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PVC KG®
PIPES FROM
THREE-LAYER PVC-U

PVC KG® PIPES FROM THREE-LAYER PVC-U
FOR INFRASTRUCTURAL SEWERAGE

PIPELIFE
always part of your life

CONTENTS

1 INTRODUCTION

1.1 Why using three-layer pipe system?

PVC KG pipe systems are distinguished with its specific structure made of internal and outer smooth layer and middle layer foam PVC. This structure allows with minimal expense of raw material, and low weight, to be achieved the necessary ring stiffness (SN≥2 kN/m^2, SN≥4 kN/m^2, SN≥8 kN/m^2 according to BSS ISO 9969).

SN – (nominal ring stiffness)

The unique characteristic of the structure is that it guarantees high ring elasticity and resistance to dynamic and static loads.

1.2 Why unplasticized polyvinyl chloride?

The unplasticized polyvinyl chloride (PVC-U) allows better hardness and stiffness of the product and reduces the risk of passing of harmful emissions of the material structure into the water, as it happens with the plasticized polyvinyl chloride for which part of the plastifiers can enter the water and thus pollute the environment. That is why the unplasticized polyvinyl chloride (PVC-U) is the natural choice for the manufacture of polyvinyl chloride infrastructure sewerage.

2 APPLICATION

PVC KG system is designed for gravity leading away of:

- Everyday,
- Industrial,
- Rain,
- Mixed and
- Drainage
- Waste waters

PVC KG finds application in:

- Wiring and
- Telecommunication

As protective pipe system
Finds application in the buildings, yard and ground sewerage systems.

3 ADVANTAGES

- Resistance to abrasion
- Chemical resistance (from pH=2 to pH=12)
- Resistance to high temperatures (40°C at constants flow and from 60°C at short-term flow)
- Shock resistance – according to the requirements of BSS EN 1411 and BSS EN 12061
- Guaranteed stiffness SN≥2 kN/m^2, SN≥4 kN/m^2, SN≥8 kN/m^2 - according to the requirements of BSS ISO 9969
- Easy transportation
- Fast and easy assembly
- Easy cutting and cutting out
- Matrix casted sealing rings of SBR (styrene butadiene).
- Guaranteed water-tightness of the system in the range of -0,3 bar to +0,5 bar according to the requirements of BSS EN 1277
- Low weight
- Long exploitation life
- Low coefficient of hydraulic roughness – theoretical 0,0011 mm, exploitation 0,015 mm (does not include local resistances)
- High hydraulic conductivity
- Full range of connecting elements (fittings, manholes and installations)
- Compatibility with corrugated PP pipes Pragma through unique system of passages and adaptors.
- Integrated part of the whole sewerage system of pipes, fittings and manholes and installations
- Pipes and fittings are with an integrated socket and elastomeric sealing ring
- All the PVC KG system elements are manufactured under constant manufacture control of the raw material and the ready product.

4 STANDARDS

4.1 Why are the standards necessary?

The standards are a set of rules and norms based on practical and theoretical observations and studies about the technical parameters which the products should meet. They define minimal requirements for the quality of the specific product. At the same time they guarantee compatibility of the products manufactured by different manufacturers.

All this makes the standard extremely important because it guarantees to all the parties: designers, engineers, architects, builders, clients, control authorities and others that the product which they use meets the specific applicaction and possesses all the qualities which allow unhindered, flawless and long exploitation.

4.2 Which standards and norms PVC KG System meets?

PVC KG system is manufactured and meets the requiremets of BSS EN 13476-2:2008

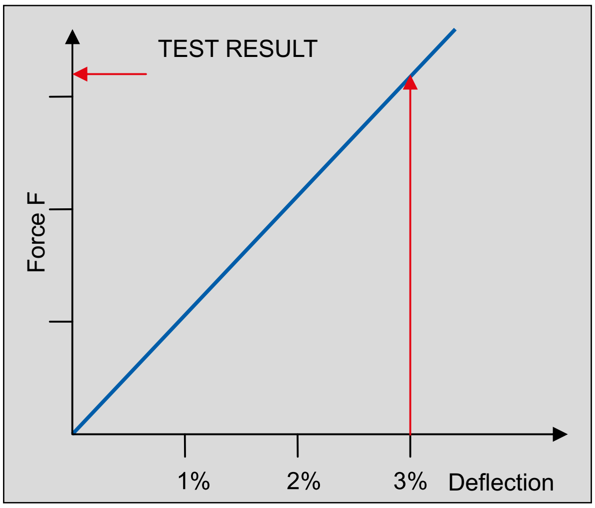
„Plastics piping systems for non-pressure underground drainage and sewerage - Structured-wall piping systems of unplasticized poly(vinyl chloride) (PVC-U), polypropylene (PP) and polyethylene (PE) - Part 2: Specifications for pipes and fittings with smooth internal and external surface and the system, Type A".

It is applicable to the valid standards and norms for design of sewerage systems: „BSS EN 752:2008 Drain and sewer systems outside buildings" and „Norms for design of sewer systems" accepted with Order № RD-02-14-140 from 17. 04.1989, on the grounds of Art. 201, paragraph 1 of the local requirements, 9 and 10 from 1989 r., amended, local requirements, 1 from 1993.

4.3 What do the standards require?

The standard BSS EN 13476-2:2008 defines minimal requiremets for the profile pipe systems, concerning the following characteristics:

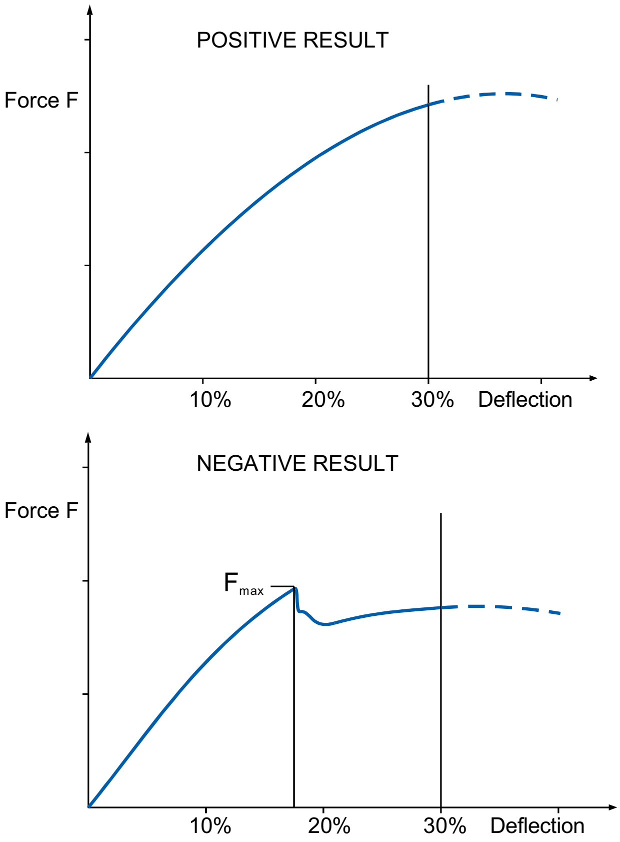
- **Ring stiffness. Tested according to BSS EN ISO 9969:2007**



The allowed stiffness are:
SN≥2, SN≥4, SN≥8, SN≥16

- **Rring flexibility. Tested according to BSS EN ISO 13968:2008 (former EN 1446)**

The standard requires keeping the structure and the elasticity of the material during deformation of the ring up to.



- Creep ratio. Tested according to BSS EN ISO 9967

Creeping is a deformation of plstics as a result of constant applied load. Creeping abates for a period of two years. Creeping is critical for the watertightness of the socket connection.

The standard requires creep ratio for PVC-U ≤ 2,5

The creep ratio is inversely proportional to the elasticity module. The bigger is the elasticity module, the less is the creeping and vica versa.

- **Tolerances on pipe connections. Tested according to BSS EN 1401-1**

The basic geometrical characteristics are included in the standard BSS EN 13476. The proper sizes and tolerances assure all system elements to be the same, to fit each other and to allow reliable and safe assembly.

This is also an important condition which concerns the connections with the elastomeric sealing ring. The pipes' sizes and the fittings are defined in accordance with their outer diameter DN/OD or their inner diameter DN/ID. The standard BSS EN 13476 defines the following nominal diameters.

DN/OD [mm]: 110, 125, 160, 200, 250, 315, 400, 500, 630, 800, 1000, 1200

According to the diameter, the standard defines the walls thickness of the smooth ends of the pipes, the sockets and the inner layers, as well as the length of each product. The tolerances stated in the standard describe mainly and only the limit value, namely minimum and maximum.

- **Impact resistance. Tested according to BSS EN 744, BSS EN 1411, BSS EN 12061**

This test checks if the pipes and the fittings will be damaged during transportation, storage and assembly.

According to the standard BSS EN 13476-part 2, there is one basic requirement: TIR ≤ 10% at temperature 0°C and at temperature -10°C.

The point of damage is assessed as a real impact norm [TIR - true impact rate] for the lot or the production where the maximum value for TIR is 10% [TIR = the total number of damages divided by the total number of impacts as a percentage as if the whole lot has been tested].

▸ Watertightness of connections with spigot socket. Tested according to BSS EN 1277

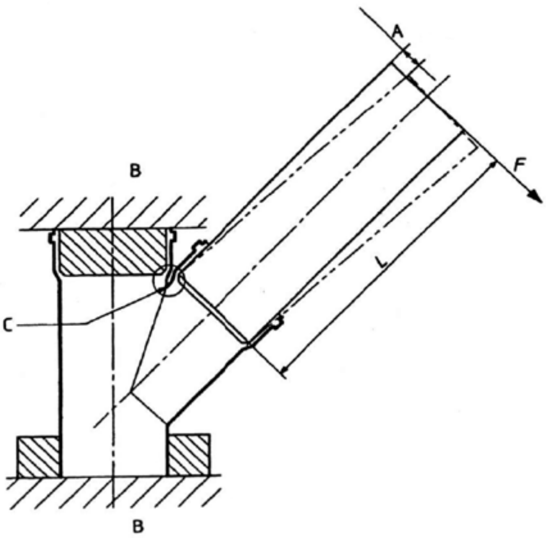
This method tests the ability of the system to keep the liquids from and out of the system (filtration/infiltration). The test confirms the connection between the soft end the spigot socket and the socket. The density of the system has an impact on the ecological aspect of the soil and the waters.

The standard requires watertightness of the connections from -0,3 bar negative pressure to +0,5 bar positive pressure.

The connections are tested at extreme conditions, including connections at angle and diameter deviation of the ring from negative to positive state. For the rain and the sewerage pipe systems this is one of the fundamental charactiristics.

▸ Mechanical strength or flexibility of fabricated fittings. Tested according to BSS EN 12256

The standard defines the mechanical strength of the fittings as certain force is applied (F), at certain distance (L) from the fitting, the displace (A) must remain within the range of 170 mm withoutbreaking the integrity of the fitting at critical point (C).



