krah-pipes.ee

KRAH
PIPES

Technical instructions

Krah drainage, water
and sewage piping systems

European Union
Regional Development Fund

Investing in your future

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KRAH Structured pipes

Materials

Polyethylene (PE63, PE80 and PE100) and polypropylene are thermoplastics with excellent properties for the application of water and sewer, as well as for the fabrication of containers for liquids and solid materials. The environmental friendly polyethylene and polypropylene are resistant to many chemicals and very suitable for conveying and storing various liquids.

Krah pipes can be produced of the following thermoplastic materials:

• Polyethylene (PE80 and PE100)
• Polypropylene (PP-R; PP-H; PP-S)

These materials feature below mentioned properties. Other materials can be used after prior acceptance of the producer and a third party for quality control. However, the processed material should have the below listed specification. Since the latest developments, polypropylene with a really high stiffness can be used, if you are interested ask for further information and data sheets.

Pipe length

The standard laying length (L) of the Krah pipes is six meters, because in this way they are easy to handle, store and transport.

DN/ID = internal diameter (mm)
L= length (mm)
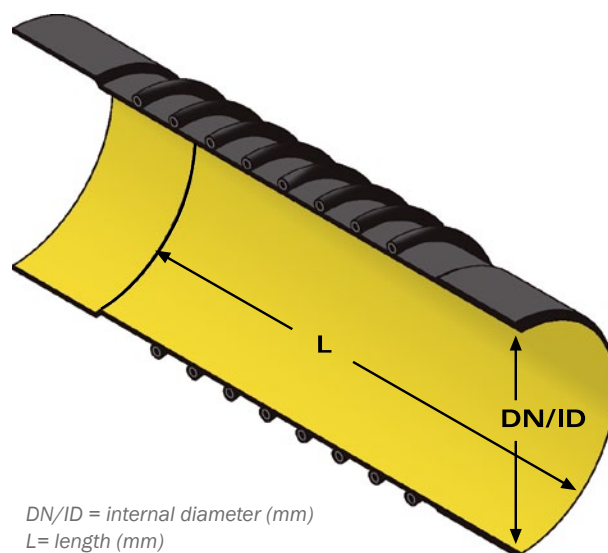
Additionally it is possible to produce pipes with any length between one and six meters. The longer a pipe is, the fewer joints are necessary and this is advantageous for the installation of the pipe. Moreover it is possible to deliver the pipes already jointed, whereby the installation time on site can be reduced signifcantly. Lengths up to 18m consisting of 3 pipe sections are common.

Pipe diameter

Krah pipes can be produced with internal diameters (ID) from DN 500mm to DN 3000mm. The nominal diameters (DN) coincidents with

Typical material specification						
Property		**Standard**	**Unit**	**PE 80**	**PE 100**	**PP-R**
Density		DIN 53479 ISO 1183	g/cm³	0.95	0.96	0.91
Melt index MFR 190/5 MFR 190/21.6 MFR 230/5	Code T Code V Code V	ISO 1133	g/10 min	ca. 0.43 ca. 10 -	0.45 6,6 -	0.50 - 1.25-1.5
Tensile modulus Short term Long term (50 years)		ISO 178	N/mm²	1.000 170	1200 170	750 160
Yield stress		DIN 53495	N/mm²			
Tensile strength		DIN 53495	N/mm²	32	38	15
Elongation at break		DIN 53495	%	> 600	> 600	> 50
Ball indentation hardness		ISO 2039	N/mm²	42	46	45
Coefficient of linear thermal expansion		DIN 53752	1/°C	1.8 x 10-4	1.8 x 10-4	1.6 x 10-4
Colour		-	-	black/ yellow	black/ yellow	gray

the internal diameter (ID) of the pipe, because in case of any change in the design of the pipe, the wall thickness can be increased or reduced while the internal diameter remains the same. This ensures that the designated hydraulic capacity for the installation is maintained.

Wall thicknesses

Both profiled and solid wall pipes with wall thicknesses up to 300mm can be produced.

