PRODUCT BROCHURE

ViaCon Pecor Quattro

VIACON

ViaCon Pecor Quattro* system

The ViaCon Pecor Quattro system is widely used in the construction of transport infrastructure and can be used for the following purposes:

- Construction of gravity sewer systems
- Construction of culverts under roads and railways
- Construction of animal crossings and culverts under forest roads
- Construction of drainage systems
- Construction of industrial ventilation systems
- Construction of agricultural ventilation systems

PARAMETERS

Pecor Quattro pipes are made of polypropylene (PP) and consist of two walls. The outer wall of the pipe is corrugated, ensuring a high ring stiffness of SN8 (8 kPa), while the inner wall is smooth, providing optimum drainage conditions. Pecor Quattro pipes have DN/ID (nominal/internal) diameters from 200 to 1,000 mm. A socket formed from the same pipe during production ensures fast installation. In addition, an elastomeric gasket placed on the spigot of the pipe ensures the required connection tightness.

The Pecor Quattro system is manufactured in accordance with EN 13476-1 [1] and EN 13476-3 [2].

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COMPONENTS OF THE SYSTEM

- Pecor Quattro SN8 pipes, which have DN/ID (nominal/internal) diameters from 200 mm to 1000 mm
- Pipe connections (elbows, T-pipes)
- Fittings (reducers, sockets, end caps)
- Pecor Quattro wells
- Pecor Quattro pipes are available in black and grey as standard (the outer corrugated wall is black, while the inner wall is light grey). Other colours can be made to order, for example the outer wall of the pipe can be orange and the inner wall can be light grey.

Pecor Quattro pipes with a ring stiffness of SN8 can be used in all load classes.

ADVANTAGES OF THE SYSTEM

- No heavy equipment required for installation
- Variety of solutions
- Quick and easy installation (low weight)
- Reduced transport costs
- Excellent mechanical and hydraulic properties
- Corrosion resistance

MATERIAL

Pecor Quattro pipes are made of polypropylene (PP). This material has special mechanical properties that ensure a high degree of ring stiffness. The raw material has a density of 900–905 kg/m3 and a modulus of elasticity of minimum 1250 MPa.

In addition, polypropylene is highly resistant to heat (operating temperature up to 93°C, short-term temperature up to 110°C), has low surface roughness, and is particularly resistant to abrasion.

Since polypropylene block copolymer is the only material used to manufacture Pecor Quattro pipes, the pipe walls become brittle at temperatures only below -10°C.

Pecor Quattro pipes and fittings are made using polypropylene with a dye/pigment:

Standard colours

- Outer wall - black
- Inner wall - light grey

Non-standard colours

- Outer wall - orange
- Inner wall - orange

HIGH RESISTANCE TO MOST CHEMICALS

Polypropylene (PP) is characterised by high resistance to most chemicals. Table 1 gives an overview of the resistance of polypropylene to various chemicals. The resistance classes used in the table are:

- S - sufficient resistance
- L - limited resistance
- I - insufficient resistance

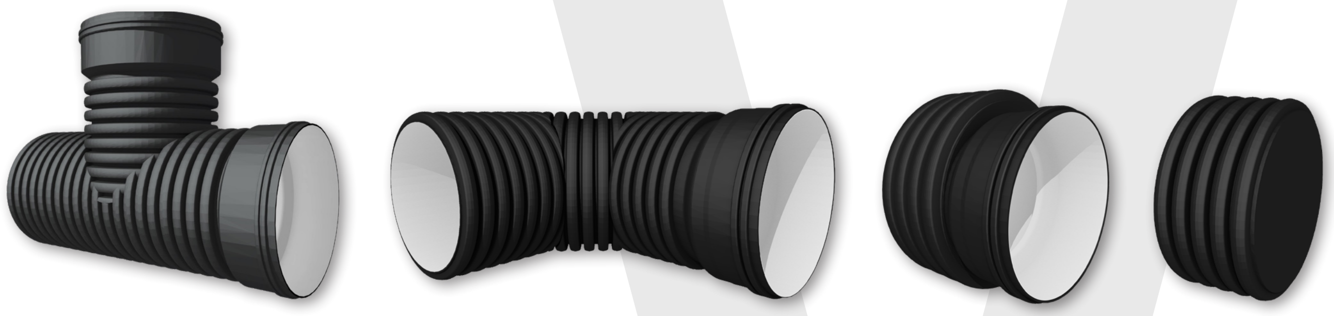


Table 1. Overview of the chemical resistance of polypropylene (PP)*

Material	Concentration	Temperature		
		20°C	60°C	100°C
Acetone	100%	S	L	-
Acetaldehyde	40% 100%	I	-	-
Ethyl alcohol	96%	S	S	S
Isopropyl alcohol	100%	S	S	-
Methyl alcohol	100%	S	S	-
Aqueous ammonia solution	Diluted	S	S	-
Aniline	100%	S	L	-
Nitrates	Saturated solution	S	S	-
Benzene	100%	L	I	-
Gasoline (aliphatic hydrocarbons)	80/20	L	I	-
Acetic anhydride	100%	S	-	-
Chlorine	Chlorine	S	I	-
Chlorates	Saturated solution	S	S	-
Cyclohexanol	10%	S	S	-
Detergents	2%	S	S	S
Phenol	90%	S	S	-
Formaldehyde	40 %	S	S	-
Xylene	100%	L	I	-
Nitric acid	50% to 98%	L	I	-
Hydrochloric acid	> 30%	S	S	-
Lactic acid	10% to 90%	S	S	-
Formic acid	1% to 50%	S	S	-
Acetic acid	25%	S	S	S
Acetic acid	Cold	S	L	-
Sulphuric acid	96%	S	S	-
Potassium hydroxide	Unsaturated solution	S	-	-
Hydrogen sulphide, gaseous	100%	S	S	-
Sodium hydroxide	Saturated solution	S	S	-
Toluene	100%	L	I	-
Hydrogen peroxide	30%	S	L	-

Resistance classes: S - sufficient resistance L - limited resistance I - insufficient resistance

**Note: for a complete list of chemical resistance, please contact ViaCon's technical division.*

GASKETS

Elastomeric gaskets are used to ensure the required tightness of the joint between the socket and the spigot of the pipe. The gasket can have a chemical resistance from pH 2 to pH 12. A list of chemicals to which Gasketgaskets are resistant is given in ISO 7620.

Gaskets are manufactured to meet the requirements of the following standards: EN 681-1 [3] and EN 681-2 [4].

TECHNICAL CHARACTERISTICS OF THE PIPES

Pecor Quattro are double-layer pipes with a smooth inner wall and a corrugated outer wall (Figure 1). The corrugated pipe wall not only provides greater strength, but also homogenises the behaviour of the pipe to the surrounding soil. The size of the corrugation depends on the pipe diameter. The corrugation diagram for Pecor Quattro pipes is given in Figure 2 and the dimensions are given in Table 2.

