internal pressure."

3.The system should be pressurized to 0.24 bar and must be regulated to prevent over pressurisation (maximum 0.35 bar)

4.The air temperature should be allowed to stabilize for several minutes while maintaining the pressure at 0.24 bar.

Head Office: Jeddah - Industrial Zone Phase (4) Building 4534 - Zip 22426 - Additional 7634 - Unit 1 - Saudi Arabia
Tel.: +966 -12 -637 0999 / 608 1100, Fax: +966 -12 -636 5925 / 637 9439 Email: sps@pipes.sa - Website: www.pipes.sa

5.During this stabilization period all plugged and capped outlets should be cleaned with a soap solution to detect leakage. If leakage is found at any connection, system pressure should be released, leaky caps or plugs should be released, leaky caps or plugs should be sealed and the procedure at Step 3 should be repeated.

6.After the stabilization period. the air pressure should be adjusted to 0,24 bar and the air supply should be disconnected or shut off.

7.The pipe system passes this test if the pressure drop is 0.035 bar or less during the time periods mentioned in the table below.

8.Should the section of line under test fail the air test acceptance requirements, the pneumatic plugs can be coupled fairly close together and moved up or down the line, repeating the air test at each location until the leak is found. This leak location method is very accurate, pinpointing the location of the leak to within one or two meters. Consequently, the area that must be excavated to make repairs is minimized, resulting in lower repair costs and considerable saved time.

Caution: Considerable energy is stored in a pipeline under pressure This is particularly true when air (even at low pressures) is the test medium. Should take great care to be sure that the pipeline is adequately restrained at charges in line direction and should follow manufacturers safety precautions for devices such as pneumatic plugs.

Note: This test will determine the rate at which air under pressure escapes from an isolated section of the pipeline. It is
suited to determining the presence or absence of pipe damage and / or improperly assembled joints.

Diameter	Time	Diameter	Time
(mm)	(min)	(mm)	(min)
100	2.50	1000	25.00
150	3.75	1100	27.50
200	5.00	1200	30.00
250	6.25	1300	32.00
300	7.75	1400	35.00
350	8.75	1500	37.50
400	10.00	1600	40.00
500	12.00	1800	45.00
600	15.00	2000	50.00
700	17.50	2200	55.00
800	20.00	2400	60.00
900	22.50	2500	65.00
1100	25.00	2600	75.00

Test time-field air test

Head Office: Jeddah - Industrial Zone Phase (4) Building 4534 - Zip 22426 - Additional 7634 - Unit 1 - Saudi Arabia
Tel.: +966 -12 -637 0999 / 608 1100, Fax: +966 -12 -636 5925 / 637 9439 Email: sps@pipes.sa - Website: www.pipes.sa

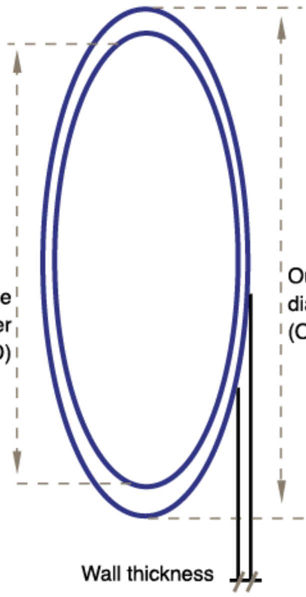
PIPE DIMENSIONS

DN Nominal Diameter (mm)	OD PN6 Outside Diameter (mm)	OD PN10 Outside Diameter (mm)	OD PN16 Outside Diameter (mm)	OD PN25 Outside Diameter (mm)	OD PN32 Outside Diameter (mm)
300	310	310	310	310	310
350	361	361	361	361	361
400	412	412	412	412	412
450	463	463	463	463	463
500	514	514	514	514	514
600	616	616	616	616	616
700	718	718	718	718	718
800	820	820	820	820	820
900	924	924	924	924	924
1000	1036	1036	1036	1036	
1200	1229	1229	1229	1229	
1400	1434	1434	1434		
1600	1638	1638	1638		
1800	1842	1842	1842		
2000	2046	2046	2046		
2200	2250	2250	2250		
2400	2453	2453	2453		
2600	2658	2658			

COUPLING DIMENSIONS

Sleeve	Sleeve	Width
ID	OD	OD
mm	mm	mm
313.0	351.8	266
364.0	405.0	266
415.0	456.0	266
466.0	508.6	266
517.0	561.0	266
619.0	663.0	266
721.0	765.0	266
772.0	818.0	316
823.0	869.0	316
927.0	973.0	316
2030.0	1076.0	316
2079.0	1125.5	316
2132.0	1179.0	316
2233.0	1281.0	316
2336.0	1391.6	316
2438.0	1494.6	316
2540.0	1597.6	316
2642.0	1700.6	316
2744.0	1803.6	316
2846.0	1906.6	316
2948.0	2009.6	316
2050.0	2112.6	316
2152.0	2215.6	316
2254.0	2318.6	316
2355.0	2420.6	316
2457.0	2523.6	316
2560.0	2627.6	316
2662.0	2730.6	316

Tolerance (-1/+1) /mm all stiffness 2500/5000,1000



Head Office: Jeddah - Industrial Zone Phase (4) Building 4534 - Zip 22426 - Additional 7634 - Unit 1 - Saudi Arabia
Tel.: +966 -12 -637 0999 / 608 1100, Fax: +966 -12 -636 5925 / 637 9439 Email: sps@pipes.sa - Website: www.pipes.sa

GRP JOINTS

JOINING PIPES

SPS GRP pipe sections are typically joined using GRP double bell couplings or bell and spigot joints. Pipe and couplings may be supplied separately or the pipe may be supplied with a coupling installed on one end. Other joining systems such as flanges, mechanical couplings, butt and strap lamination joints may also be used with SPS GRP pipe

1- SLEEVE COUPLING: GRP pipes manufactured by the continuous filament winding machine and cross winding machine are joined with sleeve couplings its elastomers profile (REKA RRA-69) inserted into the grooves of the GRP Sleeve and covering the pipe spigot ends.

- The pressure of the conveyed fluid against the profile lips.
- The compression of the elastomeric profile between the pipe external surfaces.

DOUBLE BELL COUPLING INSTALLATION AT SITE:

Cleaning and Gasket Installation the following steps (1 to 4) apply to all double bell coupling-joining procedures.

STEP 1: CLEAN COUPLING

Thoroughly clean double bell coupling grooves and rubber gasket rings to make sure no dirt or oil is present.

STEP 2: INSTALL GASKETS

Insert the gasket into the grooves, leaving two or more uniform loops of rubber (depending on diameter) extending out of the groove. Do not put any lubricant in the grooves or on the gasket at this stage. There should be a minimum of one loop for each 450mm of gasket ring circumference. With uniform pressure, push each loop of the rubber gasket into the gasket groove. When installed, pull carefully on the gasket in the radial direction around the whole circumference to check for well-distributed compression of the gasket. Check also that both sides of the gasket protrude equally above the top of the groove around the whole circumference Tapping with a rubber hammer will be helpful to accomplish the above

STEP 3: LUBRICATE GASKETS

Next, using a clean cloth, apply a thin film of lubricant to the rubber gaskets.