A displacement
B fixture
C critical point

Nominal diameter DN/OD 1) mm	Minimal moment kN.m (FxL)	Minimal displacement mm (A)
110	0,20	170
125	0,29	170
160	0,61	170
200	1,20	170
250	2,30	170
315	3,10	170
355	3,50	170
400	4,00	170
450	4,50	170
500	5,00	170
630	6,30	170
710	7,10	170
800	8,00	170
900	9,00	170
1000	10,00	170

1) For DN/ID fittings, the test is conducted as the parameters are used special for the next bigger DN/OD diameter, instead of the outer diameter of the specific DN/ID diameter.

▸ Resistance to high temperatures. Tested according to BSS EN 1437 and BSS EN 1055

During exploitation the thermoplastic pipe systems for drainage and public sewerage must be resistant to specific temperatures of waste waters. Due to this reason, the systems made of thermoplastic must be resistant to the temperatures given below when laid in the ground outside buildings.

Accordin to the empiric studies of TEPPFA (The European Plastic Pipes and Fittings Association) they are:

Long lasting temperature of the water of 45°C for dimensions ≤ 200 мм
Long lasting temperature of the water of 35°C for dimensions >200 мм

Due to the fact that these type pipe systems can be buried in basements or installed at distance of 1 m around the buildings, they must be resistant to maximal short-term flows of waste water with temperature of up to 60°C.

- Longitudinal shrinking. Tested according to BSS EN ISO 2505:2006

Of the three types thermoplastic materials (PE, PP и PVC-U), the pipe systems of unplasticized polyvinyl chloride (PVC-U) for drainage and public sewerage are the most sensitive to longtitudinal deformations as a result of differences in the temperature of the fluid and of the the environment. Due to this reason the PVC-U systems shrink longtitudinally.

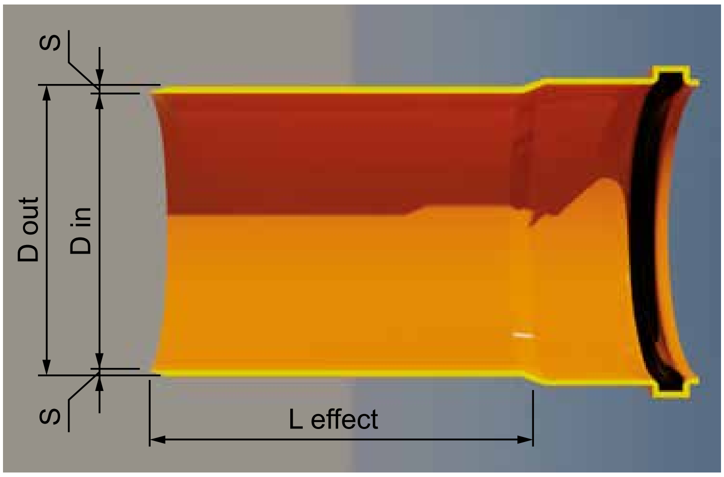
On a test pipe are made two parallel lines, as the distance between them is measured before and after heating in a drying room at 150°C. The longtitudinal shrinking must be ≤5%.

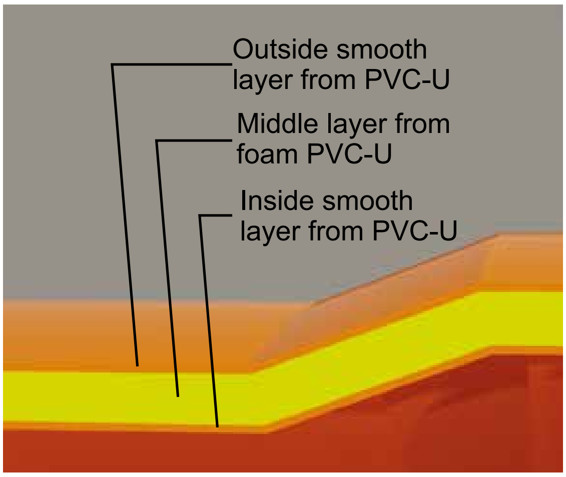
Meeting the requirement for longtitudinal shrinking guarantees that the PVC-U pipes even after shrinking won't come out of the socket connections and the watertightness of the system won't be compromised.

5 NOMENCLATURE

5.1 Coextruded, three-layer, smooth surface PVC-KG pipes from unplasticized polyvinyl chloride manufactured in Botevgrad

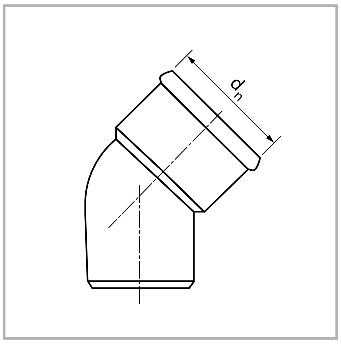
Nominal roughness (stiffness) of the pipe's ring SN	Nominal diamter DN/OD	Outer diameter D out	Inner diameter D in	Wall thickness S	Pipe's effective length L effect					Package pipes/ pallet	Package pipes/truck
kN/m²	mm	mm	mm	mm	0,5 m	1 m	2 m	3 m	5 m		
SN≥2 kN/m²	110	110	105,6	2,2	yes	yes	yes	yes	yes	60	720
	160	160	153,6	3,2	yes	yes	yes	yes	yes	49	392
	200	200	192,2	3,9	yes	yes	yes	yes	yes	20	240
	250	250	240,2	4,9	yes	yes	yes	yes	yes	12	144
	315	315	302,6	6,2	yes	yes	yes	yes	yes	12	102
SN≥4 kN/m²	110	110	103,6	3,2	yes	yes	yes	yes	yes	60	720
	125	125	118,6	3,2	yes	yes	yes	yes	yes	54	648
	160	160	152,0	4,0	yes	yes	yes	yes	yes	49	392
	200	200	190,2	4,9	yes	yes	yes	yes	yes	20	240
	250	250	237,6	6,2	yes	yes	yes	yes	yes	12	144
	315	315	299,6	7,7	yes	yes	yes	yes	yes	12	102
SN≥8 kN/m²	110	110	103,6	3,2	yes	yes	yes	yes	yes	60	720
	160	160	150,6	4,7	yes	yes	yes	yes	yes	49	392
	200	200	188,2	5,9	yes	yes	yes	yes	yes	49	392
	250	250	235,4	7,3	yes	yes	yes	yes	yes	20	240
	315	315	296,6	9,2	yes	yes	yes	yes	yes	20	240

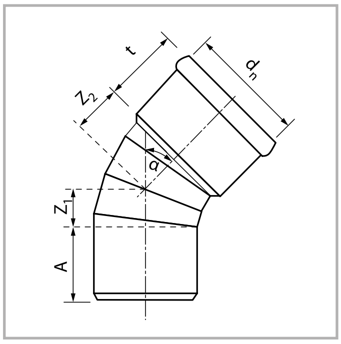




5.2 PVC KG fittings according to BSS EN 1401

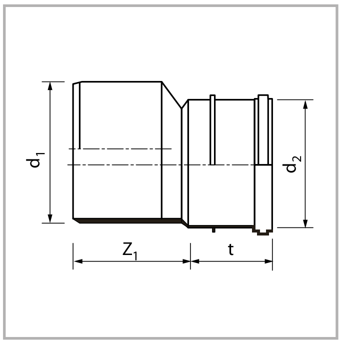
5.2.1 PVC KG Bend





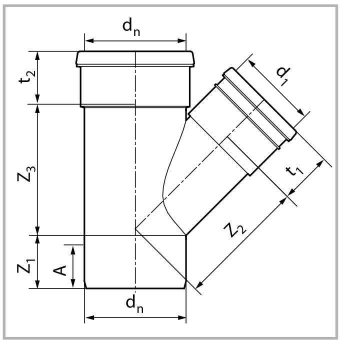
dn [mm]	α (°)	Z1 [mm]	Z2 [mm]	t [mm]	A [mm]	Product code
110	15	9	12	70	70	KGB110x15
110	30	17	23	70	70	KGB110x30
110	45	60	60	70	70	KGB110x45
110	87	60	66	70	70	KGB110x87
160	15	22	29	84	84	KGB160x15
160	30	33	44	84	84	KGB160x30
160	45	45	56	84	84	KGB160x45
160	87	95	106	84	84	KGB160x87
200	15	25	34	124	124	KGB200x15
200	30	40	50	124	124	KGB200x30
200	45	56	65	124	124	KGB200x45
200	87	115	118	124	124	KGB200x87
250	15	153	32	130	135	KGB250x15
250	30	205	84	130	135	KGB250x30
250	45	261	140	130	135	KGB250x45
250	87	483	363	130	135	KGB250x87
315	15	179	39	138	155	KGB315x15
315	30	244	104	138	155	KGB315x30
315	45	315	174	138	155	KGB315x45
315	87	595	455	138	155	KGB315x87
400	15	208	49	150	176	KGB400x15
400	30	291	131	150	176	KGB400x30
400	45	380	220	150	176	KGB400x45
400	87	734	575	150	176	KGB400x87

5.2.2 PVC KG Reducer



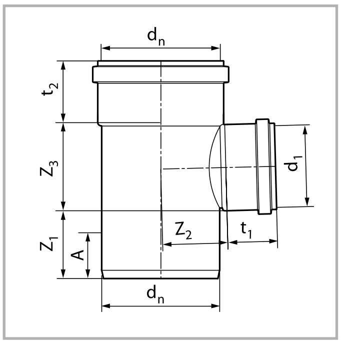
d1 / d2 [mm]	Z1 [mm]	t [mm]	Product code
160/110	140	70	KGR160/110
200/160	145	84	KGR200/160
250/200	185	165	KGR250/200
315/250	330	183	KGR315/250
400/315	415	205	KGR400/315