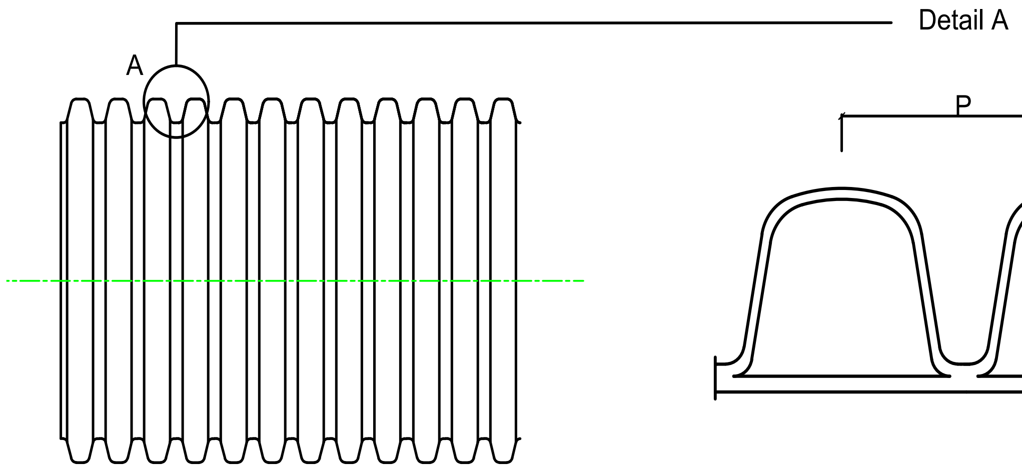


Figure 1

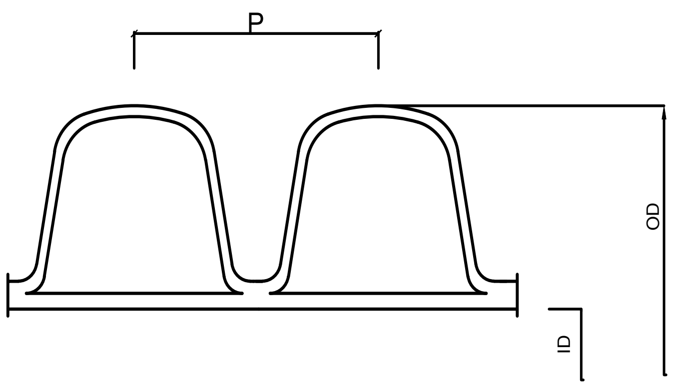


Figure 2

Table 2. Geometric parameters of Pecor Quattro pipes

DN/ID	ID [mm]	OD [mm]	Cross-sectional area [m²]	Corrugation length P [mm]
200	198	226	0.03	27.0
300	298	339	0.07	37.4
400	398	451	0.12	44.0
500	499	570	0.19	55.7
600	595	677	0.27	66.0
800	793	903	0.49	90.0
1000	988	1130	0.77	105.6

MECHANICAL AND PHYSICAL PROPERTIES. REQUIREMENTS

The mechanical and physical properties of Pecor Quattro pipes are given in EN 13476-3 [2].

Table 3 gives the requirements for the mechanical and physical properties of the pipes and fittings.

Table 3. Mechanical and physical properties of Pecor Quattro pipes

No.	Characteristics	Units of measurement	Requirements	Test method acc. to
1	Changes on heating: - test temp. (150 ± 2°C) - test time e ≤ 8 mm - 30 min, e > 8 mm - 60 min	-	No delamination, cracking, blistering is permitted	LST EN ISO 9969 [5]
2	Ring stiffness determined for pipe specimens, 300 mm in length; pipe stiffness class SN8	kNm²	≥ 8	LST EN ISO 13968
3	Pipe ring elasticity: - test temp. (23 ± 2°C) - deflection 30 % of diameter - the test force must be increased steadily without reduction	-	No cracks, marks or signs of delamination on the pipe walls permitted	LST EN 3127
4	Impact resistance (TIR) determined by the falling weight method at (0 ± 1°C) , specimen length 200 mm, weight end type (d) 90 and weight mass as specified below: 160 < dim, max ≤ 200 - 1.6 kg 200 < dim, max ≤ 250 - 2.0 kg 250 < dim, max ≤315 - 2.5 kg 315 < dim, max - 3.2 kg Weight fall height for dim, min > 110 - 2000 mm	%	TIR ≤ 10	LST EN 11173
5	Impact resistance (H50) determined by the stair method at (-10 ± 1°C), weight end type (d) 90 and weight mass as follows: 160 < dim, max ≤ 200 - 8.0 kg 200 < dim, max ≤ 225 - 10.0 kg 225 < dim, max - 12.5 kg	mm	H50 ≥ 1,000	LST EN 13259
6	Tightness of joints with elastomeric gasket, test temp. (23 ± 2°C), test parameters: 10% deflection of the spigot 5% deflection of the coupling end 1. Low internal hydrostatic pressure 0.05 bar 2. High internal hydrostatic pressure 0.5 bar 3. Air pressure 0.3 bar	-	No damage or leakage during or after the test ≤ -0.27 bar	LST EN 13259 Condition B

Table 3. Mechanical and physical properties of Pecor Quattro pipes

No.	Characteristics	Units of measurement	Requirements	Test method acc. to
7	Tightness of joints with elastomeric gasket, test temp. (23 ± 2°C), test parameters: Angular deflection: - DN ≤ 315 mm - 2° - 315 < DN ≤ 630 - 1.5° - 630 < DN - 1° 1. Low internal hydrostatic pressure 0.05 bar 2. High internal hydrostatic pressure 3. Air pressure 0.3 bar	-	No damage or leakage during or after the test ≤ -0.27 bar	LST EN 13259 Condition C
8	Tightness of joints with elastomeric gasket, test temp. (23 ± 2°C), test parameters: Condition B + Condition C	-	No damage or leakage during or after the test ≤ -0.27 bar	LST EN 13259 Condition D
9	Dimensional accuracy	mm	DN/ID 200/198; 300/297; 400/397; 500/497; 600/597; 800/793; 1000/988	LST EN ISO 3126

RING STIFFNESS OF THE PIPES

The ring stiffness is a parameter describing the strength of Pecor Quattro pipes. The stiffness class of Pecor Quattro pipes is SN8. The ring stiffness is a parameter that the manufacturer must declare with each batch of pipes produced. The declared nominal ring stiffness of Pecor Quattro pipes is the minimum guaranteed value applicable to the specified batch.

Ring stiffness tests are carried out in the company's laboratory to determine the force required to deform the inner diameter of the pipe by 3%. The ring stiffness is determined in accordance with LST EN ISO 9969 [5].

MARKING OF THE PIPES

Pecor Quattro pipes are marked in accordance with the recommendations given in LST EN 13476-3 [2].

Example of marking of Pecor Quattro pipes:

ViaCon Baltic PECOR QUATTRO DN/ID 800

EN 13476-3 SN8 PP UD ❄ RF30

Description:

- ViaCon Baltic – manufacturer;
- PECOR QUATTRO – system name
- DN/ID 800 – DN nominal diameter, ID – internal diameter (mm)
- EN 13476-3 – applicable standard
- SN8 – ring stiffness
- PP – material
- UD – used outside (U) and inside (D) of the building
- ❄ – cold resistance
- RF30 – ring flexibility
- – Certification mark for construction products