STEP 4: CLEAN AND LUBRICATE SPIGOTS

Thoroughly clean pipe spigots to remove any dirt, grit, grease, etc. Using a clean cloth, apply a thin film of lubricant to the spigots from the end of the pipe to the black positioning stripe. After lubricating, take care to keep the coupling and spigot clean.

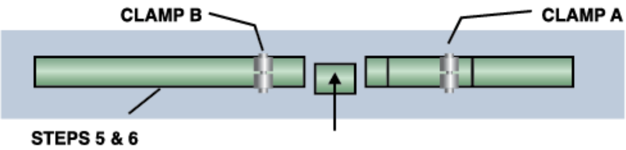
Caution: It is very important to use only the correct lubricant thin film of lubricants to the spigots from the end of the pipe to the black positioning stripe. After lubricating, take care to keep the coupling and spigot clean.

Caution: It is very important to use only the correct lubricant. SPS GRP provides sufficient lubricant with each delivery of coupling. If for some reason you run out, please contact SPS GRP for additional supply or advice on alterative lubricants. Never use a petroleum based lubricant.

Head Office: Jeddah - Industrial Zone Phase (4) Building 4534 - Zip 22426 - Additional 7634 - Unit 1 - Saudi Arabia
Tel.: +966 -12 -637 0999 / 608 1100, Fax: +966 -12 -636 5925 / 637 9439 Email: sps@pipes.sa - Website: www.pipes.sa

STEP 5: FIXING OF CLAMP

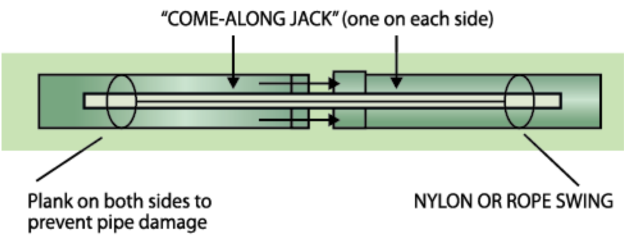
Clamp A is fixed anywhere on first pipe or left in position from previous joint. Fix clamp B on the pipe to be connected in the correct position relative to the alignment stripe on the spigot-end (home line) so as to act as a stopper



Note: The mechanical installation clamp is to act both as a stop to position the coupling and as a device on which to attach the pulling (come-along jacks) equipment. Clamp contact with the pipe. Shall be padded or otherwise protected to prevent damage to the pipe and to have high friction resistance with the pipe surface. If clamps are not available, nylon slings or rope may be used as in Figure 3.6, but care must be taken in the alignment of the acting as a stopper. However, if not available, insert the pipe spigots until the home-line (alignment stripe) aligns with the coupling edge.

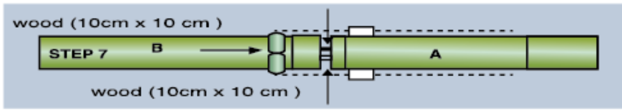
STEP 6: PIPE PLACEMENT

The pipe to be connected is placed on the bed with sufficient distance from previously joined pipe to allow lowering the coupling into position.



STEP 7: JOIN COUPLING

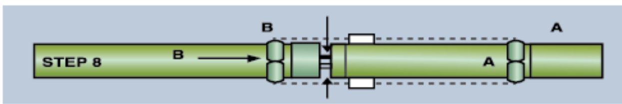
Come-along jacks are installed to connect the pipe clamps and two 10 cm x 10 cm timbers or similar (large diameters require a bulkhead) are placed between the pipe previously connected and the coupling. While these are held in position the new pipe is entered into the coupling until it rests against the pipe.



Note: Approximate joining force 1 kg/mm of diameter.
Note: For smaller diameter (100 mm to 300 mm) it might be possible to joint pipe and coupling without the use of come-along jacks. The use of levers is common to join small diameters.

STEP 8: JOIN PIPES

Come-along jacks are loosened and timbers removed before re-tightening the jacks for entering the coupling onto the previously connected pipe. Check the correct position of the edge of the coupling to the alignments tripe

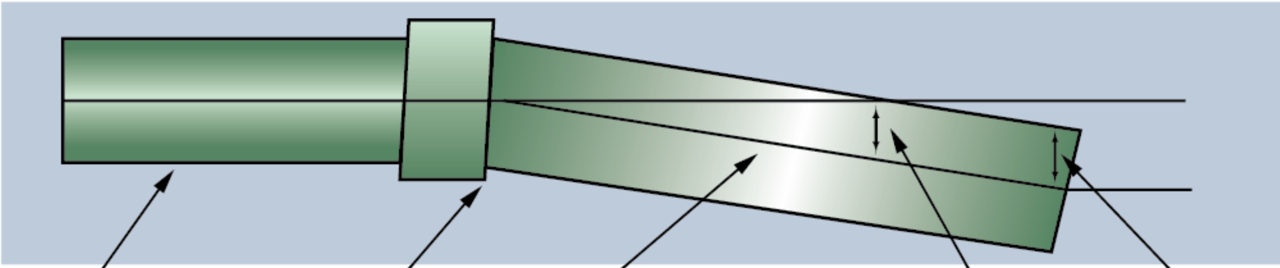


Note: When step 8 has been completed, clamp-B is left in position while Clamp A is moved on to the next pipe to be joined.

Angular Deflection of Double Bell Couplings:

Maximum angular deflection (turn at each coupling joint must not exceed the amounts given in table. The pipes should be joined in Straight alignment and thereafter deflected angularly as requird

Head Office: Jeddah - Industrial Zone Phase (4) Building 4534 - Zip 22426 - Additional 7634 - Unit 1 - Saudi Arabia
Tel.: +966 -12 -637 0999 / 608 1100, Fax: +966 -12 -636 5925 / 637 9439 Email: sps@pipes.sa - Website: www.pipes.sa



Angular Deflection at Double Bell Coupling Joint

PIPE DIAMETER	PIPE TO PIPE ANGULAR DEFLECTION	BENDING RADIUS	
		L=6m	L=12m
300 ≤ DN ≤ 600	4.0°	86	172
600 ≤ DN ≤ 750	3.5°	98	196
750 ≤ DN ≤ 900	3.0°	115	229
900 ≤ DN ≤ 1100	2.5°	138	275
1100 ≤ DN ≤ 1400	2.0°	172	344
1400 ≤ DN ≤ 1900	1.5°	229	458
1900 ≤ DN ≤ 2800	1.0°	344	688
2800 ≤ DN ≤ 3800	0.75°	458	917
3800 ≤ DN ≤ 4000	0.5°	688	1375

there after deflected angularly as required.