5.2.3 PVC-KG Tee 45°



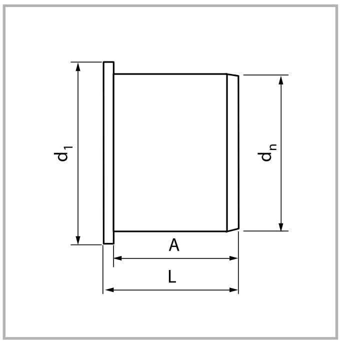
dn / d1 [mm]	Z1 [mm]	Z2 [mm]	Z3 [mm]	t1 [mm]	t2 [mm]	A [mm]	Product code
110/110	38	133	133	70	70	70	KGEA110/110x45
160/110	57	163	170	84	70	84	KGEA160/110x45
160/160	92	205	205	84	84	84	KGEA160/160x45
200/110	35	201	165	124	70	124	KGEA200/110x45
200/160	93	239	211	124	84	124	KGEA200/160x45
200/200	124	236	236	124	124	124	KGEA200/200x45
250/110	153	370	305	130	87	135	KGEA250/110x45
250/160	153	340	305	130	107	135	KGEA250/160x45
250/200	153	320	305	130	130	135	KGEA250/200x45
250/250	158	335	335	138	138	138	KGEA250/250x45
315/110	179	460	373	138	87	155	KGEA315/110x45
315/160	179	430	373	138	107	155	KGEA315/160x45
315/200	179	410	373	138	130	155	KGEA315/200x45
315/250	179	383	373	138	130	155	KGEA315/250x45
315/315	201	438	438	154	154	154	KGEA315/315x45
400/110	208	582	464	150	87	176	KGEA400/110x45
400/160	208	552	464	150	107	176	KGEA400/160x45
400/200	208	532	464	150	130	176	KGEA400/200x45
400/250	208	510	464	150	130	176	KGEA400/250x45
400/315	208	487	464	150	138	176	KGEA400/315x45
400/400	318	588	548	189	189	189	KGEA400/400x45

5.2.4 PVC KG Tee 87°30'



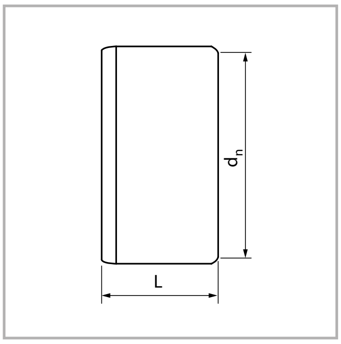
dn / d1 [mm]		
110/110	250/160	315/315
160/110	250/200	400/110
160/160	250/250	400/160
200/110	315/110	400/200
200/160	315/160	400/250
200/200	315/200	400/315
250/110	315/250	400/400

5.2.5 PVC KG Socket plug



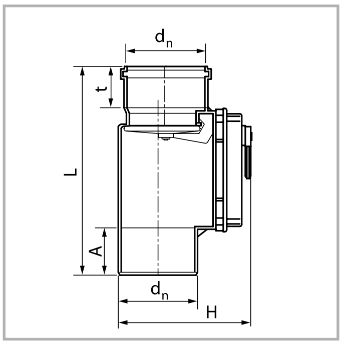
dn [mm]	d1 [mm]	A [mm]	L [mm]	Product code
110	126	43	47	KGM110
160	180	53	58	KGM160
200	220	63	68	KGM200
250	280	89	96	KGM250
315	345	92	101	KGM315

5.2.6 PVC KG End cap



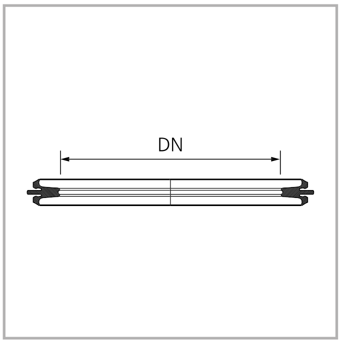
dn [mm]	L [mm]	Product code
110	46	KGK110
160	54	KGK160
200	65	KGK200
250	–	KGK250
315	–	KGK315
400	–	KGK400

5.2.7 PVC KG Non-return valve (Anti flooding valve)



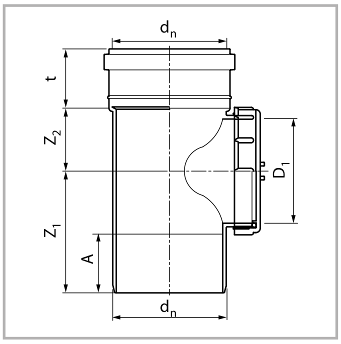
dn [mm]	t [mm]	A [mm]	L [mm]	H [mm]	Product code
110	61	61	307	230	KGKLAP110
160	74	74	337	255	KGKLAP160
200	86	100	451	300	KGKLAP200

5.2.8 PVC KG Sealing ring from SBR (styrene butadiene)



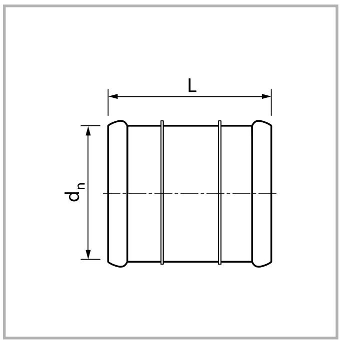
DN [mm]	Product code
110	KGKseal110
125	KGKseal125
160	KGKseal160
200	KGKseal200
250	KGKseal250
315	KGKseal315
400	KGKseal400

5.2.9 PVC KG Access pipe with threaded plug



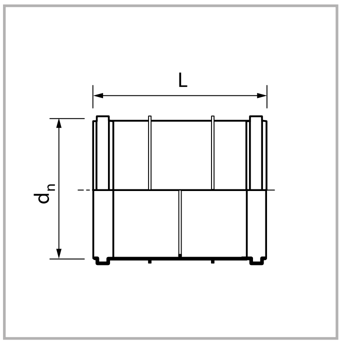
dn [mm]	Z1 [mm]	Z2 [mm]	t [mm]	A [mm]	D1 [mm]	Product code
110	210	65	70	70	102	KGRE110
160	260	90	84	84	151	KGRE160
200	358	110	165	165	193	KGRE200
250	468	235	183	183	191	KGRE250
315	490	235	205	205	191	KGRE315
400	519	235	324	234	191	KGRE400

5.2.10 PVC KG Socket



dn [mm]	L [mm]	Product code
110	120	KGU110
160	180	KGU160
200	199	KGU200
250	265	KGU250
315	320	KGU315
400	330	KGU400

5.2.11 PVC KG Double socket



dn [mm]	L [mm]	Product code
110	120	KGMM110
160	206	KGMM160
200	199	KGMM200
250	245	KGMM250
315	350	KGMM315
400	400	KGMM400

5.2.12 Lubricant

Weight [mg]	Product code
250	MGN250
2000	MGN2000

6 REQUIREMENTS FOR LAYING OF PVC KG PIPE SYSTEM

6.1 General considerations

The most important factor for achieving of good assembly of plastic collector is the interaction between the pipe and the surrounding soil. The bigger value of the pipe resistance is achieved from the soil at the lower part of the pipe horizontally in both directions. Therefore the type of the backfill and the degree of sealing in the pipe zone are very important.

Therefore for every sewage project the engineer must define the conditions for laying like:
1. Conditions of the existing soil layers and the suitability for their usage for trench basis and backfill.
2. Geotechnical characteristics of the soil used for bedding and backfill and the way they are made.
3.The appropriate type of strength of the pipe. At the very beginning of every project, the first step is to be made geotechnical study of the layers in which the pipe will be laid. This study and the lab tests must be conducted in order to be estanblished the type of the soil and its structure, the degree of sealing and the level of the subterranean waters.

6.2 Bedding characteristics

The design of the bedding depends on the geotechnical characteristics of the soil in the zone where the pipe is laid.
Generally there are two types of choice of bedding: natural laying over the existing soil layer without additional treatment and laying over bedding made of selected soil material with the necessary degree of sealing.

6.2.1 Laying over existing, uncultivated soil

In some cases can be allowed laying of PVC KG pipes on the bottom of a trench but only on grainy,dry soil which is without middle and big stones (> 20mm). These soils are fine gravel, big sand, fine sand and sandy clays. Under these conditions the pipe is laid on thin (10 to 15cм) unsealed bedding directly on the bottom of the trench. The purpose of the bedding is to improve the conditions for laying on the bottom of the trenchand to provide secure support of the pipe with a range of angle of laying α = 60-180° (see Figure 6.1)

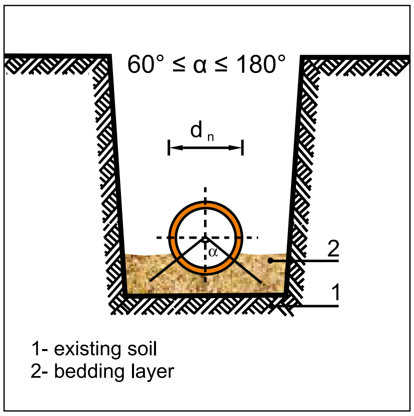


Figure 6.1 Laying in natural conditions

6.2.2 Laying over artificial basis

In some situations the pipe must be laid over additionally made basis:

1. When the natural soil can serve as a basis but due to structural damages can't fulfil this function.
2. In rocky soils, cohesive soils (clays) and alluvium soils.
3. In weak soft soils like organic alluvium and peat.
4. In all the other cases when the design documentation requires additional bedding to be made.
An example for solution of case 1 and 2 is shown on Figure 6.2. The pipeline is laid over two two layers made of sandy soils or fine gravels with a maximal size of the grains 20 mm.

- The founding layer is prepared from well sealed soils with a depth of 25 cm (minimum 15 cm).
- The bedding is from 10 to 15 cm – thick unsealed.

In cases of weak soils, depending on the thickness of the layer, under the level of laying of the sewage pipe are offered two solutions.

1. When the thickness of the weak layer is ≤ 1,0 m (see Figure 6.3).
In this case the layer weak soil is taken and in the trench is placed new well compacted mixture of crushed gravel and sand (in proportion 1:0,3) or mixture of natural gravel and crushed gravel (in proportion 1:0,3). This new founding layer is laid over geotextile.
2. When the thickness of the weak layer is > 1,0 m (see Figure 6.4)

In this case a new additional 25 cm layer well compacted mixture of crushed gravel and sand (in proportion 1:0,6) or mixture of natural gravel and sand (in proportion 1:0,3). This new layer is laid over geotextile.

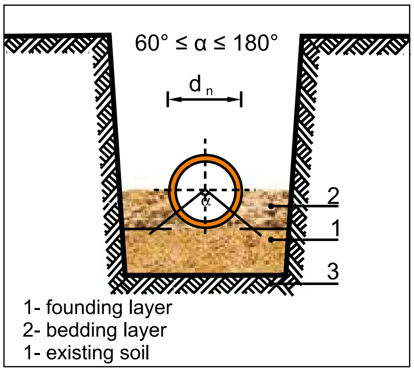
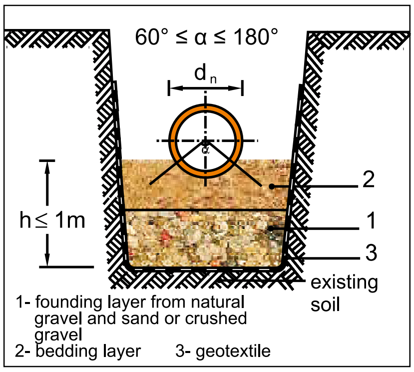


Figure 6.2 An example for laying in stable soil

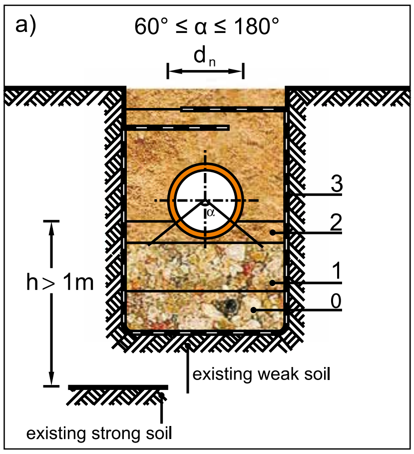
Figure 6.3 An example for laying in weak soil loess at depth ≤ 1.0 m



In all cases the sealing of the founding layer must be from 85% to 95% according to Proctor

Figure 6.4 An example for laying in weak soil loess at depth > 1.0 m

0 – additional 25 cm founding layer of crushed gravel and sand or natural gravel and crushed gravel
1 – founding layer of crushed gravel and sand or natural gravel and sand
2 – bedding
3 – geotextile



6.3 Filling around the pipe zone, backfill and final filling

Besides the founding layer and the bedding, the type of the soil and its density matters and is important for achieving of satisfactory level of assembly of the flexible pipes.