Figure 3-. Example of Pecor Quattro marking

Range of products

Pecor Quattro pipes with socket

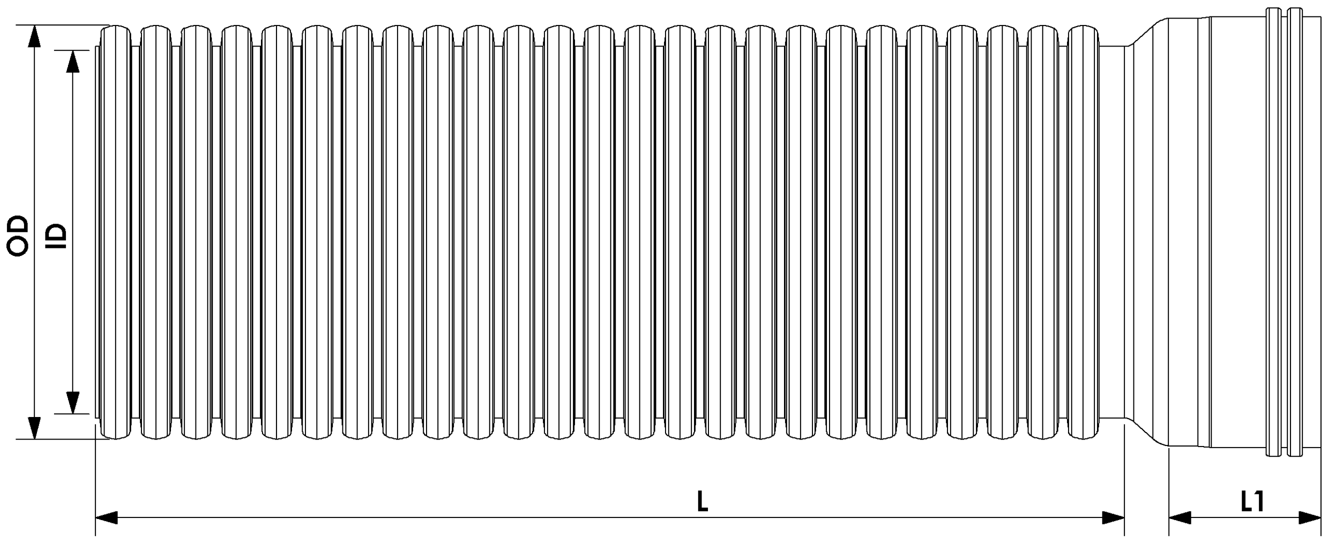


Figure 4

Table 4. Dimensions of Pecor Quattro pipes with socket

DN/ID	ID [mm]	OD [mm]	L1 [mm]	L [mm]	
200	198	226	124	-	6000
300	298	339	155	-	6000
400	398	451	183	-	6000
500	499	570	198	-	6000
600	595	677	250	4500	6000
800	793	903	295	4500	6000
1000	988	1130	345	4500	6000

Pecor Quattro pipes without socket

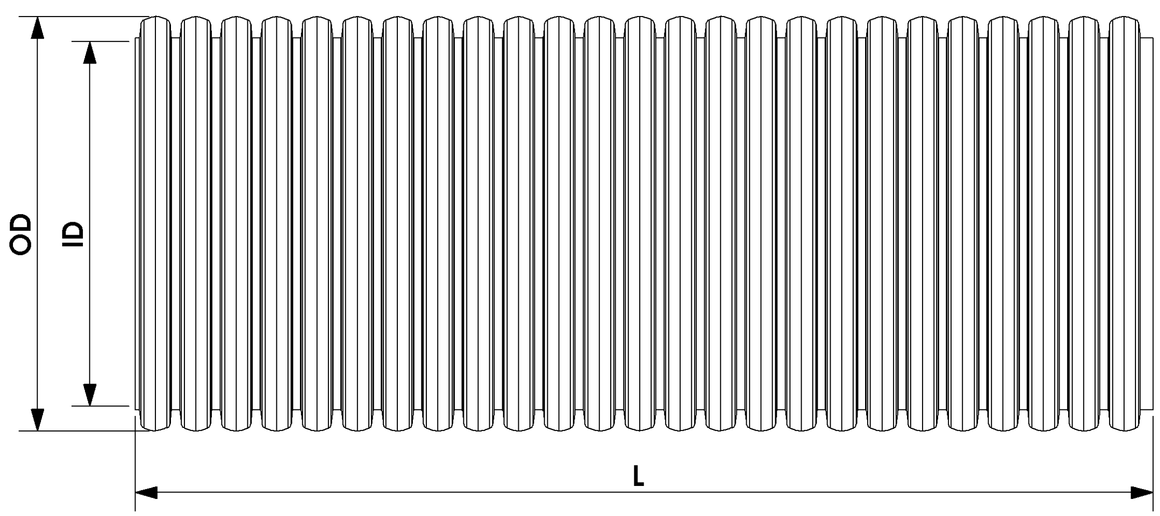


Figure 5

Table 5. Dimensions of Pecor Quattro pipes without socket

DN/ID	ID [mm]	OD [mm]	L * [mm]			
200	198	226	6,000	7,000	8,000	9000
300	298	339	6,000	7,000	8,000	9000
400	398	451	6,000	7,000	8,000	9000
500	499	570	6,000	7,000	8,000	9000
600	595	677	6,000	7,000	8,000	9000
800	793	903	6,000	7,000	8,000	9000
1000	988	1130	6,000	7,000	8,000	9000

** Other pipe lengths can be made to order*

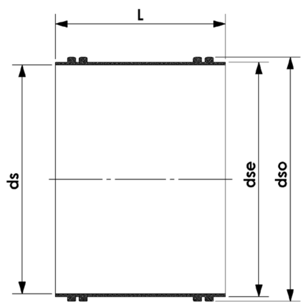
Fittings – welded

SLEEVE CONNECTOR WITHOUT AN INTERNAL LIMITER

Pecor Quattro sleeve connector is designed to connect pipes that have been cut on site, when there is no option to move the pipes longitudinally along their axis.

Table 6. Dimensions of Pecor Quattro repair double socket

DN/ID	ds [mm]	L [mm]	dse [mm]	dso [mm]
200	228	245	235	255
300	343	310	353	376
400	460	365	471	499
500	572	404	585	615
600	687	510	704	733
800	918	520	938	964
1000	1146	540	1168	1198



ELBOWS FOR CONNECTING PIPES

Table 7. Dimensions of elbows for Pecor Quattro pipes, α = 15°

DN/ID	Z1 [mm]	L1 [mm]	L2 [mm]	Ls [mm]
200	228	245	235	255
300	343	310	353	376
400	460	365	471	499
500	572	404	585	615
600	687	510	704	733
800	918	520	938	964
1000	1146	540	1168	1198

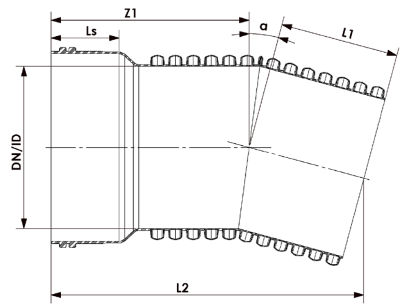


Table 8. Dimensions of elbows for Pecor Quattro pipes, α = 30°

DN/ID	Z1 [mm]	L1 [mm]	L2 [mm]	Ls [mm]
200	317	189	481	124
300	388	265	617	155
400	509	318	785	183
500	606	402	954	198
600	768	477	1182	250
800	828	828	1545	295
1000	1067	873	1822	345

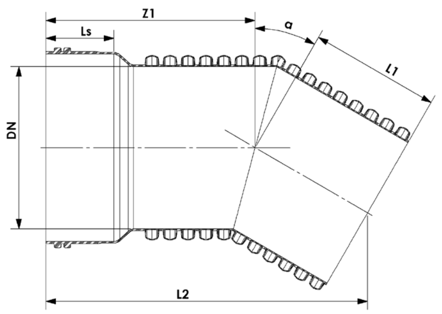


Table 9. Dimensions of elbows for Pecor Quattro pipes, α = 45°

DN/ID	Z1 [mm]	L1 [mm]	L2 [mm]	Ls [mm]
200	304	204	448	124
300	410	287	613	155
400	539	348	785	183
500	643	439	954	198
600	813	522	1181	250
800	887	887	1514	295
1000	1139	946	1808	345