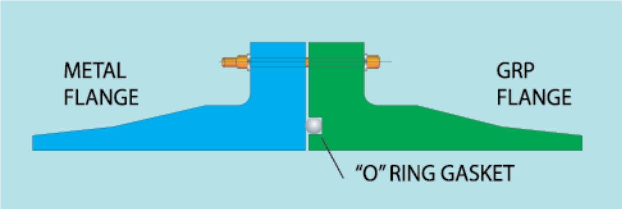
The bending radius depends on the section length of the pipe. In the above table it is shown for the standard section length of 6m to 12 m, but it can be easily calculated since it is inverse relation to the section length (for 3m section length will be half of the radius for 6m section length.

2. GRP FLANGE JOINING SYSTEM

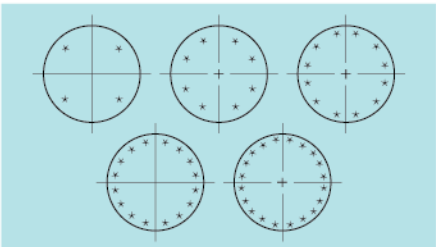
GRP flanges with diameter 350mm and larger should be jointed according to the following procedure.

1. Thoroughly clean the flange face and the 'O' ring groove with any clean rags and avoid any oil contact for both the groove and the 'O' ring.
2. Ensure the 'O' ring gasket is clean and undamaged. Do not use defective gasket
3. Position the 'O' ring in the groove and secure in position, if necessary, with small strips of adhesive tape at intermittent locations.
4. Make sure that the two flanges or connecting flange with valve or expansion joint is well aligned with GRP flanges. Any misalignment could lead to high stress at flange neck and could cause damage
5. Insert bolts, washers and nuts. All hardware must be clean and lubricated to avoid incorrect tighter ring Washers must be used on all GRP flanges.

Head Office: Jeddah - Industrial Zone Phase (4) Building 4534 - Zip 22426 - Additional 7634 - Unit 1 - Saudi Arabia
Tel.: +966 -12 -637 0999 / 608 1100, Fax: +966 -12 -636 5925 / 637 9439 Email: sps@pipes.sa - Website: www.pipes.sa



1.Using a torque wrench, tighten all bolts to 35 N-m torque, following bolt tightening sequence shown in Fig, SPS-2
2.Repeat his procedure, raising the bolt until the flanges almost touch at their inside edges with a gap of 2-3mm or maximum bolt torque of 100 N-m. Do not exceed this torque without consulting SPS for advice. If done so, this may cause permanent damage to the GRP flange.
3.Pressure should be established over the flange face by tightening bolts in 7N in Fig (5 lb-ft) For flanges with more than 20 bolts, similar increment according to the sequence alternating bolt tightening sequences shall be used, As per ASTM D4024-00).
4.Check bolt torque one hour later and adjust as seen necessary to 100 N-m?
5.The maximum torque, in any case, should not be more than 110 to 130 N-m Care should be exercised while increasing the torque uniformly
6.The above procedure is applicable for all diameters.



Note: When connecting two GRP flanges, only one flange should have a gasket groove in the face.

OTHER JOINING METHODS

1. Flexible Steel Couplings:

(Strobe, Tee Kay, ete- See Fig. SPS-3). These couplings can be used for joining as well as for repair. The coupling consists of a steel mantle with an interior rubber-sealing sleeve.

Three grades are available:

- Epoxy or PVC -coated steel mantle.
- Stainless steel mantle.
- Hot dip galvanized steel mantle.

Control of bolting torque with these couplings is most important After initial bolt up, the coupling should be wrapped with a rubber mallet to help seat and bow the basket. Bolt torque should then be adjusted up to proper levels. Depending on coupling size, this procedure may need to be repeated several times Do not over torque as this may overstress the bolts. Follow the manufacturer's recommended assembly instructions.

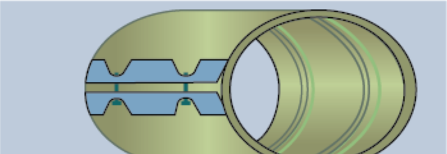


FIG SPS 3

2. Mechanical Steel Couplings:

(Viking Jolnson, Dresser etc. See Fig. SPS-4). These couplings can be used for joining, typically to other types of pipe or to rigid items. Bolting torque must be controlled not to exceed the manufacturer's maximum recommended Values. Excess torque could damage the pipe.

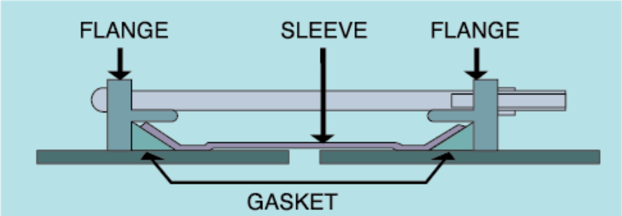


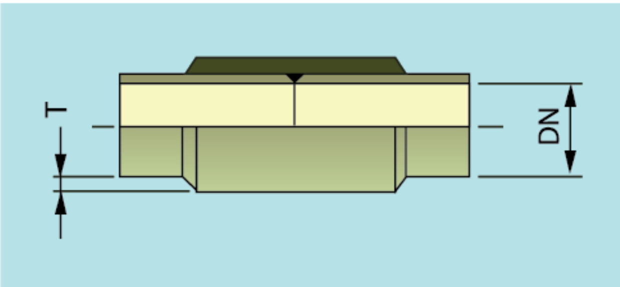
FIG SPS 4

Head Office: Jeddah - Industrial Zone Phase (4) Building 4534 - Zip 22426 - Additional 7634 - Unite 1 - Saudi Arabia
Tel.: +966 -12 -637 0999 / 608 1100, Fax: +966 -12 -636 5925 / 637 9439 Email: sps@pipes.sa - Website: www.pipes.sa

3. Butt And Strap Joint System (Lamination Joint System)

This permanent joint cosists of a hardening of impregnated glass, mats and tissues laminated according to specified width and thickness. The laminated joint provides continuity in both hoop and axial directions The application field of butt and strap joint is related to diameter and pressure classes of pipes to diameter and pressure classes of pipes and fittings to be joint The dimensions of butt and strap joint are calculated according to the following formulae.