Minimum wall thickness in accordance with the standard EN 13476, Figure 5.		
Normal pipe dimensions DN/ID (mm)	s1 PE pipe (mm)	s1 PP pipe (mm)
300	2.0	2.0
400	2.5	2.5
500	2.5	3.0
600	3.3	3.5
800	4.5	4.5
1000	5.0	5.0
> 1200	5.0	5.0

The quality of the pipe is highly depending on the quality of the waterway wall, therefore all Krah pipes are produced with a minimum waterway wall of 4mm.

Profiled pipe wall

The great advantage of this development is that a profiled pipe has a very low weight, but at the same time can be used for high load applications. A lot less material is needed to produce a pipe with the same statical properties than a solid wall pipe, which means significant savings in material costs.

The supportable static load is determined for every profile geometry by the factors elastic modulus (N/mm2) of the respective material and the moment of inertia of the profile geometry (mm4/mm) referring to the pipe diameter. The result is called ring stiffness. By using a

profiled pipe, the weight can be reduced up to 65% compared to a solid wall pipe with the same ring stiffness. Krah pipes offer the best security and durability. The wall thicknesses of our pipes can be adapted in small steps to the respective load.

Internal pressure

The Krah pipe system can withstand low working pressure up to 3 bar, depending on the thickness of the waterway wall (s1). Equivalent to DIN 8074 the hoop stress formula can be used to calculate the s1 as the minimum wall thickness.

Co-extrusion

If requested all pipes can be delivered either with a bright, inspection friendly or an electroconductive inner surface made by the co-extrusion process.

The co-extrusion ensures an inspection friendly, bright inner surface and at the same time a long term UV-resistant outer surface (for example for the storage of pipes outside for a long time).

Norms and standards

The Krah pipe system is designed to meet the requirements of present applicable international norms and standards. Krah AG is member of the major standardization committees to guarantee that the pipes are corresponding to the standards, but also that the standards are corresponding to the pipes.

1. Technical parameters

1.1. Specific light weight

The Krah pipes have a very low weight and therefore are easy to handle during installation, which makes the usage of a crane on site in most of the cases unnecessary.
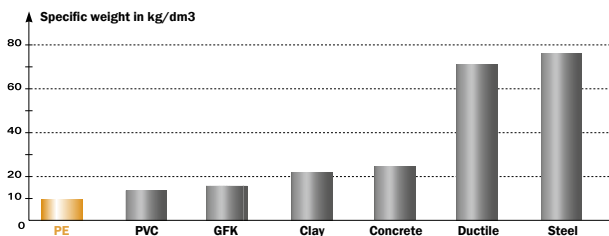
Material characteristic values

By using profiled pipes we can safe weight up to 65% compared to equivalent solid wall pipes with the same statical capacity.

1.2. Flexibility

Pipes made of Polyethylene and Polypropylene have considerable advantages to other pipe materials like concrete, steel, ductile etc. Due to their material the Krah pipes posses over a high elongation at break. This signifies, that the pipe can support even loads or deformations, that were not included in the actual calculation and design of the pipe, like for examples earthquakes. The Krah pipes deform conform with the movement of the earth without any breaks or cracks, so that the activity of the pipeline is not drastically affected. As soon as the overload and earth movement ends, the pipe will go back to its initial condition and position.

Another advantage is the high flexibility. Even in areas which are highly affected by 11 earthquakes, our pipes are hardly damaged in comparison to pipes made of other materials. Despite the flexibility of the Krah pipes they have a great capacity to carry loads, so that they are also suitable for road construction.

1.3. Abrasion resistance

Polyethylene and polypropylene pipes are among the most abrasion proof pipes. This has been tested in the so-called Darmstadt procedure and the results are shown in the below diagram and confirm the quality of polyethylene pipes. Tests have been performed at the "Süddeutsche Kunststoffzentrum" for its approval.
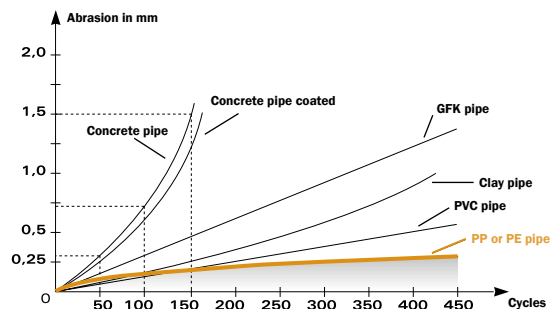

Abrasion curve of various pipe materials according to the Darmstadt procedure.