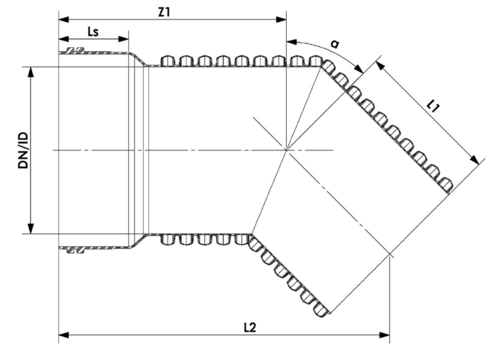


Table 10. Dimensions of elbows for Pecor Quattro pipes, α = 60°

DN/ID	Z1 [mm]	L1 [mm]	L2 [mm]	Ls [mm]
200	320	220	431	124
300	435	312	591	155
400	572	381	762	183
500	685	481	925	198
600	862	571	1148	250
800	952	862	1384	295
1000	1221	1027	1735	345

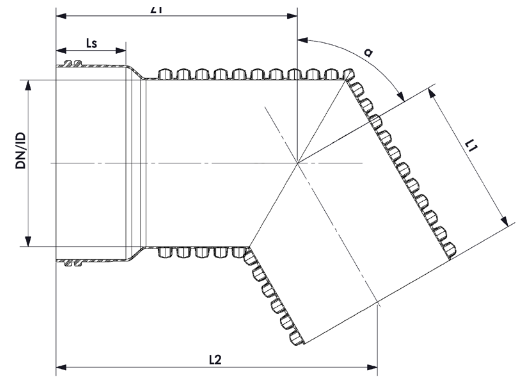


Table 11. Dimensions of elbows for Pecor Quattro pipes, α = 90°

DN/ID	Z1 [mm]	L1 [mm]	L2 [mm]	Ls [mm]
200	389	321	448	124
300	494	456	579	155
400	645	560	751	183
500	777	706	911	198
600	976	913	1141	250
800	1101	1224	1314	295
1000	1398	1462	1656	345

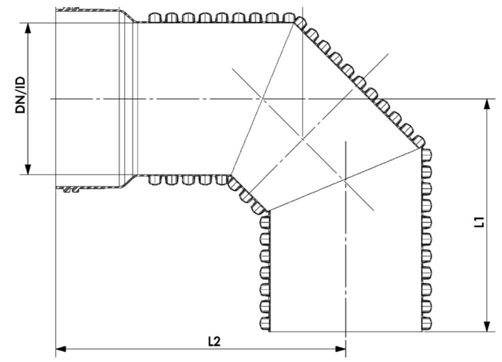
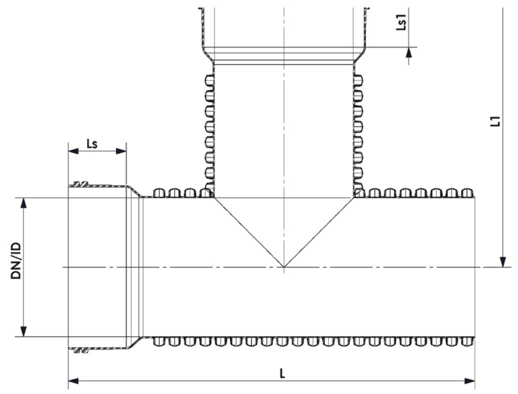


Table 12. Dimensions of T-pipes for Pecor Quattro pipes, α = 90°

DN/ID	DN1/ID	L [mm]	L1 [mm]	Ls [mm]	Ls1 [mm]
200	200	748	431	124	124
300	200 300	983 983	468 612	155 155	124 155
400	300 400	1159 1159	649 746	183 183	155 183
500	400 500	1767 1767	770 857	198 198	183 198
600	500 600	1743 1743	877 1193	250 250	200 250
800	600 800	2160 2160	1050 1126	295 295	250 295
1000	800 1000	2727 2727	1290 1408	345 345	295 345



ECCENTRIC TRANSITIONS FOR REDUCING THE DIAMETER OF PIPES

Table 13. Dimensions of Pecor Quattro eccentric reducers with one socket

DN/ID	DN2/ID	L [mm]	Z1 [mm]	Z2 [mm]
300	200	278	150	124
400	200 300	304 337	176 176	124 155
500	300 400	384 412	223 223	155 183
600	400 500	453 468	264 264	183 198
800	600	703	360	250
1000	800	782	422	295

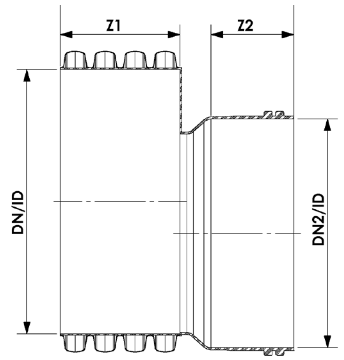
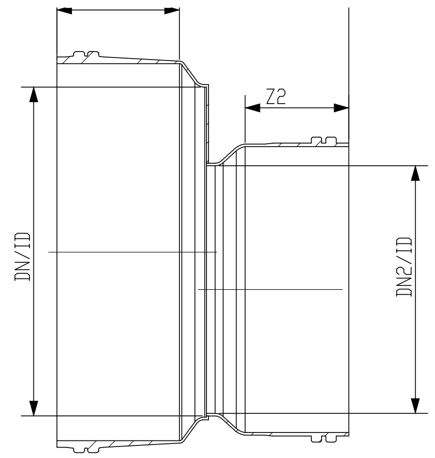


Table 14. Dimensions of Pecor Quattro eccentric reducers with two sockets

DN/ID	DN2/ID	L [mm]	Z1 [mm]	Z2 [mm]
300	200	289	155	124
400	200 300	317 351	183 183	124 155
500	300 400	366 394	198 198	155 183
600	400 500	532 547	250 250	183 198
800	600	703	295	250
1000	800	757	345	295



PLUGS (CCAPS)

Table 15. Inner plugs – dimensions

DN/ID	OD	L [mm]
200	226	167
300	339	190
400	451	225
500	570	228
600	677	335
800	903	365
1000	1130	427

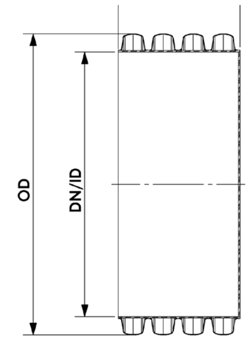
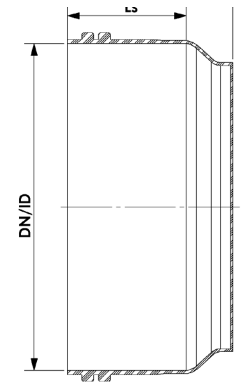


Table 16. Outer cap – dimensions

DN/ID	OD	L [mm]
200	133	124
300	166	155
400	194	183
500	209	198
600	348	250
800	365	295
1000	402	345



Installation

One of the methods of connecting Pecor Quattro pipes is to insert the spigot of one pipe with a gasket into the socket of another pipe. For proper installation, follow these steps:

- Check that the pipe, the socket and the gasket are not damaged.
- Remove all dirt from the spigot (last groove) and the inside of the socket.
- Mark the insertion depth (i.e. the depth to which the pipe will be inserted into the socket) on the spigot with a permanent marker (e.g. waterproof).
- Insert the elastomeric gasket into the last groove between the first and second ring.
- Lubricate the inside of the socket and the outside of the gasket with joint lubricant.
- Note: do not use lubricants that may damage the gasket, such as petroleum-based lubricants or oils.
- Insert the end of the pipe with the sealing ring into the opening of the other pipe with the socket, pushing it until it rests against the end of the coupling. Pipes are considered properly installed when the free end of the pipe rests against the constriction of the coupling end. For detailed steps for the installation of sealing gaskets, see the following sections.
- Important: the gasket must be placed on the first-second corrugation and/or can also be placed on second-third corrugation, so that it properly ensures the tightness of the joined socket.