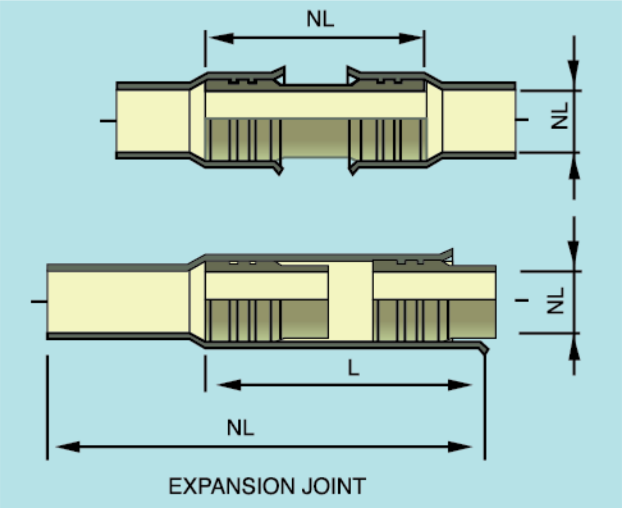
T = P (ID +2T)/ (2H P)
L = P (ID 2T)/2S
T = THICKNESS OF LAMINATION, Mpa
P = DESIGN PRESSURE, Mpa
ID= INSIDE DIA., mm
T = PIPE THICKNESS, mm
H = ALLOWABLE HOOP STRESS, Mpa
S = ALLOWABLE SHEAR STRESS, Mpa



DN	PN10		PN16	
	T	L	T	L
100	4	100	5	130
150	5	160	7	230
200	6	200	9	290
250	7	240	11	350
300	8.5	270	13	400
350	10	310	14.5	460
400	11	350	16	520
450	12	380	18	580
500	13	420	20	640
600	15	490	23.5	750
700	18	560	27	870
800	20	640	31	990
900	22	710	34.5	1100
1000	24.5	780	38	1220
1100	26	850	41.5	1220
1200	27.5	920	45	1300
1300	29	990	49	1300
1400	32	1060	52	1340
1500	35	1100	56	1340

Head Office: Jeddah - Industrial Zone Phase (4) Building 4534 - Zip 22426 - Additional 7634 - Unite 1 - Saudi Arabia
Tel.: +966 -12 -637 0999 / 608 1100, Fax: +966 -12 -636 5925 / 637 9439 Email: sps@pipes.sa - Website: www.pipes.sa

COUPLING AND EXPANSION JOINT



DN	COUPLING	EXPANSION JOINT	
	L	NL	BL
100	393	1172	672
150	467	1208	708
200	467	1208	708
250	467	1208	708
300	592	1208	756
350	592	1256	756
400	592	1256	756
450	704	1315	815
500	704	1315	815
600	704	1315	815
700	704	1315	815
800	704	1315	815
900	750	1336	836

FITTINGS AND ACCESSORIES

Supply the following fittings such as Flanges, Elbows, Wyes, Tees, Couplings, and reducers. large diameter fittings are available upon request.

FABRICATION METHODS

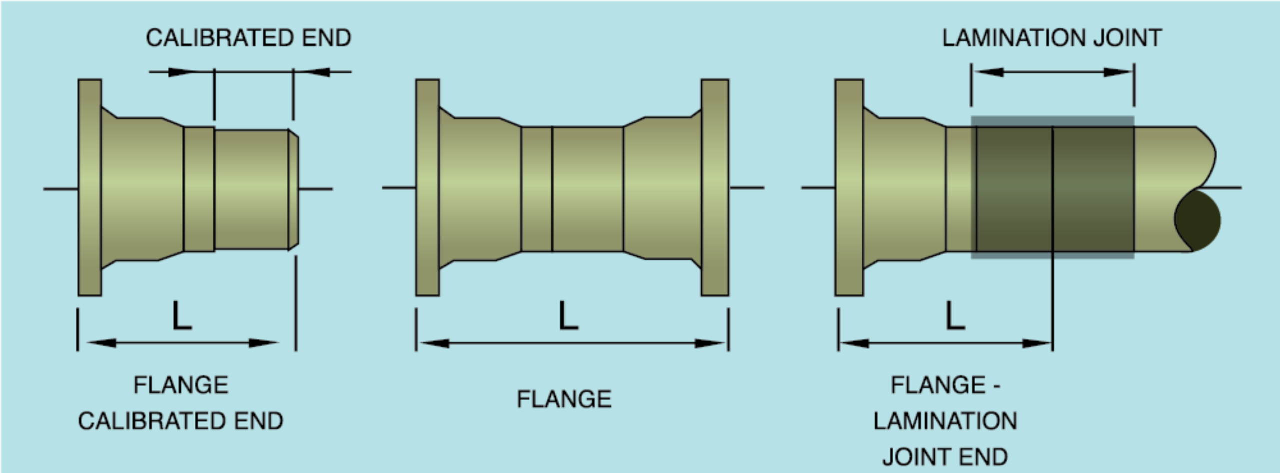
Fittings are manufactured by the hand lay-up, contact molding and spray-up process. In hand lay-up and contact molding, previous veil and alternate layers of mat and woven roving saturated with resin are applied on the mold. The operation is repeated to reach the required thickness.
To fit the special needs of the costumers a study and development can be performed for making non-standards products. Before supplying such products, SPS/GRP needs to be sure that the product is made according the relevant standards and that is tested and proven as a good one.

WALL STRUCTURE

GRP fitting wall such as the pipe wall consist of three layers perfectly adherent one to the other in order to have monolithic structure, each having different characteristics and properties in relation to their function. Liner and top coat are the same as the pipe. The difference consists in the mechanical resistant layer due to the type of reinforcement used..

Head Office: Jeddah - Industrial Zone Phase (4) Building 4534 - Zip 22426 - Additional 7634 - Unite 1 - Saudi Arabia
Tel.: +966 -12 -637 0999 / 608 1100, Fax: +966 -12 -636 5925 / 637 9439 Email: sps@pipes.sa - Website: www.pipes.sa

FLANGES

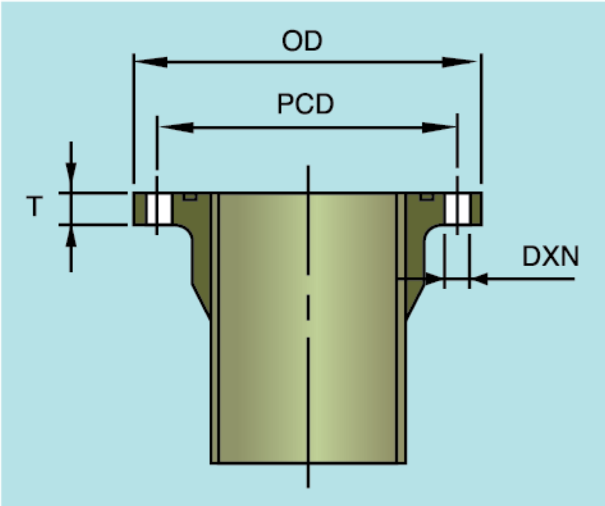


OVER-ALL LENGTH, L (mm)			
DN	FL/CAL. END	FL/FL	FL/ LAM.JOINT END
100	105	340	170
150	120	470	235
200	125	540	270
250	135	620	310
300	160	720	360
350	170	800	400
400	190	910	455
450	210	1000	500
500	230	1100	550
600	270	1290	645
700	315	1500	750
800	360	1710	855
900	400	1900	950
1000	430	2060	1030
1100	480	2160	1080
1200	520	2240	1120
1300	550	2300	1150
1400	580	2360	1180
1500	620	2440	1220

NOTE: Calibrated end you should Joint The Pipe By Coupling
NOTE: Plain End you should Joint the pipes with lamination flanges.