6.3.1 Filling around the pipe zone and backfill

The criterion for selection of appropriate material suitable for using for filling the pipe zone around the pipe and directly above the crown of the pipe to the surface of the trench is based on achieving of optimal resistance and stiffness of the soil after the sealing.

The appropriate soil material includes most types and classes natural granulated materials with maximal size of the grains not more than 10% of the nominal diameter of the pipe but not more than 60 mm. The material for backfill must not contain foreign materials (admixtures) like snow, ice or frozen soil lumps.

Figure 6.5 pipeline section
a – basic filling
b – earth covering
c – zone around the pipe
d – bedding (if required)
e – founding layer (if required

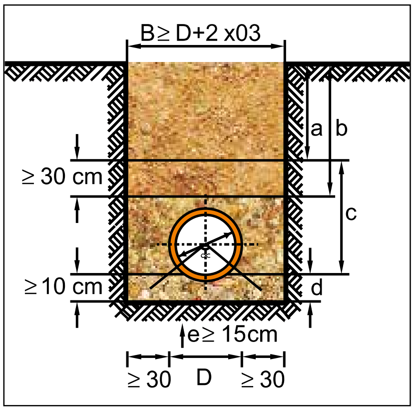


Table 3.1 Characteristics of the materials for filling around the pipe and backfill

FILLING AROUND THE PIPE ZONE AND FOLLOWING BACKFILL

Material	Particles diameter [mm]	Notes
Gravel, Crushed stones	8-22, 4-16 8-12, 4-8	The most appropriate soil material, maximum from 5 to 20% particles with size of 2 mm
Gravel	2-20	Appropriate soil material, maximum from 5 to 20% particles with size of 0.2 mm
Sand, Moraine gravel	0.2-20	Relatively appropriate soil material, maximum up to 5% particles with size of 0.02 mm

6.3.2 Degree of sealing

The necessary degree of sealing of the backfill depends on the loading conditions.

- For road surface the mimimum sealing of the soil in the pipe zone is 95%
- Outside the road surface the filling must be sealed to:

- 85% if the depth is < 4.0 m
- 95% if the depth is ≥ 4.0 m

The material of the backfill must be sealed on layers with a thickness of 10 to 30 cm.

The height of the backfill above the crown of the pipe must be:

- minimum 15 cm for pipe with a diameter D < 400 mm
- minimum 30 cm for pipe with a diameter D ≥ 400 mm

6.3.3 Final backfill

The material of the final backfill of the trench can be dug soil if possible the achievement of maximal size of the particles of 30 mm. For canalswith a diameter D < 400 mm and basic filling with a depth of 15 cm, the material of the final backfill must not contain particles bigger than > 60 mm.
For road surfaces the minimum sealing of the final backfill must be 95%.

6.3.4 Compaction of the material for filling

The requirements for the degree of sealing depend on the general load and must be stated in the design documentation. Depending on the equipment, the thickness of the layers and the pliability of the soil to sealing, different degrees of sealing can be achieved. In Table 3.2 are given data which are applicable to gravel, sand, clay and alluvium soils.

Table 3.2 Compaction methods

Compaction methods							
Equipment	Weight [kg]	Maxumum thickness of the layer before the compaction [m]		Minimum thickness of the first filling above the pipe [m]*	Number of repetitions for achieving the sealing		
		gravel, sand	clay, alluvium		85% according to Proctor modified test	90% according to Proctor modified test	95% according to Proctor modified test
Fine treading	-	0.10	-	-	1	3	6
Manual compaction	min. 15	0.15	0.10	0.30	1	3	6
Vibration compaction	50-100	0.30	0.20-0.25	0.50	1	3	6
Separate mechanical compaction**	50-100	0,20	-	0.50	1	4	7
Mechanized compaction	50-100 100-200 400-600		- - 0.20	0.50 0.40 0.80	1 1 1	4 4 4	7 7 7

* before using tools for sealing
** sealing on both sides of the pipe

6.3.5 Trench width

The trench width must allow the proper spreading and sealing of the filling material. The minimum width of the zone on both sides of the pipe for laying of the filling is b_{min}=30 cm. Therefore the mimimum trench width (B) on the level of the pipe's crown is:

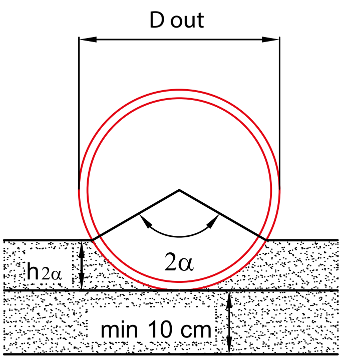
$$\mathbf{B = D + (2 \times b_{min})}$$

If the resistance of the soil basis is smaller than the predetermined, the trench width must be:

$$\mathbf{B \geq 4 \times d_n}$$

Similar situation can be achieved with grain soils with low density (ID < 0.33) иor soils with limit IL > 0.0.

The necessary filling for achieving the desired angle of laying

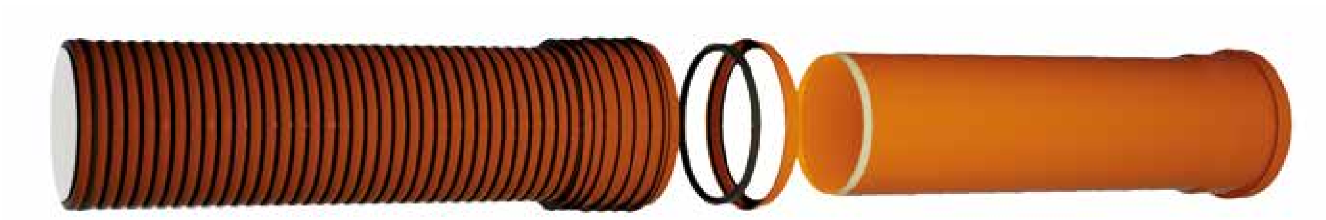


DN [mm]	D out [mm]	Angle of laying 2α			
		60°	90°	120°	180°
		h2α [cm]			
DN/OD160	160	1	2	4	8
DN/OD200	200	1	3	5	10
DN/OD250	250	2	4	6	12
DN/OD315	315	2	5	8	16

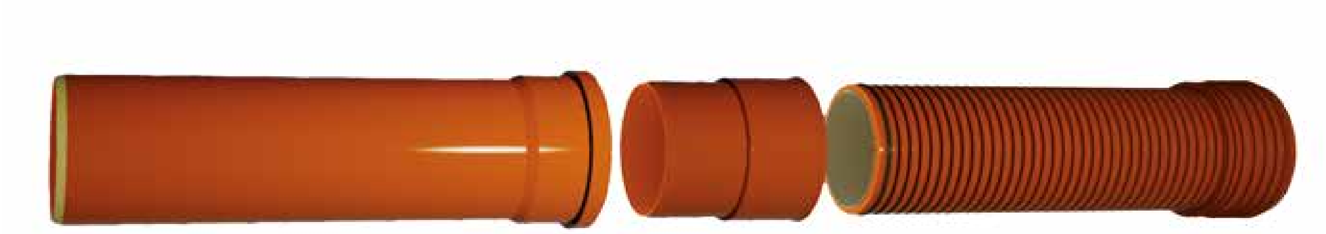
7 PVC KG PIPE SYSTEM ASSEMBLY

7.1 Connecting of PVC KG pipes

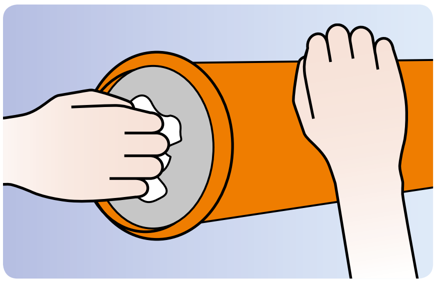
PVC KG pipe | PVC KG Tee | PVC KG pipe



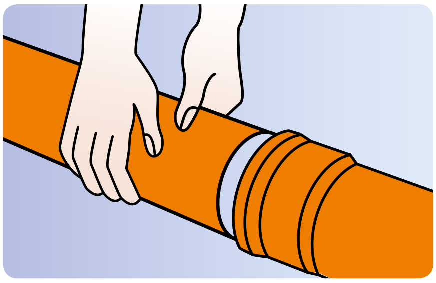
Pragma® pipe | Assembly ring with a sealing | PVC KG pipe



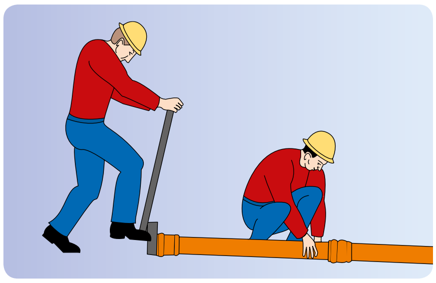
PVC KG pipe | PVC-U PVC KG Adaptor to PVC | Pragma® pipe



Take out the rubber sealing from the socket. Clean with a dry cloth the rubber sealing and socket groove. Put lubricant on the non socket of the pipe.



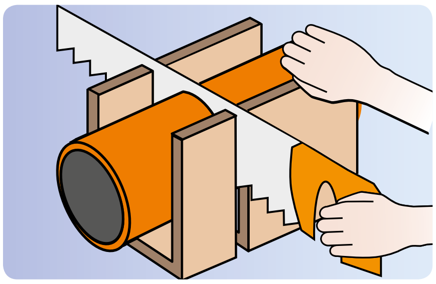
Mark the spot where the pipe must enter into the socket. After that carefully insert the pipe in the socket with a rotating movement.