Pecor Quattro structural pipes can be customised to any installation length. If the pipe has to be cut to length, the cut must be made in the groove between the rings. Do not cut the pipes at other points. After cutting the pipe, remove any debris.

Trenches for installing pipes

GENERAL

Pecor Quattro pipes are designed for installation in open trenches. Open trenches can be with or without supports, with slopes, including partial supports. The excavation technology for open trenches for the construction of drain pipes must comply with the following standards EN 1610 [6].

OPEN TRENCHES WITHOUT SUPPORTS

Open trenches without vertical wall supports may only be excavated in dry soil where there is no groundwater and in soil where there are no embankments at the edges of the trench and the width of the trench space is at least as wide as the trench depth.

Possible trench depths:

- 4.0 m in rocky soils
- 2.0 m in well compacted soils
- 1.0 m in other soils

Open trenches without supports and with slopes may only be excavated if there is no groundwaterin in the soil and there are no loads acting on the edge of the soil. Unless otherwise recommended by the design, open trenches with slopes may be excavated to a depth of up to 4 m and slopes may be of the following parameter:

- 2:1 – highly cohesive soil
- 1:1 – stony, rocky, fractured soil
- 1:1.25 – other highly cohesive soils and clay soils,
- 1:1.50 – loose soil.

In the case of open trenches, provide easy and quick drainage of rainwater from a strip three times as wide as the depth of the trench.

No transport infrastructure is permitted next to an open soil trench without a supporting edge. The distance "b" of the edge of the trench measured on the plan from the edge of the adjacent road is calculated according to the formula

$$b \geq \frac{H}{tg\varphi} + 0{,}5$$

where:

- **H** is the depth of the trench (measured from the ground surface to the bottom of the trench),
- **φ** is the angle of internal friction of the soil.

OPEN TRENCHES WITH SUPPORTS

Open trenches must be protected against rainwater flooding by raising the upper edge of the support at least 15 cm above ground level. If the trench is excavated below the groundwater level, the water level is to be lowered to 0.5 m below the bottom of the trench. The type of support and the lowering of the water table in open trenches must be specified in the design. Heavy equipment must not be placed above the pipeline during the removal of the supports. When removing the supports, ensure that the backfill requirements are met.

TRENCH DEPTH AND WIDTH

The depth and width of the trench is determined based on the detailed design. The depth of the trench must be sufficient to prevent freezing of the liquid flowing through the pipes.

It is recommended to ensure (in accordance with CEN/TR 1046:2014 [7]) that in areas subject to vehicular traffic, the backfill height is at least 0.6 m. In addition, in areas with high groundwater levels, it is recommended to ensure that the backfill soil provides sufficient protection against pipe uplift.

In accordance with EN 1610 [6], the minimum trench width depends on the outer diameter of the pipe (Table 17) and the depth of the pipe (Table 18), and it is recommended to go beyond these parameters. For installation purposes, the trench width may be larger than the width values given in Table 17 and Table 18. The width of the trench must be provided by the designer.

Table 17. Minimum trench width according to pipe diameter (EN 1610 [6])

Nominal diameter DN [mm]	Minimum trench width, W_{min*} = OD* + x [m]		
	Open trenches with supports	Open trenches without supports	
		β* > 60°	β* ≤ 60°
DN ≤ 225	OD + 0.40	OD + 0.40	OD + 0.40
225 > DN ≤ 350	OD + 0.50	OD + 0.50	OD + 0.40
350 > DN ≤ 700	OD + 0.70	OD + 0.70	OD + 0.40
700 > DN ≤ 1200	OD + 0.85	OD + 0.85	OD + 0.40
DN > 1,200	OD + 1.00	OD + 1.00	OD + 0.40

* *W_{min} – minimum trench width*
OD – outer diameter of the pipe, [m]
β – angle of the trench wall, [°]

Table 18. Minimum trench width according to depth (EN 1610 [6])

Trench depth [m]	Minimum trench width [m]
Trench depth ≤ 1.00	No requirements
1.00≤ Trench depth ≤ 1.75	0.80
1.75 < Trench depth ≤ 4.00	0.90
Trench depth > 4.00	1.00

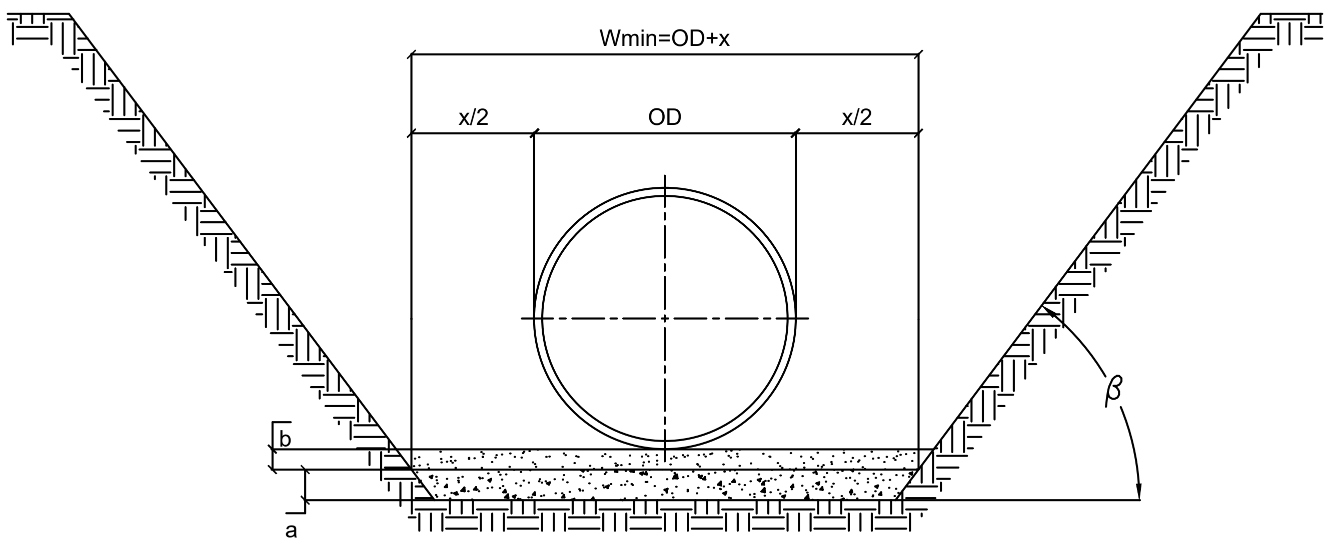


Figure 5

Foundation soil, bedding, and backfill

GENERAL

In order to ensure that the flexible pipes react adequately to soil actions, a number of requirements have to be fulfilled with regard to the preparation of the foundation and the bedding, and the backfilling of the trench. The service life of the pipe system depends on the quality of this work.

The minimum load-bearing capacity of the soil on which the pipes are to be laid must be determined by the designer. Flexible pipes, which cannot bear the same loads as concrete pipes, can be laid on soils with a lower load-bearing capacity. If the foundation fails to meet the bearing capacity requirements, the design must provide for measures to reinforce the soil (e.g. replacing the soil with a different type, using geosynthetic materials, etc.).

In cases where the groundwater level often rises above the level of the pipeline foundation (several times a year), the design must include separate measures to reinforce the backfilled soil and prevent the leaching of finer particles (preventing particle migration).

BEDDING AND BACKFILL MATERIALS

The particle size of the material (gravel, sand and gravel mixture) used for the pipe bedding and backfill depends on the diameter of the pipe corrugation rings.