Head Office: Jeddah - Industrial Zone Phase (4) Building 4534 - Zip 22426 - Additional 7634 - Unite 1 - Saudi Arabia
Tel.: +966 -12 -637 0999 / 608 1100, Fax: +966 -12 -636 5925 / 637 9439 Email: sps@pipes.sa - Website: www.pipes.sa

FLANGES

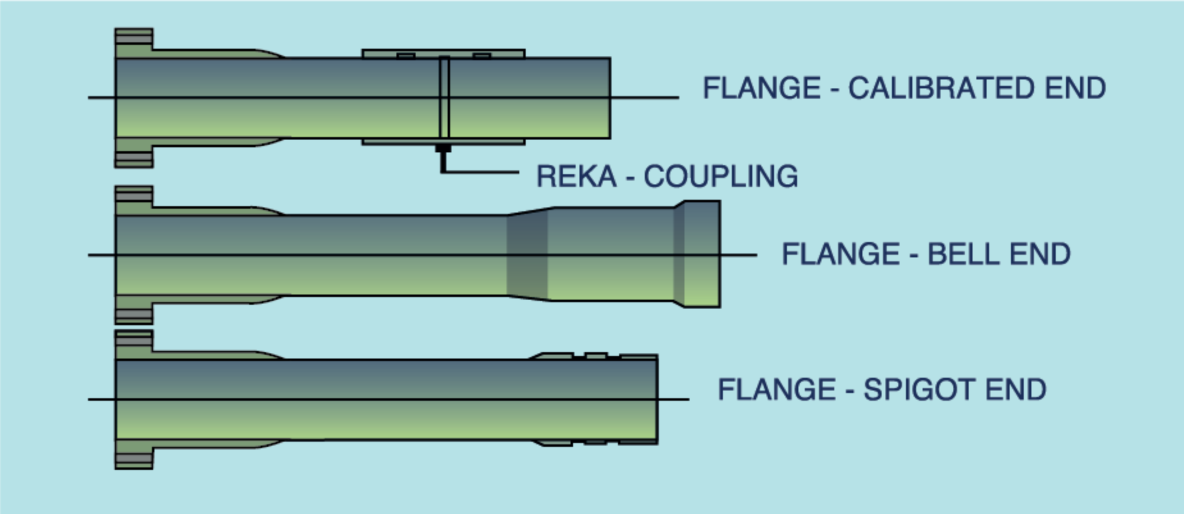


DN	DRILLING									
	PN10					PN16				
	T	OD	PCD	HOLE DIA.	No. OF HOLES	T	OD	PCD	HOLE DIA.	No. OF HOLES
100	23	220	180	16	8	28	220	180	16	8
150	25	285	240	20	8	31	285	240	20	8
200	30	340	295	20	8	36	340	295	20	12
250	35	395	350	20	12	41	405	355	22	12
300	40	445	400	20	12	48	460	410	22	12
350	41	505	460	20	16	50	520	470	22	16
400	41	565	515	22	16	52	580	525	27	16
450	45	615	565	22	20	57	585	640	27	20
500	47	670	620	22	20	60	715	650	30	20
600	53	780	725	27	20	66	840	770	33	20
700	61	895	840	27	24	76	910	840	33	24
800	67	1015	950	30	24	85	1025	950	36	24
900	73	1115	1050	30	28	90	1125	1050	36	28
1000	85	1230	1160	33	28	105	1255	1170	39	28
1100	90	1340	1270	33	32	105	1355	1270	39	32
1200	90	1455	1380	36	32	105	1485	1390	45	32
1300	95	1575	1490	39	32	110	1585	1490	45	32
1400	95	1675	1590	39	36	110	1685	1590	45	36
1500	100	1785	1700	39	36	110	1820	1710	52	36

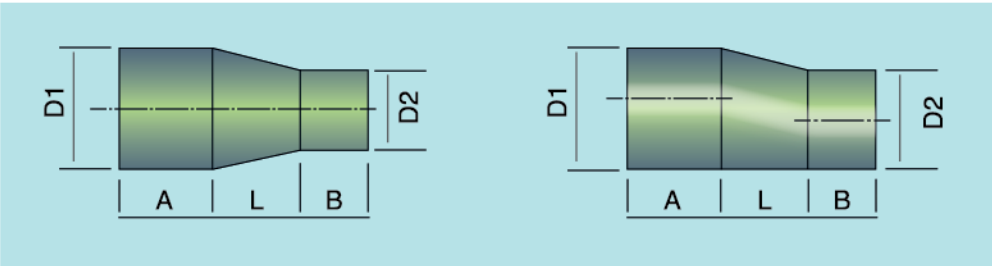
NOTE: The Length For The Flange With The Pipe One Meter
If You Need Specific Length Call Sps To Define

Head Office: Jeddah - Industrial Zone Phase (4) Building 4534 - Zip 22426 - Additional 7634 - Unite 1 - Saudi Arabia
Tel.: +966 -12 -637 0999 / 608 1100, Fax: +966 -12 -636 5925 / 637 9439 Email: sps@pipes.sa - Website: www.pipes.sa

FLANGE COUPLING



REDUCER



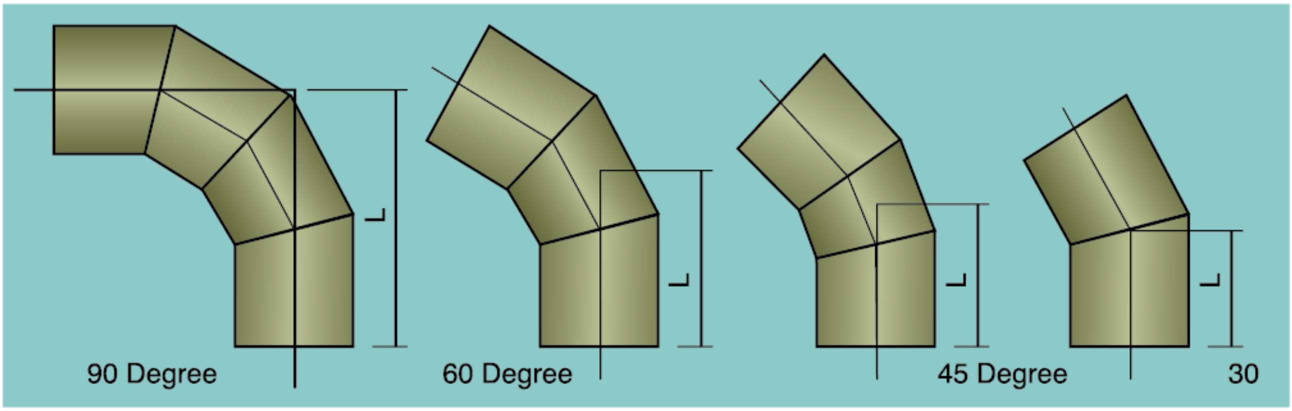
CONCENTRIC REDUCER **ECCENTRIC REDUCER**