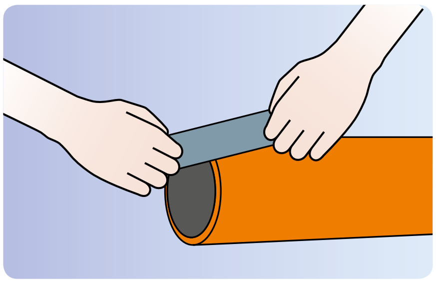
When the diameters or the lengths of the pipes are big, a lever can be used. In this case put a wooden block in the socket in order to avoid the direct contact with the lever and possible breaking.

7.2 Cutting of PVC KG pipes. Beveling of the non socket end of the short part

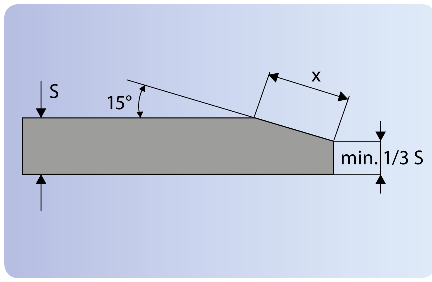
On the construction site sometimes it is necessary shortening of the pipe's length. On the figures below is shown how it is made and what additional actions are necessary.



Cutting of a pipe. The pipe can be cut with a hand-saw or with a cutting machine. Before cutting the pipe must be fixed.



The non socket end of the short pipe must be beveled at and angle of 15° in order to fit tight to the internal side of the socket. Beveling can be done with sandpaper, file or grinding machine.



A diagram of beveling of non-socket shortened pipe

7.3 Attaching to sewage collectors from PVC KG pipes

Attaching to sewage collectors from PVC KG pipes is made by two basic ways:

- Attaching through fork-joint and bend (see 5.2.2 and 5.2.3). It is recommended for attaching to newly laid collect which has not been exploited yet.

- Attaching through saddle with a screw with in-situ connection (see 5.2.9 and 5.2.11). It is recommended for attaching to already existing collector which is already in exploitation.

- In both of the above mentioned cases it is recommended attachiching to the collector to be made in the upper third of the collector section at and angle φ with regard to the vertical axis of the collector. Depending on the situation of the collector and the attached canal there are three basic ways:

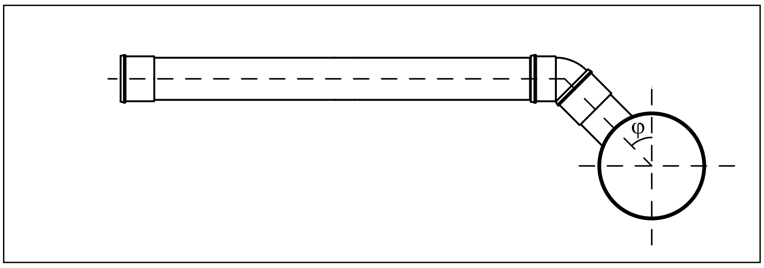


Figure 7.1 Attaching of side canal to collector

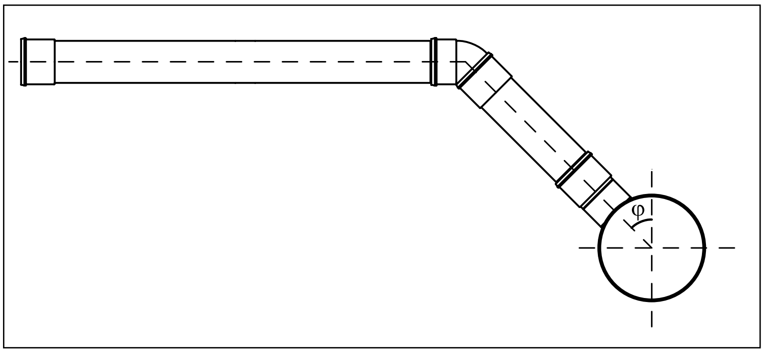


Figure 7.2 Attaching of side canal to collector in case of displacement

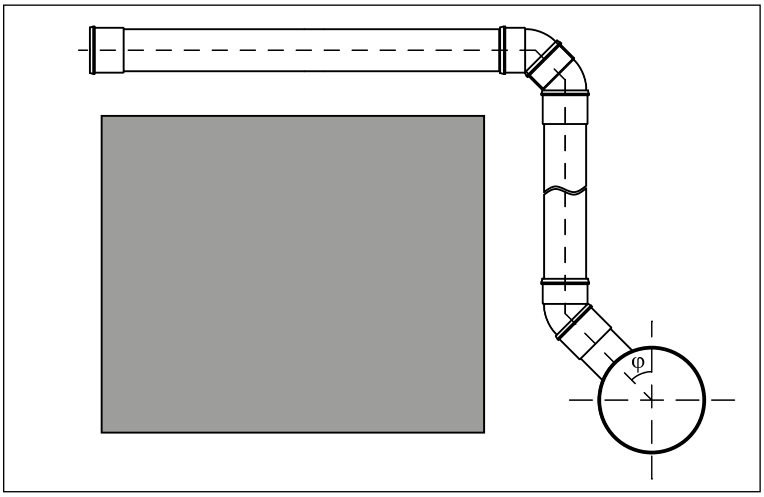


Figure 7.3 Attaching of side canal to collector in case of displacement and obstacle

7.4 Attaching to PRO® manholes

Pipelife PRO® manholes are designed and manufactured for safe and secure attaching with the PVC KG pipes and the fittings.

8 TRANSPORTATION, LOADING AND UNLOADING AND STORE

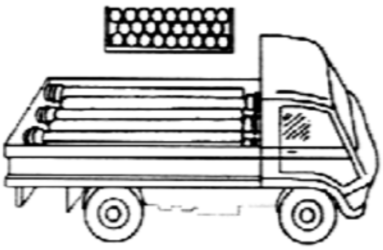
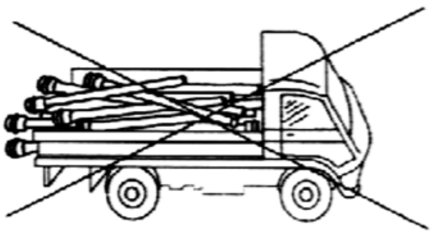
Wrong transportation (as well as wrong storage) can lead to deformations or damages of the pipes, the fittings and the sealing rings which can create problems during laying and functioning of the mounted pipes.

The pipes must be transported in vehicles with smooth clean load surface i.e. without unevennessesor for for example protruding nails. The pipes must lay with its whole length on the floor (see Figure 8.1).

When loading and unloading it must be avoided harsh lifting and dropping of the pipes. Their throwing and manual unloading is unacceptable (see Figure 8.4). For mechanized loading and unloading of pipes packed in the plant, it must be used appropriate lifting devices for example engine truck or crane.

The pipes must be stored on smooth surface, as the allowed height is from 2.0 [m] to 3.0 [m] (for pipes in pallets). When storing free pipes the allowed height is up to 1.0 [m]. It is recommended the arrangement of the pipes during transportation and during storage to be in both directions – on two adjacent lines the socket (respectively non socket) ends to point in opposite directions (see Figure 8.5). Thus the loading between the different lines of pipes is even and it is not necessary to put additional wooden supports between the lines. The wooden supports are placed only under the lowest line. The pipe must lay at least on three wooden supports with minimum width of 10 [cm].

The pipes of the PVC KG pipe system can be stored on open spce. They endure the influence of the UV rays minimum two years as they retain the physical-mechanical properties unchanged, regardless of the change in the colour (fading)

	Correct	Wrong
Transportation	 *Figure 8.1*	 *Figure 8.2*
Unloading	 *Figure 8.3*	 *Figure 8.4*

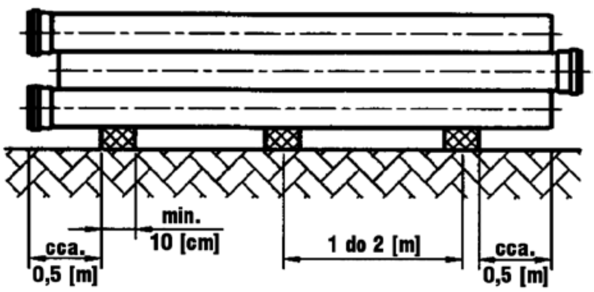
<table>
<tr><td>Storage</td><td>

Figure 8.5</td></tr>
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9 HYDARAULIC SCALING OF THE PVC KG SYSTEM

9.1 General assumptions

A hydraulic design concerns selecting parameters for gravity flow sewers, which normally do no flow full. The objective of hydraulic design is to determine the most economic pipe diameter at which the required discharge is passed. In practice, computation of hydraulic pipe parameters are based on the following assumptions:

1. The assumption of a uniform flow, meaning:

- the depth (h), flow area (f) and velocity (v) at every cross-section remain constant at the whole considered pipe section;
- the energy grade line, water surface and pipe bottom slope are parallel.

2. In the pipe system, the flow regime is turbulent.

9.2 Governing formulas

In practice, for computational purposes, the following semi-empirical equations are used:

1) $$Q = V \cdot F \; ; \; F = \frac{\Pi \cdot d^2}{4}$$

2) $$Q = \frac{\Pi \cdot d^2 \cdot V}{4}$$

where:
Q – flow rate, [m³/s]

V – average flow Velocity, [m/s]

F – flow area, [m²]

Motion resistance on the pipe lenght are calculated based on unitary hydraulic gradient. Unitary hydraulic gradient for closed pipes with a settled turbulent motion is calculated based on Darcy-Weisbach formula:

3) $$i = \lambda \cdot \frac{1}{d} \cdot \frac{v^2}{2g}$$

Hydraulic resistance coefficient (λ) is calculated based on Colebrook-White formula:

$$\frac{1}{\sqrt{\lambda}} = -2\lg\left(\frac{2{,}51}{Re \cdot \sqrt{\lambda}} + \frac{k}{3{,}71 \cdot d}\right)$$

$$Re = \frac{V \cdot d}{\nu}$$

where:

i – unitary losses for conquering a friction resistance equal to slope of a pipe bottom with a free surface of water, [m/m]

d – inner diameter of the pipe, [m]

V – average flow velocity, [m/s]

g – acceleration of gravity, [m/s²]

λ – linear resistance coefficient

Re – Reynold number

ν – coefficient of kinematic viscosity [m²/s]

(for water at temp 10°C ν = 1,308x10⁻⁶ [m²/s])

k – coefficient of absolut roughness, [mm]

The Bretting formula for pipes flowing partly full:

4) $$\frac{q_n}{Q} = 0.46 - 0.5 \cdot \cos\left(\Pi \cdot \frac{h_n}{d}\right) + 0.04 \cdot \cos\left(2\Pi \cdot \frac{h_n}{d}\right)$$

where:
Q – flow rate in the pipe flowing full, [m³/s]

q_n – flow rate in the pipe flowing partly full, [m³/s]

h_n – actual depth of flow, [m]

d – inner diameter of the pipe, [m]

Ratio of absolute pipe wall – k, [mm]