Inside the bedding or backfill layer closest to the Pecor Quattro pipe walls (approx. 0.3–0.5 m from the wall) and where the material is in contact with the pipe walls, the recommended maximum individual particle size is 31.5 mm.

Larger particle sizes may be used in other locations provided the following conditions are met:

- Uniformity coefficient $C_u \geq 4$
- Curvature coefficient $1 \leq C_c \leq 3$
- Permeability $k_{10} > 6$ m/day

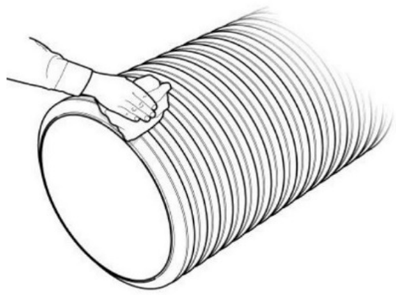
PRINCIPLES OF BEDDING LAYING

- The width of the bedding under the pipe must be greater than the diameter of the pipe to allow for adequate compaction of the soil; the minimum trench width is given in Tables 17 and 18.
- The thickness of the lower bedding layer must be at least 15 cm (recommended 20 cm) and the thickness of the upper bedding layer must be at least 10 cm (Fig. 7).
- To ensure proper installation of the pipe, the top layer of the bedding must be loosely packed to allow the corrugated pipe rings to press freely into it.
- The degree of compaction of the bedding must not be less than Is = 0.98 according to the Proctor test.

Installation of pipes and gaskets

STEP 1

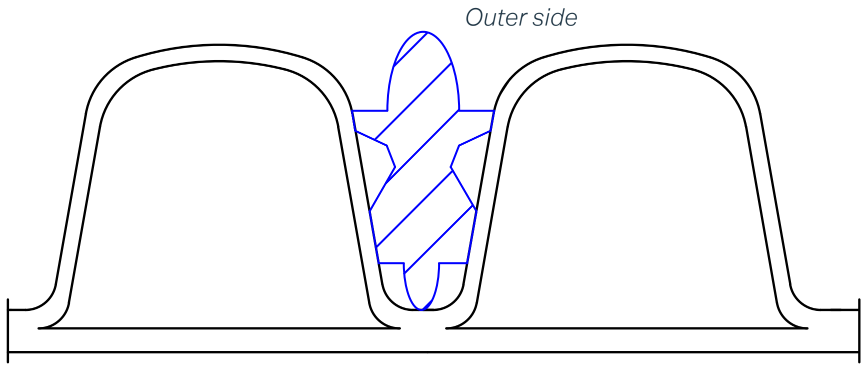
The end of the pipe must be clean, smooth, and free from defects and dirt.



STEP 2

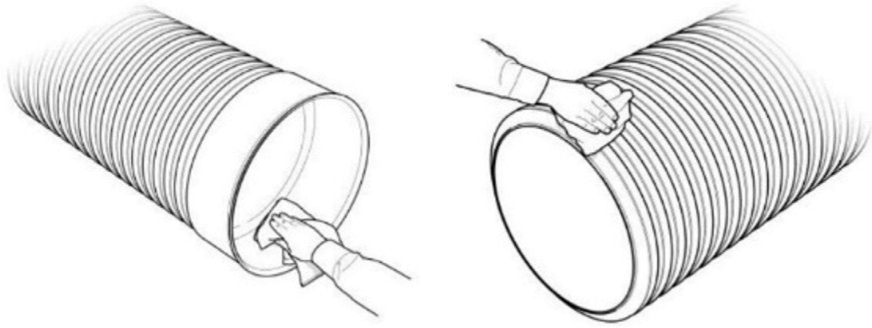
Before placing the gasket on the pipe, it is important to make sure that the marking is on the outside. The marking of the gasket indicates the outside of the gasket.

The gasket must be lubricated with a special grease to fit around the pipe and placed between the first two corrugations of the pipe.

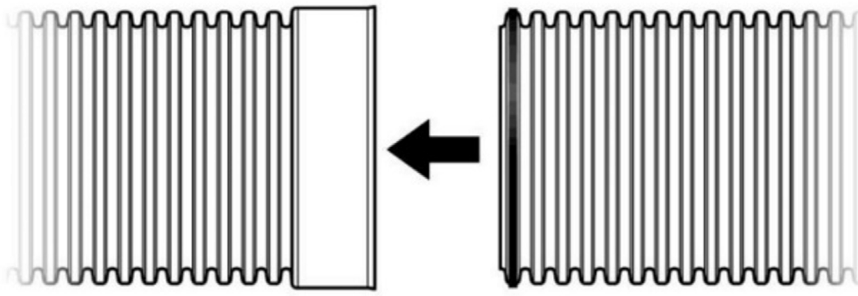


STEP 3

- Before joining the pipes:
- Check that the end of the pipe is clean.
- Check that the inside of the socket is clean.



- Apply a paste/grease specially designed for joining gaskets to the inside of the socket.
- Apply a paste/grease specially designed for joining gaskets to the outside of the gasket.
- Make sure that the axial differenc between the two pipes to be joined is not more than 15° in all directions



Principles of backfilling

- The backfill must be placed in layers evenly on both sides of the pipe; the thickness of the loosely packed layer must not exceed 30 cm (Fig. 6).
- The backfill layers around or over the pipe must be compacted using lightweight compaction equipment (vibratory plates or vibratory rams). Heavier compaction equipment may only be used when the thickness of the backfill above the pipe is at least 30 cm (when the "primary" layer of the backfill is formed). In addition, it is essential that the "support" layer is properly compacted in the corner area between the pipe and the bedding.
- Before starting to compact the backfill, care must be taken to ensure that the pipe stays in place.
- The degree of compaction of the backfill material must be at least 0.98 in accordance with the requirements of EN 1997-1 (EUROCODE 7) and at least 0.95 in the vicinity of the pipe.
- Where no minimum backfill height has been established, the use of heavy machinery above the pipeline is prohibited during construction work. If machinery has to pass over the pipeline during construction, the minimum height of the backfill must be specified in the design, considering the load of the vehicles passing over it. Any deviations from the above principles must be agreed with the designer and the technical division of ViaCon Baltic, UAB.

Once the primary backfill layer has been formed, form the main backfill layer. Table 19 gives recommendations for soil compaction in accordance with LST CEN/TR 1046:2014 [7] for good and medium density classes, depending on the soil and the type of compaction equipment used.

Table 20 gives the Standard Proctor Density (SPD) values for the 3 density classes.

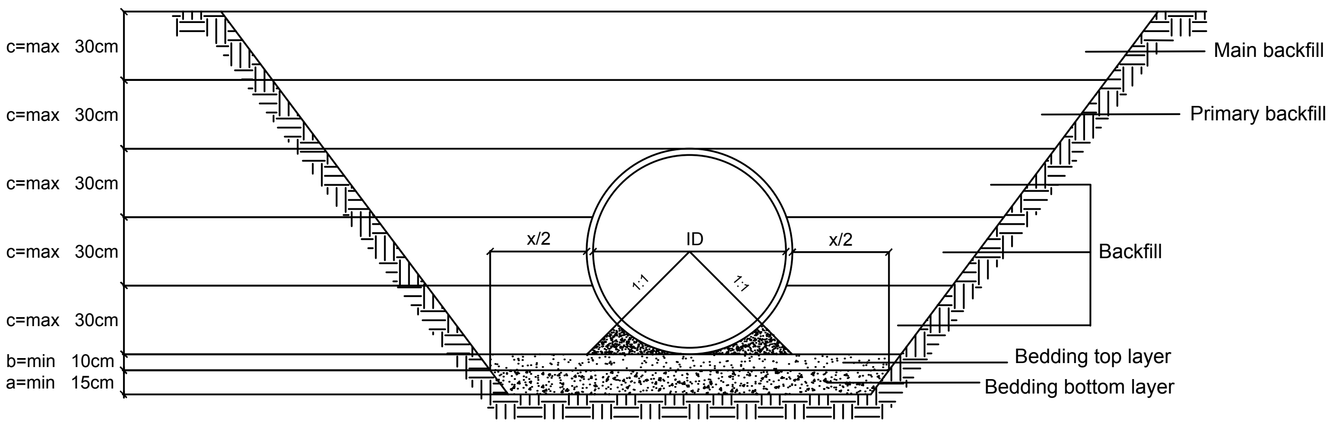


Fig. 6. Laying the bedding and compacting the backfill when installing Pecor Quattro pipes.