1. Length of A and B = Length of lamination according to DN and Pressure.
2. Length of L = (D1 - D2) x 2.5

NOTE: The Length For The Flange With The Pipe One Meter
If You Need Specific Length Call Sps To Define

Head Office: Jeddah - Industrial Zone Phase (4) Building 4534 - Zip 22426 - Additional 7634 - Unite 1 - Saudi Arabia
Tel.: +966 -12 -637 0999 / 608 1100, Fax: +966 -12 -636 5925 / 637 9439 Email: sps@pipes.sa - Website: www.pipes.sa

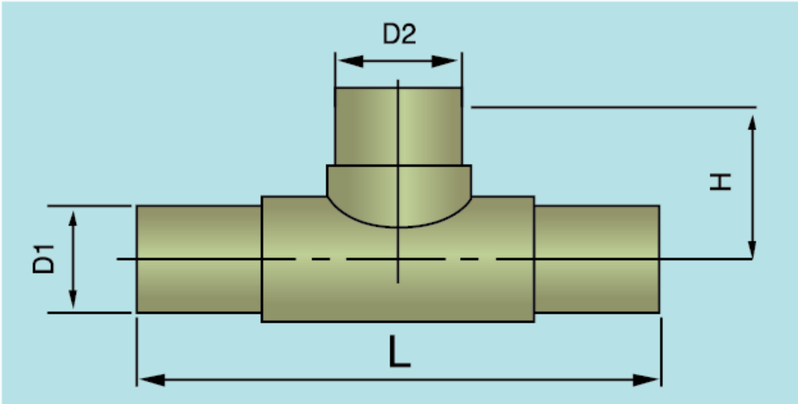
ELbOW - MITE RED



DN	L (PN10)				L (PN16)			
	90°	60°	45°	30°	90°	60°	45°	30°
100	223	160	142	113	283	220	202	173
150	345	250	223	180	415	320	293	250
200	446	320	284	227	536	410	374	317
250	548	390	346	273	658	500	456	383
300	640	449	397	310	770	579	527	440
350	736	514	453	352	886	664	603	502
400	798	544	474	359	968	714	644	529
450	884	599	520	390	1084	799	720	590
500	986	669	581	437	1216	899	811	667
600	1144	764	658	567	1404	1024	918	827
700	1302	859	736	534	1607	1164	1014	839
800	1466	958	818	587	1816	1308	1168	937
900	1624	1053	895	636	2014	1443	1285	1026
1000	1782	1148	972	684	2202	1568	1392	1104
1100	1940	1243	1050	732	2290	1593	1400	1082
1200	2103	1343	1132	930	2373	1613	1402	1200
1300	2262	1437	1209	834	2462	1637	1409	1034
1400	2420	1532	1286	883	2550	1662	1416	1013
1500	2578	1627	1364	931	2638	1687	1424	991

Head Office: Jeddah - Industrial Zone Phase (4) Building 4534 - Zip 22426 - Additional 7634 - Unite 1 - Saudi Arabia
Tel.: +966 -12 -637 0999 / 608 1100, Fax: +966 -12 -636 5925 / 637 9439 Email: sps@pipes.sa - Website: www.pipes.sa

TEE - EQUAL AND UNEQUAL



D1	D1	CALIBRATED		JOINT LAMINATION	
		L	H	L	H
100	100	240	120	370	185
150	100-150	300	145	520	260
200	100	380	210	690	355
	150-200	400	210	690	355
250	100	470	260	840	440
	150-250	490	260	840	440
300	100-150	580	330	1000	530
	200-300	600	330	1000	530
350	100-150	680	385	1150	615
	200-350	690	385	1150	615
400	100-200	800	400	1320	660
	250-400	800	450	1320	710
450	100-200	910	445	1470	735
	250-450	910	505	1470	795
500	100-250	1000	500	1640	820
	300-500	1020	570	1640	890
600	100-250	1200	600	1950	975
	300-600	1200	660	1950	1035

D1	D1	CALIBRATED		JOINT LAMINATION	
		L	H	L	H
700	100-300	1400	700	2270	1135
	350-700	1400	780	2270	1215
800	100-350	1600	800	2590	1295
	400-800	1600	900	2590	1395
900	100-400	1840	900	2900	1450
	450-900	1840	1020	2900	1570
1000	100-450	2000	1000	3200	1600
	500-1000	2000	1140	3200	1740
1100	100-500	2200	1100	3400	1750
	550-1100	2200	1240	3400	1840
1200	100-500	2400	1200	3600	1900
	600-1200	2400	1340	3600	1940
1300	100-600	2600	1300	3800	1900
	700-1300	2600	1400	3800	2040
1400	100-600	2800	1400	40000	2100
	700-1400	2800	1540	4000	2140
1500	100-700	3000	1500	4200	2200
	800-1500	3000	1640	4200	2240

NOTE: The Length For The Flange With The Pipe One Meter
If You Need Specific Length Call Sps To Define

4.7 Negative Pressure

A minimum burial depth of 1.0 meter is recommended for negative pressure (vacuum) situations so as to provide proper soil stabilizing support.

Installation Type 1

The maximum allowable negative pressure (vacuum) in the pipe is a function of both native soil and backfill soil stiffness. Tables 4.8A through 4.8D give the maximum burial depths for allowable negative pressure of 1.0, 0.75, 0,50 and 0.25 bars.

Table 4.8A- SN 2500
Table 4.8B - SN 5000
Table 4.8C - SN 10000
Table 4.8D - Small Diameter Pipe

Head Office: Jeddah - Industrial Zone Phase (4) Building 4534 - Zip 22426 - Additional 7634 - Unite 1 - Saudi Arabia
Tel.: +966 -12 -637 0999 / 608 1100, Fax: +966 -12 -636 5925 / 637 9439 Email: sps@pipes.sa - Website: www.pipes.sa

Installation Type 2

Table 4.9 gives the maximum burial depths for the allowable negative pressures for the three stiffness classes for Type 2 installations.

Table 4.8 A

Standard Trench Installation Type 1 Maximum Burial Depth (meters) for Allowable Negative Pressure (bars).