Laboratory roughness	0,0011 [mm]
Pipe's roughness in exploitation (without regard of the local resistance)	0,015 [mm]
Artificially bigger roughness the local resistances at the main sewage collectors	0,25 [mm]
Artificially bigger roughness with regard to the local resistances at secondary sewage collectors	0,40 [mm]

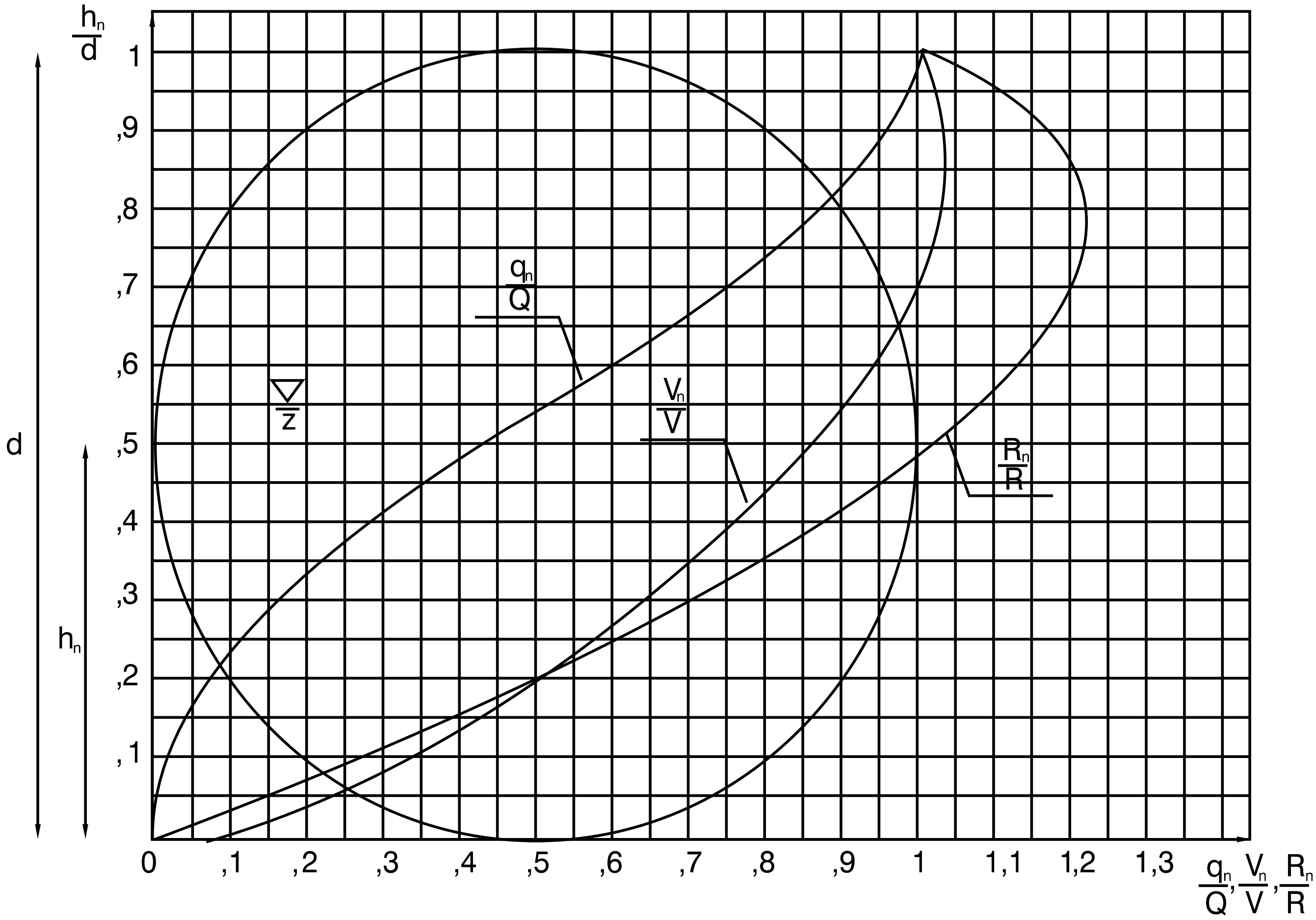
The values of the artificially bigger roughness are recommended but not compulsory. The designers can choose another artificially bigger value of K or another method for calculation of local resistances.

9.3 Software and scaling tables

Besides the following nomographs Pipelife offers to the designers other helpful tools for hydraulic scaling. In the "For the designer" section in www.pipelife.bg can be found and used a web software for hydraulic calculation of a particular sewage section, a software for hydraulic calculation of the sewage network and scaling tables for filling h/D=0.5, h/D=0.7 и h/D=1.0

9.4 Hydraulic nomographs

9.4.1 A nomograph for hydraulic scaling of circular pipes with partially full profile



$\frac{h_n}{d}$ correlation between the flow depth and the pipe's diameter (d)

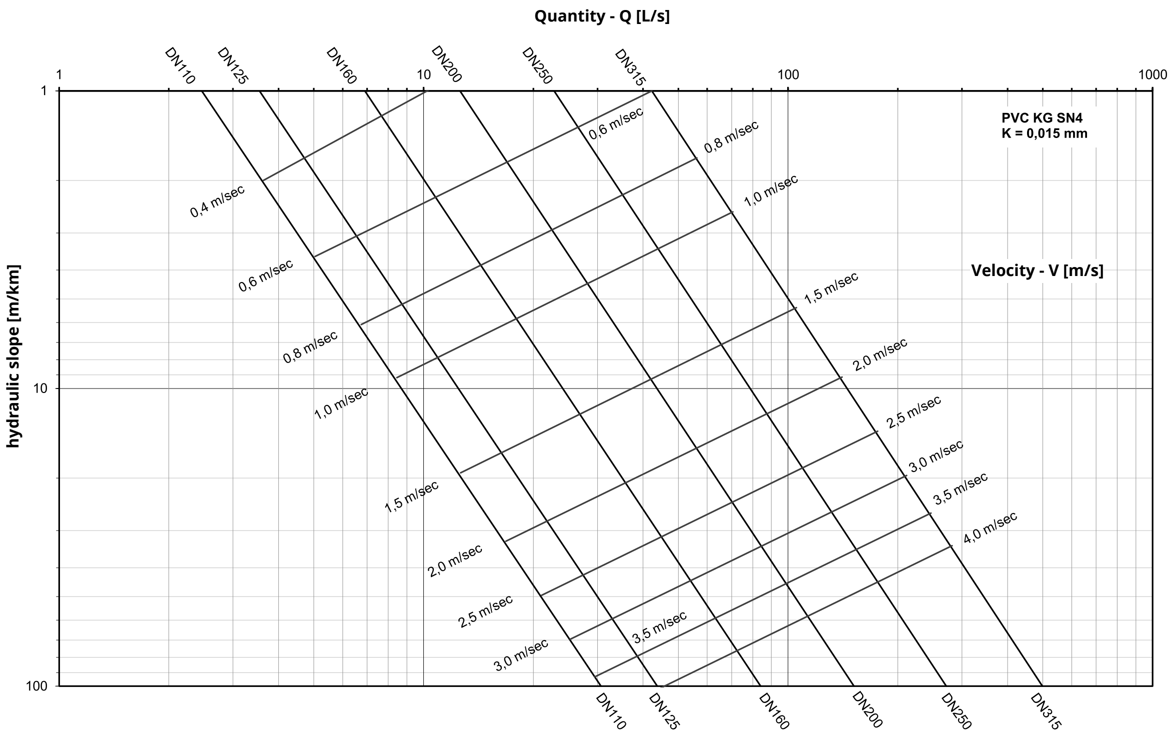
$\frac{q_n}{Q}$ correlation between the actual flow with filling (h_n) and outflow for full profile

$\frac{V_n}{V}$ correlation between the actual velocity with filling (h_n) and velocity for full profile

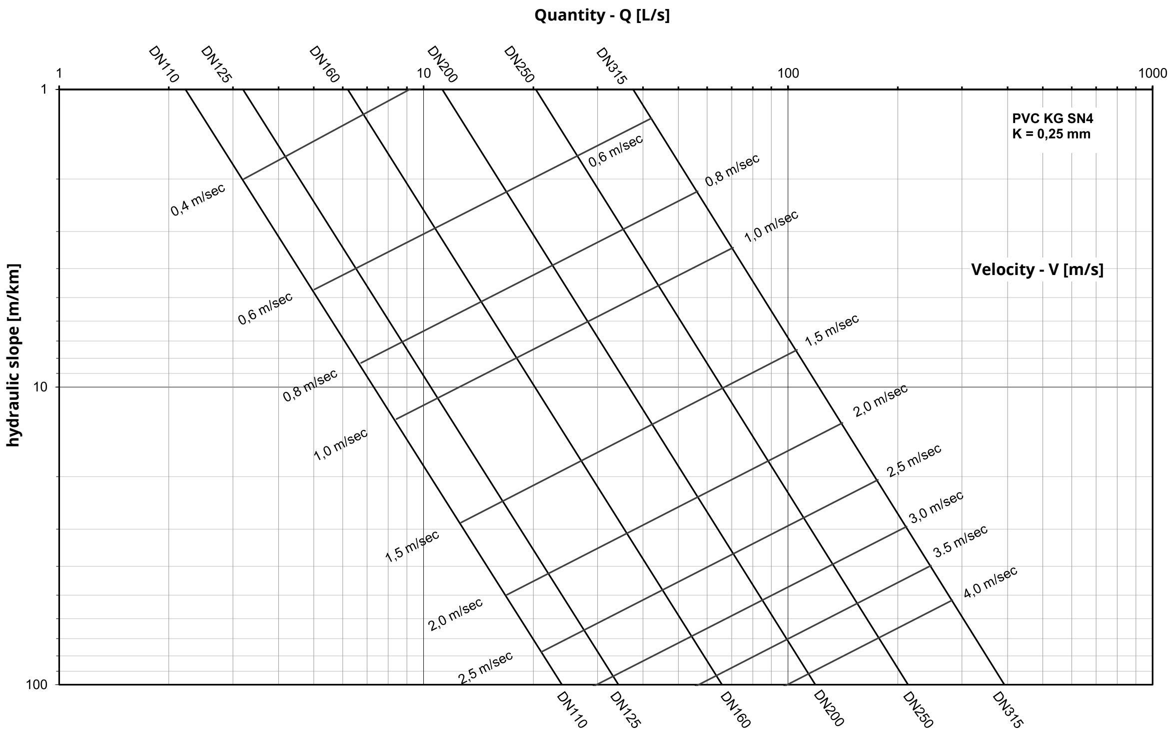
$\frac{R_n}{R}$ correlation between the hydraulic radius with filling (h_n) and hydraulic radius for full profile