Table 19. Recommended layer thickness and number of cycles (LST CEN/TR 1046:2014) [7]

Equipment	Number of cycles / compaction class		Maximum layer thickness / soil group after compaction [m]				Minimum thickness over the top of the pipes before compaction [m]
	Good	Medium	Group 1	Group 2	Group 3	Group 4	
Foot or hand compactor min. 15 kg	3	1	0.15	0.10	0.10	0.10	0.20
Vibratory compactor min. 70 kg	3	1	0.30	0.25	0.20	0.15	0.50
Vibratory plate							
min. 50 kg	4	1	0.10	-	-	-	0.15
min. 100 kg	4	1	0.15	0.10	-	-	0.15
min. 200 kg	4	1	0.20	0.15	0.10	-	0.20
min. 400 kg	4	1	0.30	0.20	0.15	0.10	0.30
min. 600 kg	4	1	0.40	0.30	0.20	0.15	0.50
Vibratory ram							
min. 15 kN/m	6	2	0.35	0.25	0.20	0.20	0.60
min. 30 kN/m	6	2	0.60	0.50	0.30	0.30	1.20
min. 45 kN/m	6	2	1.00	0.75	0.40	0.40	1.80
min. 65 kN/m	6	2	1.50	1.10	0.60	0.60	2.40
Rollers with double drums							
min. 5 kN/m	6	2	0.15	0.10	-	-	0.20
min. 10 kN/m	6	2	0.25	0.20	0.15	-	0.45
min. 20 kN/m	6	2	0.35	0.30	0.20	-	0.60
min. 30 kN/m	6	2	0.50	0.40	0.30	-	0.85
Heavy roller with 3 drums (without vibration) min. 50 kN/m	6	2	0.25	0.20	0.20	-	1.00

Table 20. Standard Proctor Density (SPD) values for different compaction classes (LST CEN/TR 1046:2014) [7])

Compaction class	Compaction description	Backfill material group			
		Group 4 (%)	Group 3 (%)	Group 2 (%)	Group 1 (%)
N	Non-compacted	75 to 80	79 to 85	84 to 89	90 to 94
M	Medium compaction	81 to 89	86 to 92	90 to 95	95 to 97
W	Good compaction	90 to 95	93 to 96	96 to 100	98 to 100

Design

General

Flexible structures made of plastic pipes interact with the surrounding backfill layer (i.e. the surrounding soil) due to the applied loads. Such pipes, like any other engineering structures, are subject to continuous and variable loads.

Flexible structures made of plastic pipes can be installed in any soil, provided that the soil meets the load-bearing requirements (based on appropriate geological and engineering studies).

The load-bearing capacity of a soil is considered sufficient if it provides stability for the road structure or the filling above.

If the load-bearing capacity of the soil is insufficient, the soil must be reinforced by:

- Using geosynthetic materials
- Increasing the thickness of the foundation material layer
- Replacing the soil, if necessary
- Other effective measures capable of providing sufficient load-bearing capacity.

Plastic pipes may not be laid directly on top of solid foundations, including rocky soils. In this case, a layer of soil (sand, gravel or similar material) of at least 20 cm must be placed to allow for compaction. Pipes may only be laid on this layer.

In the case of a multiple culvert design, i.e. where the pipes to be backfilled are laid side by side, care must be taken to ensure that the distance between the pipes is sufficient to achieve the appropriate degree of compaction.

Fig. 8 shows the minimum distance between pipes:

- when D ≤ 0.6 m – then C ≥ 0.3 m
- when 0.6 < D ≤ 1.8 m – then C ≥ D/2

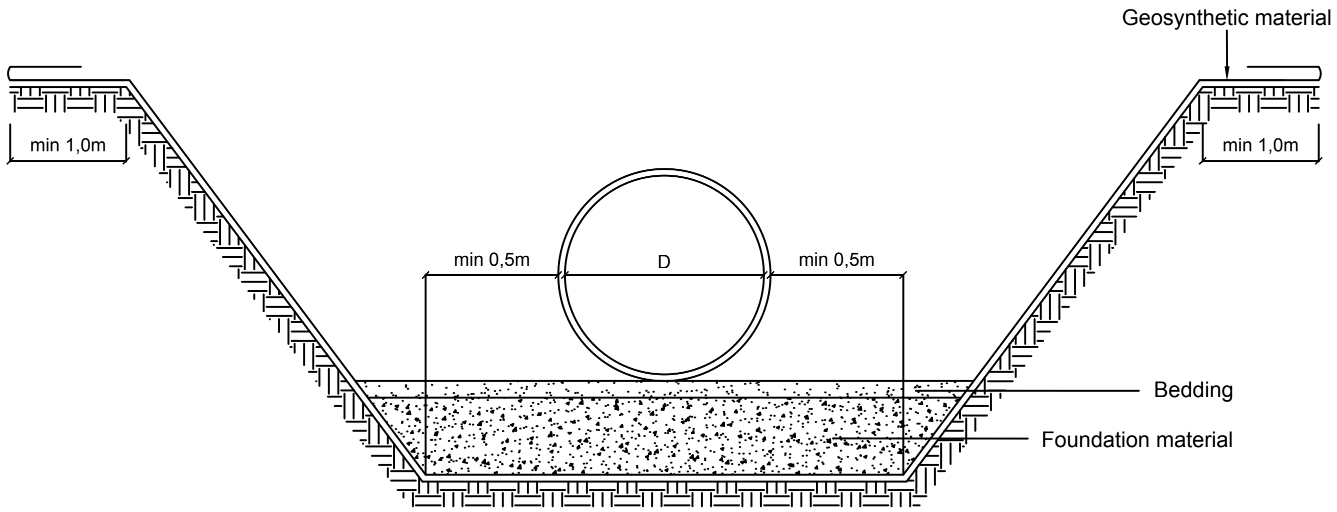


Fig. 7. Pipe laying on low load-bearing capacity soils.

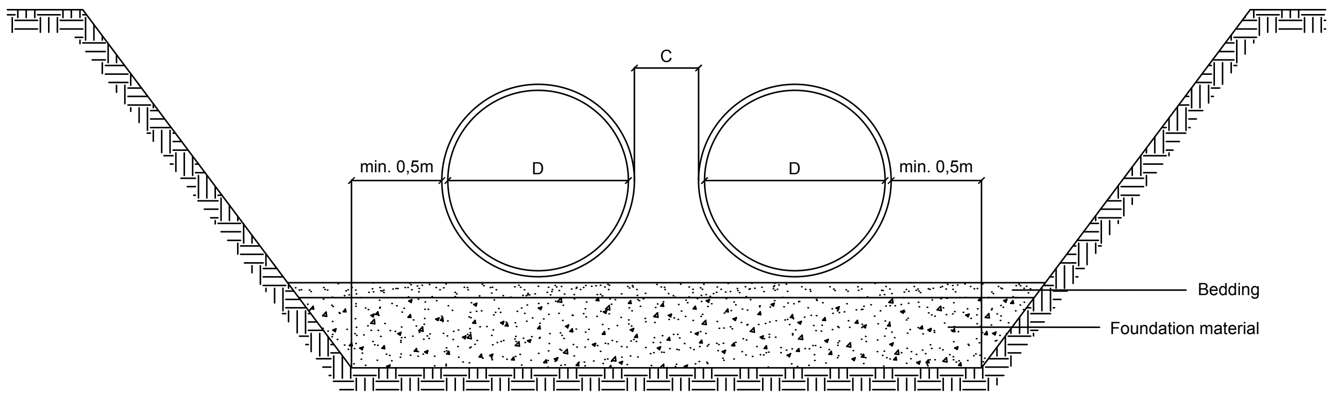


Fig. 8. Distance between pipes in the same trench.