	SN 2500					
E'b	Native Soil Group					
MPa	1	2	3	4	5	6
10000 SITS No Traffic Load						
20.7	15.0	12.0	5.5	1.5	NA	NA
13.8	12.0	9.0	4.0	1.0	NA	NA
10.3	9.0	7.0	3.0	NA	NA	NA
6.9	5.0	4.0	1.8	NA	NA	NA
4.8	2.4	1.4	NA	NA	NA	NA
3.4	NA	NA	NA	NA	NA	NA
2.1	NA	NA	NA	NA	NA	NA
1.4	NA	NA	NA	NA	NA	NA
	(-) 0.75 bar					
20.7	17.0	13.0	8.0	3.5	NA	NA
13.8	14.0	11.0	6.5	2.6	NA	NA
10.3	11.0	9.0	5.5	2.4	NA	NA
6.9	7.5	6.5	4.0	1.6	NA	NA
4.8	4.5	4.0	2.4	1.0	NA	NA
3.4	2.4	2.4	1.4	NA	NA	NA
2.1	NA	NA	NA	NA	NA	NA
1.4	NA	NA	NA	NA	NA	NA
	(-) 0.50 bar					
20.7	18.0	15.0	10.0	5.5	1.0	NA
13.8	15.0	13.0	8.5	4.5	1.0	NA
10.3	13.0	11.0	7.5	4.0	1.0	NA
6.9	9.0	8.5	6.0	3.5	NA	NA
4.8	7.0	6.0	4.5	2.8	NA	NA
3.4	4.5	4.0	3.5	2.0	NA	NA
2.1	2.4	2.4	2.0	1.4	NA	NA
1.4	1.0	1.0	1.0	NA	NA	NA
	(-) 0.25 bar					
20.7	18.0	15.0	10.0	5.5	1.0	NA
13.8	15.0	13.0	8.5	4.5	1.0	NA
10.3	13.0	11.0	7.5	4.0	1.0	NA
6.9	9.0	8.5	6.0	3.5	NA	NA
4.8	7.0	6.0	4.5	2.8	NA	NA
3.4	4.5	4.0	3.5	2.0	NA	NA
2.1	2.4	2.4	2.0	1.4	NA	NA
1.4	1.0	1.0	1.0	NA	NA	NA

Head Office: Jeddah - Industrial Zone Phase (4) Building 4534 - Zip 22426 - Additional 7634 - Unite 1 - Saudi Arabia
Tel.: +966 -12 -637 0999 / 608 1100, Fax: +966 -12 -636 5925 / 637 9439 Email: sps@pipes.sa - Website: www.pipes.sa

Table 4.8 B

Standard Trench Installation Type 1 Maximum Burial Depth (meters) for Allowable Negative Pressure (bars).

	SN 5000					
E'b	Native Soil Group					
MPa	1	2	3	4	5	6
	(-) 1.0 bar					
20.7	23.0	18.0	12.0	7.5	NA	NA
13.8	18.0	15.0	10.0	6.5	NA	NA
10.3	15.0	13.0	9.0	5.5	NA	NA
6.9	11.0	10.0	8.0	3.5	NA	NA
4.8	9.0	7.5	6.0	2.4	NA	NA
3.4	6.0	4.5	3.0	1.4	NA	NA
2.1	1.4	1.4	NA	NA	NA	NA
1.4	NA	NA	NA	NA	NA	NA
	(-) 0.75 bar					
20.7	23.0	18.0	12.0	7.0	2.0	NA
13.8	18.0	15.0	10.0	6.5	1.6	NA
10.3	15.0	13.0	9.0	6.0	1.4	NA
6.9	11.0	10.0	8.0	5.0	1.2	NA
4.8	9.0	7.5	6.5	4.5	NA	NA
3.4	6.0	6.0	5.0	3.5	NA	NA
2.1	4.0	3.5	3.0	2.0	NA	NA
1.4	1.6	1.4	1.4	NA	NA	NA
	(-) 0.50 bar					
20.7	23.0	18.0	12.0	7.0	3.2	NA
13.8	18.0	15.0	10.0	6.5	3.0	NA
10.3	15.0	13.0	9.0	6.0	3.0	NA
6.9	11.0	10.0	8.0	5.0	2.6	NA
4.8	9.0	7.5	6.5	4.5	2.4	NA
3.4	6.0	6.0	5.0	4.0	2.0	NA
2.1	4.0	4.0	3.5	3.0	1.4	NA
1.4	3.0	3.0	3.0	2.4	NA	NA
	(-) 0.25 bar					
20.7	23.0	18.0	12.0	7.0	3.2	1.8
13.8	18.0	15.0	10.0	6.5	3.0	1.4
10.3	15.0	13.0	9.0	6.0	3.0	1.4
6.9	11.0	10.0	8.0	5.0	2.6	1.4
4.8	9.0	7.5	6.5	4.5	2.4	1.2
3.4	6.0	6.0	5.0	4.0	2.0	1.2
2.1	4.0	4.0	3.5	3.0	2.0	NA
1.4	3.0	3.0	3.0	2.6	1.6	NA

Head Office: Jeddah - Industrial Zone Phase (4) Building 4534 - Zip 22426 - Additional 7634 - Unite 1 - Saudi Arabia
Tel.: +966 -12 -637 0999 / 608 1100, Fax: +966 -12 -636 5925 / 637 9439 Email: sps@pipes.sa - Website: www.pipes.sa

Table 4.8 C

Standard Trench Installation Type 1 Maximum Burial Depth (meters) for Allowable Negative Pressure (bars)

	SN 10000					
E'b	Native Soil Group					
MPa	1	2	3	4	5	6
	(-) 1.0 bar					
20.7	24.0	19.0	12.0	8.0	3.5	NA
13.8	19.0	16.0	11.0	7.0	3.5	NA
10.3	15.0	13.0	10.0	6.5	3.0	NA
6.9	12.0	10.0	8.5	5.5	2.8	NA
4.8	9.0	8.5	7.0	5.0	1.6	NA
3.4	7.0	6.5	5.5	4.5	NA	NA
2.1	4.5	4.5	4.0	3.5	NA	NA
1.4	3.5	3.5	3.5	2.5	NA	NA
	(-) 0.75 bar					
20.7	24.0	19.0	12.0	8.0	3.5	NA
13.8	19.0	16.0	11.0	7.0	3.5	NA
10.3	15.0	13.0	10.0	6.5	3.0	NA
6.9	12.0	10.0	8.5	5.5	3.0	NA
4.8	9.0	8.5	7.0	5.0	2.8	NA
3.4	7.0	6.5	5.5	4.5	2.6	NA
2.1	4.5	4.5	4.0	3.5	2.4	NA
1.4	3.5	3.5	3.5	3.0	1.4	NA
	(-) 0.50 bar					
20.7	24.0	19.0	12.0	8.0	3.5	1.4
13.8	19.0	16.0	11.0	7.0	3.5	1.4
10.3	15.0	13.0	10.0	6.5	3.0	1.4
6.9	12.0	10.0	8.5	5.5	3.0	1.2
4.8	9.0	8.5	7.0	5.0	2.8	1.2
3.4	7.0	6.5	5.5	4.5	2.6	1.2
2.1	4.5	4.5	4.0	3.5	2.4	NA
1.4	3.5	3.5	3.5	3.0	2.0	NA
	(-) 0.25 bar					
20.7	24.0	19.0	12.0	8.0	3.5	1.6
13.8	19.0	16.0	11.0	7.0	3.5	1.6
10.3	15.0	13.0	10.0	6.5	3.0	1.6
6.9	12.0	10.0	8.5	5.5	3.0	1.6
4.8	9.0	8.5	7.0	5.0	2.8	1.6
3.4	7.0	6.5	5.5	4.5	2.6	1.6
2.1	4.5	4.5	4.0	3.5	2.4	1.6
1.4	3.5	3.5	3.5	3.0	2.0	1.6