9.4.2 Nomographs for hydraulic scaling of non-pressure flow in circular PVC KG® pipes with a full profile

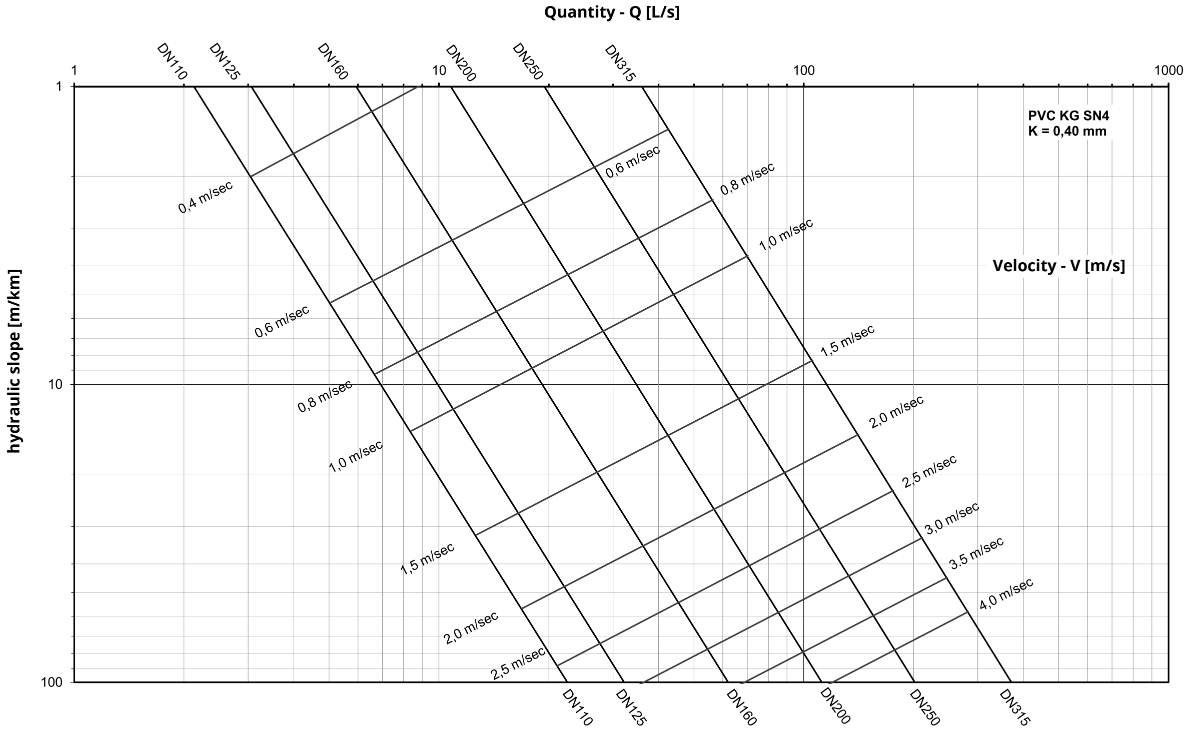
For k = 0.015 [mm], water temperature t = 10°C, full profile
Darcy-Weisbach/Colebrook-WhiteFormula



For k = 0.25 [mm], water temperature t = 10°C, full profile
Darcy-Weisbach/Colebrook-WhiteFormula



For k = 0.40 [mm], water temperature t = 10°C, full profile
Darcy-Weisbach/Colebrook-WhiteFormula



9.5 Hydraulic Slopes and velocities of flow in PVC KG pipes slopes

The minimum channel slope is required to achieve the lowest flow velocity which will prevent suspended solids from settling out and clogging the pipe.

In general, solid particles, e.g. sand particles, can deposit on the bottom to a depth corresponding to the particle friction angle Θ (see Figure 9.1) expressed as

5) $$\frac{h_n}{d} = \frac{1}{2} \cdot (1 - \cos \Theta)$$

where:
hn – depth of flow, [m]
d – inside pipe diameter, [m]
Θ - internal friction angle, [°]

If Θ = 35°

then hn/d = 0,1

The area of deposition may be allowed to a relatively flat zone of the channel bottom.

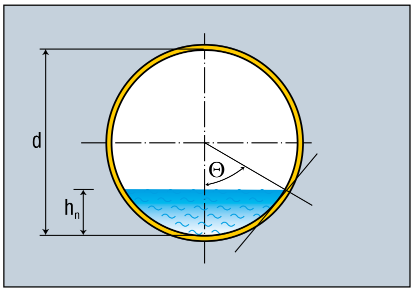


Figure 9.1.
Angle of friction

The safe lower limit of velocity to avoid sedimentation depends on the type of sediments.

Usually, the permissible minimum velocities (V_{sc}) which ensure selfcleaning of the channel should not be, at full flow, lower than:

V_{sc} = 0,8 m/s for sanitary sewers
V_{sc} = 0,6 m/s for storm sewers
V_{sc} = 1,0 m/s for combined sewers

When determining the slope of the pipeline, one should select the permissible velocities taking into account the pipe diameter. To this end, a simple formula can be used: 6)

6)
$$i_{min} = \frac{1}{d}$$

where:
i_{min} = minimum permissible slope
d = internal pipe diameter

The minimum slope of the sewer pipeline can also be expressed by the tractive force (t), given as: 7)

7)
$$\tau = \gamma \cdot R \cdot i$$

where:
γ = specific weight of waste water, [kg/m^3]
R = hydraulic radius, [m]
i = hydraulic slope, [m/m]

The actual tractive force is: 8)

8)
$$\tau_0 = \gamma \cdot R \cdot i \cdot k_1$$

where:
$R = \frac{d}{4}$, hidraulic radius for circual full flow pipe

k_1 = correction factor, $k_1 \, f\left(\frac{h_n}{d}\right)$

From the above, the critical tractive force for the actual depth of flow (hn) is: 9)

9)
$$\tau_0 = \gamma \cdot i \cdot \frac{d}{4} \cdot \frac{R_n}{R}$$

The critical tractive force which fulfil the condition of the channel self-cleaning is: 10)

10)
$$\tau_0 \geqslant 1.5\,\text{Pa} \quad \text{(for storm water)}$$

$$\tau_0 \geqslant 1.5\,\text{Pa} \quad \text{(for sewage)}$$

Thus, from Equation 9, after rearranging, the minimum slope of the pipe is: 10a)

10a)
$$i_{min} = \frac{0.612 \cdot 10^{-3}}{d \cdot \frac{R_n}{R}} \quad \text{(for storm water)}$$

10b)
$$i_{min} = \frac{0.815 \cdot 10^{-3}}{d \cdot \frac{R_n}{R}} \quad \text{(for sewage)}$$

10 STATIC SCALING OF PVC KG® SYSTEM

10.1 Interaction between the pipe and the surrounding soil

From the technical point of view, the plastic PVC KG system is a flexible structure having a high ability to take up stress without failing. The classical method to evaluate the strength of a structural material is to describe the actual relation between the stress and the strain when the material is loaded. A vertical load imposed on the pipe causes a deflection (δV), a reduction in the vertical diameter of the flexible pipe, which takes causes it to take an elliptical shape (see Figure 10.1)

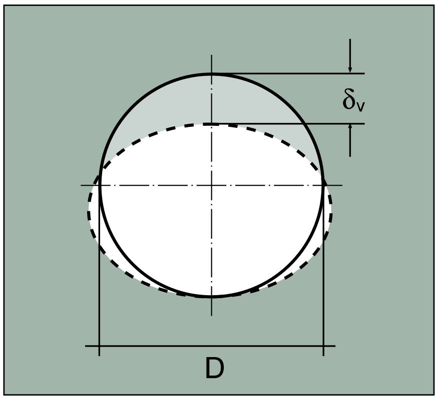


Figure 10.1 Deflection of circular pipe due to vertical load

Deflection of the pipe causes bending stress in the pipe wall and exerts pressure on the surrounding soil, and the passive earth pressure decreases the bending stress in the pipe wall. The bending stress in the pipe wall caused by deflection is in momentary balance with the soil pressure acting against the outside of the pipe wall. The force the of the soil counteracting the pipe pressure depends on the vertical load, soil type and stiffness (density) in the pipe zone and on the pipe stiffness.

For rigid pipes such as concrete, etc., the pipe alone has taken the main vertical forces acting on the pipe, while flexible pipe makes use of the horizontally acting soil support exerted as a result of the pipe deflection. Consequently, for the flexible pipe, the integration between the soil and the pipe has to be considered far more extensively than in the case of rigid pipes.

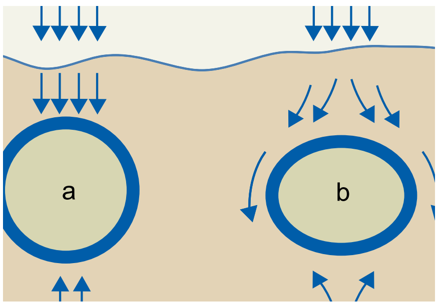


Figure 10.2

The design concept of flexible pipes can be explained with the classical Spangler formula: 11)

11)
$$\frac{\delta_v}{D} = \frac{f(g)}{(SN + S_s)}$$

where:
δv – deflection of the pipe diameter
D – initial underformed pipe diameter
q – vertical load
SN – pipe ring stiffness
S_s – soil stiffness

Equation (11) describes the relative deflection of a pipe subjected to a vertical load (qv) supported by the pipe ring stiffness and the soil stiffness. This equation clearly shows that pipe deflection can be limited to the permissible magnitude by increasing one or both of the two factors, pipe ring stiffness and soil stiffness in the pipe zone. Additionally, it can be said that pipe with greater ring stiffness is less subjected to interaction with the soil and is less dependent on the soil density in the pipe zone. Whereas application of a suitable enbedment of properly compacted material (higher cost of installation) enables the use of pipes of lower ring stiffness (lower in cost), in making a decision both the engineering and economic advantages of the alter-natives must be considered

10.2 Load

The soil pressure distribution for the Scandinavian Method [by Janson, Molin 1991] is shown in Figure 10.3. The buried pipe is loaded with vertical load (q_v), which causes stress and strain, and with the counteracting horizontal load (q_h).