1.4. Impact resistance

The high impact resistance, even at low temperatures, ensures a robust pipe, resistant against impacts during transport, installation on the site and during the whole service life conditions.

1.5. Hydraulics

Inner diameter and hydraulic properties of Krah pipes will remain constant regardless of the wall thickness or the profiles due to the smooth anti adhesive inner pipe surface. The nominal diameter (e.g. DN/ID 500) corresponds to the respective inner diameter according to DIN 16961. Compared to other pipe materials like concrete, smaller diameters can be used, which means that costs for material and installation can be reduced considerably.

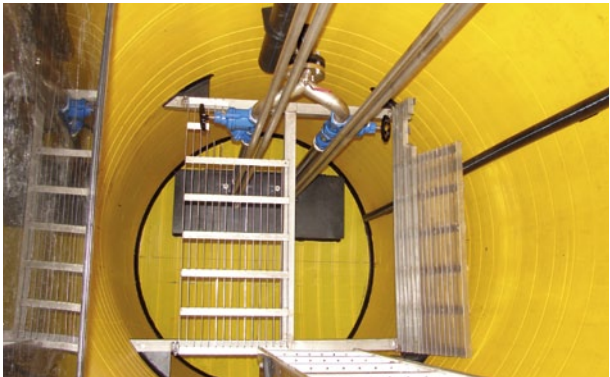*Tank 60m³*
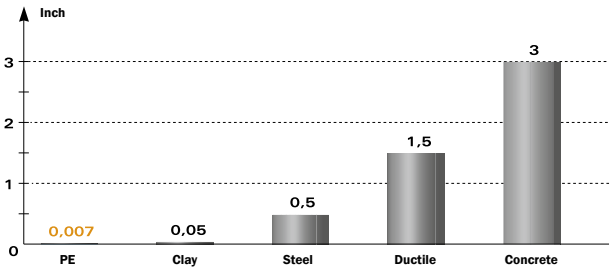
Wall roughness

1.6. UV-resistance

Black polyethylene pipes are permanently resistant to atmospheric corrosion and UV radiation. Thus the pipes can be used and stored outside without the pipe material being damaged. No aging effect will occur.

Pump room

Pump room (internal view)

2. Profiles

The ring stiffness will be determined for each profile, based upon the long-term elasticity module of the Polyethylene (Young's module), the moment of inertia of the profile and the diameter of pipe. Using structural pipe walls significantly reduces the weight of the pipes compared to pipes used in regular construction with equal ring stiffness. The structural wall of Krah pipes makes it possible to use these pipes for large static loads.
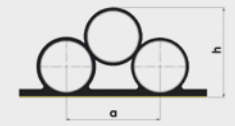
2.2. Profile types of KRAH pipes

Profile type: PR

The main properties of the profile serie PR is the smooth inside and the profiled outside. The low weight and the high stiffness are significant.

The fields of application for this kind of profiles are pipeline systems like for example sewer, drain, storm drain and ventilation.

Profile type: OP

This profile has a smooth inside surface and the outside surface is profiled with an Olympic-rings-alike pattern. The main characteristics of this profile are also its low weight and very high stiffness.

Profile type: SQ

This profile pipe has a smooth inside and outside including internal profiles with one or more layers. This profile has a very high long-term stiffness therefore it is very suitable for extremely high loads and big diameters.