Head Office: Jeddah - Industrial Zone Phase (4) Building 4534 - Zip 22426 - Additional 7634 - Unite 1 - Saudi Arabia
Tel.: +966 -12 -637 0999 / 608 1100, Fax: +966 -12 -636 5925 / 637 9439 Email: sps@pipes.sa - Website: www.pipes.sa

Table 4.8 D

Standard Trench Installation Type 1 Maximum Burial Depth (meters) for Allowable Negative Pressure (bars)

	Small Diameter Pipe (SN 10000)					
E'b	Native Soil Group					
MPa	1	2	3	4	5	6
	(-) 1.0 bar					
20.7	18.0	14.0	9.5	6.0	2.8	NA
13.8	14.0	12.0	8.0	5.0	2.6	NA
10.3	12.0	10.0	7.5	5.0	2.6	NA
6.9	9.0	8.0	6.5	4.5	2.4	NA
4.8	7.0	6.0	5.5	4.0	2.2	NA
3.4	5.0	5.0	4.5	3.5	NA	NA
2.1	3.5	3.5	3.5	2.8	NA	NA
1.4	2.6	2.6	2.6	2.4	NA	NA
	(-) 0.75 bar					
20.7	18.0	14.0	9.5	6.0	2.8	NA
13.8	14.0	12.0	8.0	5.0	2.6	NA
10.3	12.0	10.0	7.5	5.0	2.6	NA
6.9	9.0	8.0	6.5	4.5	2.4	NA
4.8	7.0	6.0	5.5	4.0	2.2	NA
3.4	5.0	5.0	4.5	3.5	2.0	NA
2.1	3.5	3.5	3.5	2.8	1.8	NA
1.4	2.6	2.6	2.6	2.4	1.4	NA
	(-) 0.50 bar					
20.7	18.0	14.0	9.5	6.0	2.8	1.2
13.8	14.0	12.0	8.0	5.0	2.6	1.2
10.3	12.0	10.0	7.5	5.0	2.6	1.2
6.9	9.0	8.0	6.5	4.5	2.4	1.2
4.8	7.0	6.0	5.5	4.0	2.2	1.2
3.4	5.0	5.0	4.5	3.5	2.0	1.2
2.1	3.5	3.5	3.5	2.8	1.8	NA
1.4	2.6	2.6	2.6	2.4	1.8	NA
	(-) 0.25 bar					
20.7	18.0	14.0	9.5	6.0	2.8	1.2
13.8	14.0	12.0	8.0	5.0	2.6	1.2
10.3	12.0	10.0	7.5	5.0	2.6	1.2
6.9	9.0	8.0	6.5	4.5	2.4	1.2
4.8	7.0	6.0	5.5	4.0	2.2	1.2
3.4	5.0	5.0	4.5	3.5	NA	1.2
2.1	3.5	3.5	3.5	2.8	NA	1.2
1.4	2.6	2.6	2.6	2.4	NA	1.2

Head Office: Jeddah - Industrial Zone Phase (4) Building 4534 - Zip 22426 - Additional 7634 - Unite 1 - Saudi Arabia
Tel.: +966 -12 -637 0999 / 608 1100, Fax: +966 -12 -636 5925 / 637 9439 Email: sps@pipes.sa - Website: www.pipes.sa

Table 4.9

Standard Trench Installation Type 2 Maximum Burial Depth (meters) for Allowable Negative Pressure (bars)

Allowable Negative Pressure (bars)	Native Soil Group					
	1	2	3	4	5	6
SN 2500						
(-) 1.00	NA	NA	NA	NA	NA	NA
(-) 0.75	NA	NA	NA	NA	NA	NA
(-) 0.50	1.0	1.0	1.0	NA	NA	NA
(-) 0.25	2.6	2.6	2.6	2.2	1.2	NA

Allowable Negative Pressure (bars)	Native Soil Group					
	1	2	3	4	5	6
SN 5000						
(-) 1.00	NA	NA	NA	NA	NA	NA
(-) 0.75	1.6	1.4	1.4	NA	NA	NA
(-) 0.50	3.0	3.0	3.0	2.4	NA	NA
(-) 0.25	3.0	3.0	3.0	2.6	1.6	NA

Allowable Negative Pressure (bars)	Native Soil Group					
	1	2	3	4	5	6
SN 10000						
(-) 1.00	3.5	3.5	3.5	2.5	NA	NA
(-) 0.75	3.5	3.5	3.5	3.0	1.4	NA
(-) 0.50	3.5	3.5	3.5	3.0	2.0	NA
(-) 0.25	3.5	3.5	3.5	3.0	2.0	1.6

Head Office: Jeddah - Industrial Zone Phase (4) Building 4534 - Zip 22426 - Additional 7634 - Unite 1 - Saudi Arabia
Tel.: +966 -12 -637 0999 / 608 1100, Fax: +966 -12 -636 5925 / 637 9439 Email: sps@pipes.sa - Website: www.pipes.sa

Unburied Pipe Sections

Some sections of a buried pipeline such as in valve pits or chambers may be non-soil supported. As the stabilizing support of the soil is not present the negative pressure capability will be limited. Table 4.10 gives the maximum allowable negative pressure for lengths between restraints of 3, 6 and 12 meters.

Table 4.10

Maximum Allowable Negative Pressure (bars)
for Unburied Sections
Pipe Length Between Restraints 3m/6m/12m

PN	SN2500			SN5000			SN10000		
	3m	6m	12m	3m	6m	12m	3m	6m	12m
6	.50	.25	.25	.75	.50	.50	1.0	1.0	1.0
10	.50	.25	.25	.75	.50	.50	1.0	1.0	1.0
16	.50	.25	.25	1.0	.50	.50	1.0	1.0	1.0
20	.50	.25	.25	1.0	.50	.50	1.0	1.0	1.0
25	NA	NA	NA	1.0	.50	.50	1.0	1.0	1.0
32	NA	NA	NA	NA	NA	NA	1.0	1.0	1.0
NA = Not Available Product									

شركة مصنع أنظمة الأنابيب السعودي المحدودة

SAUDI PIPES SYSTEMS CO. LTD.

Only products bearing NSF logo are certified

Only products bearing UL logo are certified

Only products bearing WRAS logo are certified

Head Office: Jeddah - Industrial Zone Phase (4) Building 4534 - Zip 22426 - Additional 7634 - Unit 1 - Saudi Arabia
Tel.: +966 -12 -637 0999 / 608 1100, Fax: +966 -12 -636 5925 / 637 9439
Email: sps@pipes.sa - Website: www.pipes.sa