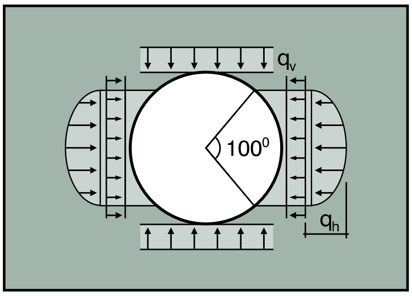


Figure 10.3 Scandinavian Model of soil pressure distribution

VERTICAL LOADS

1. Load due to soil above the pipe: 12)

12)
$$q_z = \gamma_z \cdot H$$

where:
$\gamma_z = 18$ to 20 kN/m^3 for pipes above the ground water table

For pipes below the water table, the total pressure shall be increased with the hydrostatic pressure: 13)

13)
$$q_w = \gamma_w \cdot h$$

In this case, vertical load is: 14)

14)
$$q_z = \gamma_z(H-h) + (\gamma_{zw} \cdot h) + (\gamma_w \cdot h)$$

where:
γ_{zw} = 11 kN/m^3
γ_w = 10 kN/m^3

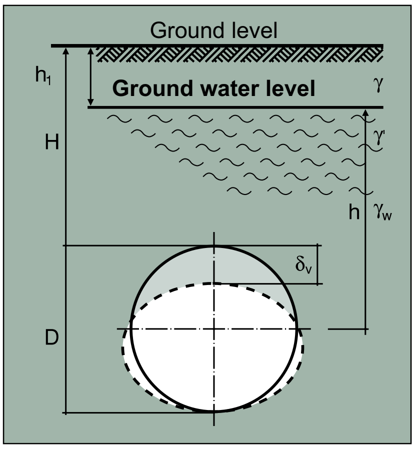


Figure 10.4 Geometry of buried pipe

Under normal conditions of pipe installation, the vertical load (q_v) component is larger than the horizontal load (q_h) component. The difference (qv - qh) causes a reduction of the vertical pipe diameter and an increase in the horizontal pipe diameter. The pipe side walls, when deforming, mobilise a passive earth pressure of a value depending on the imposed vertical load and on the ratio between the soil stiffness and pipe stiffness. This last is expressed as the pipe ring stiffness (SN). The components of load which are likely to be imposed on a pipe in the vertical plane are:
- the effect of the soil above the pipe
- the effect of loads superimposed on the surface of the ground, such as those from buildings, vehicle wheel loads, etc.

10.3 Types of soils according to ENV 1046

Type of soil	Soil group					Cov-ering
	Group of soils according to ATV127	Typical name	Symbol	Distinguishing feature	Examples	
Gravel	G1	Gravel with a single size	(GE) [GU]	Steep soil particle size line, with predominant particles with the same size	Crushed stone, river and bank gravel, moraine, cinder, volcanic ash	**YES**
		Gravels with a different size of the particles, gravel-sand	[GW]	Incessant soil particle size line, a few soil particle size groups		
		Gravels with the same size of the particles, gravel-sand	(GI) [GP]	Steep soil particle size line, one or more soil particle size groups are missing		
		Sand with a single size	(SE) [SU]	Steep soil particle size line, one soil particle size group dominates	Sand from dunes and bottom alluvium, river sand	**YES**
		Sands with a different size of the particles, sand-gravel	[SW]	Steep soil particle size line, a few soil particle size groups	Moraine sand, bank sand, shore sand	
		Sands with the same size of the particles, sand-gravel	(SI) [SP]	Steep soil particle size line, one or more soil particle size groups are missing		
	G2 и G3	Alluvium gravels, gravel-alluvium-sand with the same size of the particles	(GU) [GM]	Wide/ soil particle size ine with interruptions with fine alluvium particles	Crashed gravel, beveled fragments, clay gravel	**YES**
		Clay gravels, gravel-sand-clay with the same size of the particles	(GT) [GC]	Wide/ soil particle size line with interruptions with fine alluvium particles		
		Alluvium sands, sand-alluvium with the same size of the particles	(SU) [SM]	Wide/ soil particle size line with interruptions with fine alluvium particles	Quick sand, sand loess	
		Clay sands, sand-clay with the same size of the particles	(ST) [SC]	Wide/ soil particle size line with interruptions with fine alluvium particles	Sand soil, alluvium clay, alluvium lime clay	
Cohesive		Nonorganic alluvium, fine sands, rock particles, alluvium or fine sands	(UL) [ML]	Low stability, short reaction, zero to weak plasticity	Loess, clay	**YES**
	G4	Nonorganic clay, plastic soil clay	(TA)(TL) (TM) [CL]	Medium to high stability, slow reaction, low to medium plasticity	Alluvium clay, clay	
Organic		Soils with a mixed size of the particles and admixture of humus and talc	[OK]	Admixtures of plants / non-plant, rots, low weight, high porosity	Upper layers, hard sand	**NO**
		Organic alluvium and organic alluvium clay	[OL](OU)	Medium stable, from slow to very fast reaction, low to medium plasticity	Sea chalk, upper soil layer	
		Organic clay, clay with organic admixtures	[OH](OT)	High stability, zero reaction, medium to high plasticity	Mud, soil	
Organic		Peat, others high organic soils	(HN)(H2) [Pt]	Non-homogenous peat, thread-like, colors from brown to black	Peat	**NO**
		Slime	[F]	Slimes in the alluvium, often spreaded with sand / clay/talc, very soft	Slime	

10.4 Necessary data for statistical calculation of the PVC KG® pipe system

With regard to the correct laying and exploitation of the sewage pipes of the PVC KG® system it is important to calculate the impact of the static and the dynamic pressure. For this purpose it is necessary to take into account the soil's type, the availability of subterranean waters, the degree of covering sealing according to Proctor. The calculation can be made with the Pipelife's web software in the "For the designer" section" on www.pipelife.bg.

Also Pipelife possesses a EASYPIPE software which if necessary can make more detailed calculated statistics of the laid pipes. Both programs are based on the methodology for statistical calculation of pipes laid in the ground according to ATV 127. For the preparation of this calculation by the Pipelife's engineering team it is necessary to submit the following data:

Project data	**Project**	
	Client	
	Designer	
	Date	

Data about the soil around and in the excavation zone	**Basic soil groups**	**Zones (Figure 10.5)**			
		E1	**E2**	**E3**	**E4**
	G1 - not connected				
	G2 - weakly, slightly connected soils				
	G3 - mixed connected soils, coarse, raw clay (blocked with slime, sand, sand with big particles and fine gravel, connected deposit stone soils)				
	G4 - connected (e.g. clay)				

Data about the pressure	**h – Height of covering above the pipe's crown, [m] (Figure 10.6)**		
	Soil's density for covering, [kN/m3]		
	Additional static pressure (for example when storing), [kN/m2]		
	Hw max – maximal level of subterranean waters above the pipe's crown, [m] (Figure. 10.7)		
	Hw min – minimal level of subterranean waters above the pipe's crown, [m] (Figure 10.7)		
	Short-term internal pipe's pressure, [bar]		
	Long-term internal pipe's pressure, [bar]		
	Traffic pressure (mark one of the following cases)	**Traffic frequency**	
		Regularly	**Irregularly**
	LT12 – 12 tons - 2 (semi)axes		
	HT26 – 26 tons - 2 (semi)axes		
	HT39 – 39 tons - 3 (semi)axes		
	HT60 – 60 tons - 3 (semi)axes		

Surface	**First layer**		**Second layer**	
	Thickness h1, [m]	**Elasticity module E1, [MPa]**	**Thickness h2, [m]**	**Elasticity module E2, [MPa]**

Laying	**Embank-ment / Excavation**	**Excavation width above the pipe's crown - b (м) - (from 0,1 up to 20 м)**				
		Excavation angle of repose - β (degrees)				
		Conditions of the excavation from group A1 to A4 (see types of groups at the end)	**A1**	**A2**	**A3**	**A4**
		Conditions of the bedding layer fro group B1 to B4 (see types of groups at the end)	**B1**	**B2**	**B3**	**B4**
		Type of bedding layer	**Angle of laying -2α**			
			60°	**90°**	**120°**	**180°**
		Sand cushion				
		Concrete bedding layer				

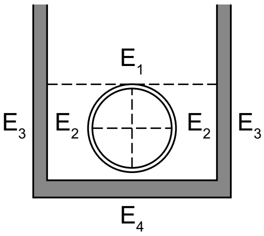


Figure 10.5

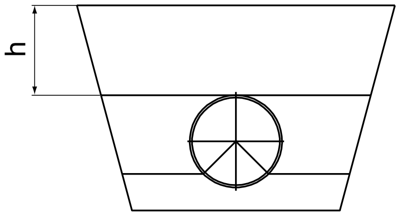


Figure 10.6

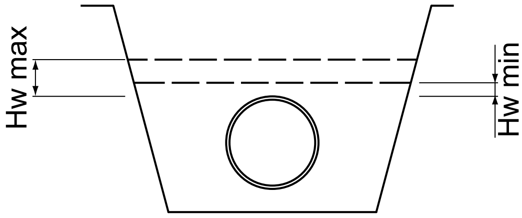


Figure 10.7

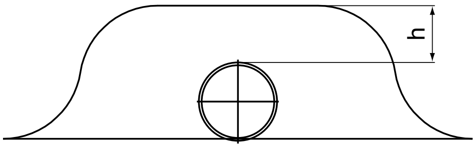


Figure 10.8

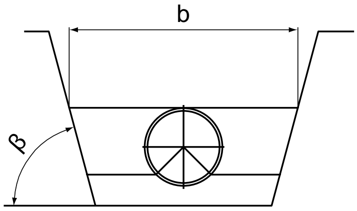


Figure 10.9

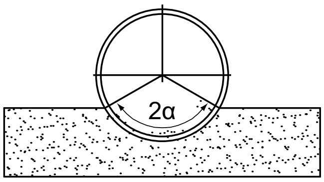


Figure 10.10

The "Cover Condition" ('A1' to 'A4') defines the method of securing and backfilling the trench from the pipe crown to the ground surface.

A1 - Trench backfill compacted against the native soil by layers (without verification of compaction degree); applies also to pile walls.

A2 - Vertical shuttering of the pipe trench using trench sheeting, which is not removed until after backfilling. Shuttering plates or equipment that are removed step by step during backfilling. Uncompacted trench backfill Washing-in of the backfill (suitable only for soils of group G1)

A3 - Vertical shuttering of the pipe trench using sheet piling, lightweight piling profiles, wooden beams, shuttering plates or equipment which are not removed until after backfilling.

A4 - Backfilling compacted in layers against the native soil with verification of the required compaction degree to ZTVE-StB (see Section 4.2); applies also to beam pile walls (Berlin shuttering). Cover condition A4 is not applicable with soils of group G4.

The "Bedding Condition" ('B1' to 'B4') describes the method of securing and backfilling the trench in the pipe zone (trench bottom up to pipe crown).

B1 - Bedding compacted by layers against the native soil or in the embankment (without verification of the degree of compaction); applies also to beam pile walls.

B2 - Vertical shuttering in the pipe zone using trench sheeting that reach down to the trench bottom and is not removed until after backfilling and compaction. Shuttering boards or equipment under the assumption that the soil is compacted after the trench sheeting is removed.

B3 - Vertical shuttering within the pipe zone using sheet piling or lightweight piling profiles and compaction against the trench sheet reaching down below the trench bottom. There is no safe calculation model for determining vertical lining with wooden planks, boards or devices that are not removed until after backfilling and compacting the pipe zone.

B4 - Bedding compacted by layers against the native soil or in the embankment with verification of the required compaction degree according to ZTVE-StB. Embedding condition B4 is not applicable with soils of group G4.

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