Profile no	lx [mm⁴/mm]	e [mm]	se [mm]
PR	317 - 47 548	6.02 - 36.38	15.61 - 82.94
OP	14 942 - 194 000	32.98 - 75	56.39 - 132.44
SQ1	7 700 - 27 000	22.74 - 37.52	45.35 - 68.68
SQ2	34 400 - 107 900	41.32 - 65.07	74.48 - 108.99
SQ3	92 000 - 300 000	60.04 - 95.99	103.35 - 153.18

List of typical profiles
lx = moment of inertia, e = distance of inertia,
se = equivalent solid wall thickness

Profile type: VW

The type VW is a homogeneous solid pipe with smooth inside and outside surface. These pipes can be used for internal working pressure. The minimum wall thickness measures 5mm, the maximum thickness is 80mm.

Profile type: ST

Pipes with the profile type ST are specially made for vertical tanks, where different wall thicknesses in one pipe are required to save material. The calculation method is according to DVS 2205.

Profile type	Cross-section	View
PR		
OP		

Stepped pipes	minimum	maximum
Nominal width (Di)	300 (mm)	4000 (mm)
Number of steps (n)	two	six
Length of step (L)	200 (mm)	length of a pipe
Wall thickness of step (s)	5 (mm)	300 (mm) for PE 150 (mm) for PP
Step distance	5 (mm)	

Technical data of stepped pipes
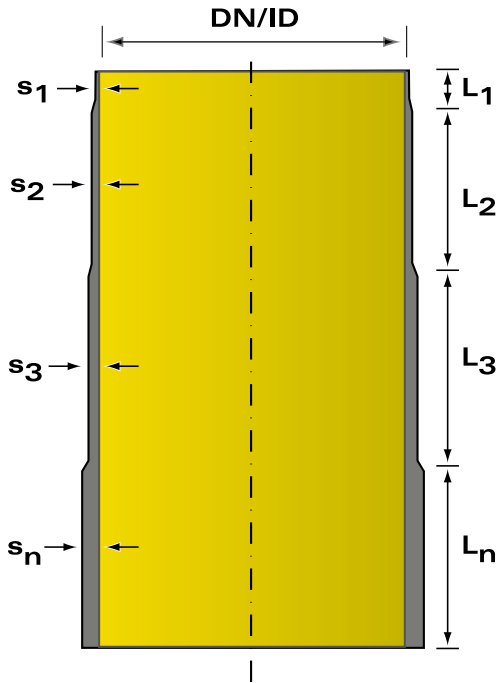
Sketch of a stepped vertical storage tank
S1 = wall thickness of the step i
L1 = length of the step i

ID	Profile	SN	h	OD	a
500	PR21	2	27	554	120
	PR34	4	39	578	120
	PR34	6	39	578	120
	PR34	8	39	578	100
600	PR21	2	29	658	120
	PR34	4	39	678	120
	PR34	6	41	682	120
	PR42	8	46	692	100
800	PR34	2	39	878	120
	PR42	4	48	896	120
	PR54	6	60	920	120
	PR54	8	60	920	120
1000	PR42	2	46	1092	100
	PR54	4	60	1120	120
	PR65	6	71	1142	140
	PR65	8	73	1146	140

ID	Profiil	SN	h	OD	a
1200	PR54	2	60	1320	120
	PR65	4	71	1342	120
	PR75	6	83	1366	140
	PR75	8	85	1370	140
1400	PR65	2	71	1542	140
	PR75	4	83	1566	140
	PR75	6	87	1574	140
	PR75	8	91	1582	140
1500	PR65	2	71	1642	120
	PR75	4	85	1670	140
	PR75	6	89	1678	120
	PR75	8	95	1690	140
1600	PR65	2	73	1746	140
	PR75	4	87	1774	140
	PR75	6	93	1786	140
	PR75	8	97	1794	140
1800	PR75	2	83	1966	140
	PR75	4	91	1982	140
	OP65	6	122	2044	120
	OP65	8	127	2054	120
2000	PR75	2	85	2170	120
	OP65	4	117	2234	120
	OP65	6	127	2254	120
	OP65	8	132	2264	140
2200	PR75	2	89	2378	120
	OP65	4	127	2454	100
	OP65	6	135	2470	100
	OP65	8	142	2484	120
2400	PR75	2	93	2586	140
	OP65	4	132	2664	120
	OP65	6	141	2682	120
	OP65	8	151	2702	100
3000	OP65	2	131	3262	100
	OP65	4	148	3296	120
	OP65	6	169	3338	100
	SQ354-299.51	8	171	3342	61