Using the flow rate to determine the culvert diameter

For the design of civil engineering structures using plastic pipes as culverts, it is necessary to comply with the applicable guidelines and local regulations.

The recommended minimum internal diameter of the pipe depends on the requirements for the internal maintenance of the culvert and on the risk of ice blockage of the culvert. The culverts may be completely filled (in the case of pressurised flow) or may allow water to flow freely through them. If the system is pressurised, appropriate anti-flooding measures must be provided at the inlet and outlet of the pipe system.

The design water flow must be calculated to determine the diameter of the culvert. The Manning formula is recommended for this purpose:

$$Q = \frac{A \cdot R_h^{\frac{2}{3}} \cdot I^{\frac{1}{2}}}{n}$$

where:

- **n** is the roughness coefficient, [-]
- **A** is the cross-sectional area of the culvert, [m^2]
- **R**$_h$ is the hydraulic cross-sectional radius, [m]
- **I** is the slope of the water surface, [-]

The coefficient of roughness "n" declared by the plastic pipe manufacturer may be used. It is usually between 0.007 and 0.014.

Minimum backfill height

If the backfill has been placed in accordance with the above requirements for culverts subject to high loads, the amount of backfill depends on the diameter of the pipe. For pipes with a diameter between 600 and 1000 mm, the height of the backfill must be at least 0.50 m; for pipes with a diameter greater than 1000 mm, the height of the backfill may not be less than 0.5 of the pipe diameter. For other diameters, the minimum backfill height must be 0.30. However, for wastewater collection systems, the minimum backfill height of 0.60 m is recommended.

If the layers are thicker than the recommended minimum backfill height, the thickness of the backfill layer under the pipe may be reduced by 0.1 m (to be supported by structural calculations).

For all types of plastic pipes, the backfill height may be reduced if reinforced concrete slabs are used to spread the loads or if geogrid is used to reinforce the backfill layer (minimum strength in both directions: 20 kN/m). The reduction of internal forces must be specified in each individual case.

External loads

Flexible structures made of plastic pipes with a ring stiffness of less than 8 kN/m^2 (in accordance with LST EN ISO 9969 [5]) may be used under all types of roads. However, please note that any variable loads must not exceed the maximum level specified in the design.

Rigid pipes laid in the ground and made of traditional materials such as concrete, reinforced concrete, or stone ceramics have practically no deflection under load. As their cross-section is not deformable, the highest loads are applied to the upper and lower parts of the pipe, especially when the soil on the sides of the trench is poorly compacted. This load distribution has the very serious disadvantage that the bending moments in the cross-sections subjected to the highest loads are very high and the maximum load concentration occurs immediately after backfilling the trench and removing the supports.

Plastic pipes installed in trenches react differently to the load. Due to their flexibility, they react to the surrounding soil, distributing the loads. Thus, when designing this type of pipe, consider its behaviour in contact with the surrounding soil. The loads acting on plastic pipes are distributed evenly. The distribution of internal forces is very advantageous in plastic pipes, since the values of the lateral bending moments are much lower than those of rigid pipes of a corresponding diameter.

However, the deflection process of the pipe is not free, since the soil surrounding the plastic pipe limits the amount of deformation of the cross-section (elongation of its horizontal diameter). The stiffer the soil on the sides of the pipe (the stiffness depends on the type of soil and the degree of compaction), the more limited the deflection. The passive pressure of the soil counteracts the pressure exerted on the soil by the sides of the pipe.

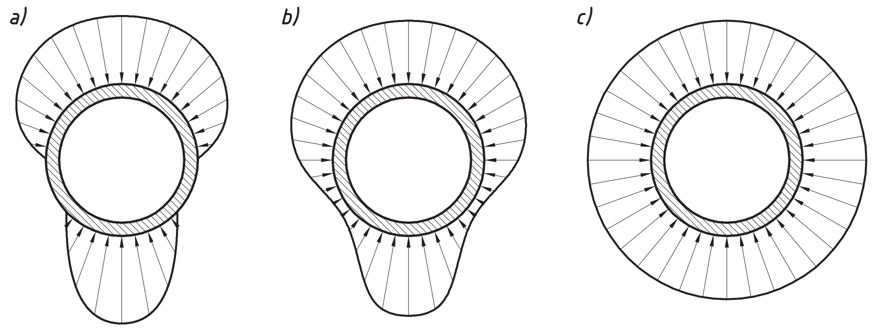


Figure 9. Load distribution in pipes: (a) rigid, (b) flexible, (c) perfectly flexible (under identical construction and loading conditions)

Transport and storage

Transport

For the transport of pipes, fittings and sockets, any means of transport suitable for the size concerned may be used. All pipes and fittings must be loaded so as not to move during transport. Care must be taken during loading to prevent damage to pipes, fittings, connectors, or any other components. Pipes must be moved and must not be dragged. In order to protect the rings, sockets, and other parts of the corrugated pipes, the pipes must not be pushed off the vehicle or lifted using chains or steel cables.

Storage

Pecor Quattro pipes must be stored on a level surface, in a horizontal position, on wooden poles of a thickness that prevents the socket from touching the ground. In order to protect the sockets from deflection, wooden inserts must be used between the layers of Pecor Quattro pipes. The sockets must not touch each other. The pipes must be secured so they do not move. The pipes, fittings, and other elements of the system may be stored outdoors without additional protective measures for 12 months from the date of manufacture.

If the pipes are to be stored for longer periods of time, appropriate protective measures must be taken against adverse environmental conditions such as UV rays.

If the pipes, fittings, and wells are covered with a light-proof tarpaulin, adequate ventilation must be ensured. All components must be protected against fire.

Sources and standards

[1] EN 13476-1 Plastic piping systems for non-pressure underground drainage and sewerage – Structured-wall piping systems of unplasticized poly(vinyl chloride) (PVC-U), polypropylene (PP) and polyethylene (PE) – Part 1: General requirements and performance characteristics.

[2] EN 13476-3 Plastics piping systems for non-pressure underground drainage and sewerage - Structured-wall piping systems of unplasticized poly(vinyl chloride) (PVC-U), polypropylene (PP) and polyethylene (PE) – Part 3: Specifications for pipes and fittings with smooth internal and profiled external surface and the system, Type B.

[3] EN 681-1 Elastomeric seals. Material requirements for pipe joint seals used in water and drainage applications. Part 1: Vulcanized rubber.

[4] EN 681-2 Elastomeric seals. Material requirements for pipe joint seals used in water and drainage applications. Part 2: Thermoplastic elastomers.

[5] EN ISO 9969 Thermoplastics pipes. Determination of ring stiffness.

[6] EN 1610 Construction and testing of drains and sewers.

[7] CEN/TR 1046:2014 Thermoplastics piping and ducting systems – Systems outside building structures for the conveyance of water or sewage – Practices for underground installation

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