Figure 1.1 Profile types of KRAH pipes

3. Designing

3.1. Calculating of hydraulic parameters

Hydraulic calculations

The basis for hydraulic calculations for pipes is the European standard EN 752:2008 [1]. To calculate the average flow velocity in drainage and sewage piping systems the flow is considered to be in turbulent mode. This standard includes two equations for calculating the turbulent flow: Colebrook-White's and Manning's equations.

Colebrook-White's equation

The average flow velocity in a round pipe completely filled with fluid can be calculated using the following equation:

$$v = -2\sqrt{(2gDI)}\,\log_{10}\left(\frac{k}{3.71D} + \frac{2.5\mathbf{l}v}{D\sqrt{(2gDI)}}\frac{1}{J}\right) \qquad (1)$$

where:
v is the cross-sectional average velocity of flow, m/s;
g – the acceleration of gravity, m/s2;
D – the pipe inside diameter, m;
I – the dimensionless hydraulic gradient;
k – the roughness of pipe inside wall, m;
v – the kinematic viscosity of fluid, m2/s

In cases where the pipe which is partially full of fluid or non-circular for calculating the average speed using this equation (1), internal diameter D is replaced with 4Rh, where Rh is hydraulic radius (ratio of the flow section A and wetted perimeter χ). Figure 1 presents how this value 4Rh/D correlates with the relative fulfillment of the pipe (h is depth of water in pipe).

Relative fulfill-ment of the pipe h/D	Correlation between hydraulic radius and diameter $4R_h/D$	Relative fulfill-ment of the pipe h/D	Correlation between hydraulic radius and di-ameter $4R_h/D$
0.1	0.2500	0.6	1.1104
0.2	0.4824	0.7	1.1848
0.3	0.6836	0.8	1.2168
0.4	0.8568	0.9	1.1920
0.5	1.0000	1.0	1.0000

Manning's equation

Average flow velocity in a pipe with round or non-round cross-section in cases of full or partial fulfillment is calculated with the following equation:

$$v = KR_h^{2/3}I^{1/2} \qquad (2)$$

where:
K is Manning's coefficient, m1/3/s;
Rh – the hydraulic radius, m;
I – the dimensionless hydraulic gradient

Head losses

Pipe roughness (k) or Manning's coefficient (K) will determine the friction head, which is related to the material of the pipe, the unevenness in pipe joints and debris which accumulates below the surface of the water.

In addition to that, head losses occur in the branching of pipes, at changes of cross-section, in manholes, in bends and other fittings. For calculating purposes the following equation can be used:

$$h_L = \frac{k_L v^2}{2g} \qquad (3)$$

where:
hL is the local head loss, m;
kL – the dimensionless coefficient of local obstruction;
v – the average velocity, m/s;
g – the acceleration of gravity, m/s2

Total head loss

To calculate the total head loss the following methods are recommended [1]:

- To add local head losses to friction head losses caused by flow in pipes;
- Assuming higher hydraulic roughness while calculating the friction head losses, the local head losses are considered to accrue to the total head loss.

When using recommended hydraulic roughness in calculating the pipes it is necessary to determine whether the impact of local head losses has been added to the value of the roughness. In practice, the k values for the roughness of the pipe inside wall are normally between 0.03 mm and 3.0 mm and Manning's coefficient K is between 70 and 90 m1/3s-1.

An approximate comparison between estimations of computational velocities based upon equations (1) and (2) can be performed using the following equation:

$$K = 4\sqrt{g\left(\frac{32}{D}J\right)^{1/6}} \log_{10}\left(\frac{3.7D}{k}J\right) \qquad (4)$$

where:
K is Manning's coefficient, m1/3/s;
g – the acceleration of gravity, m/s2;
D – the pipe inside diameter, m;
k – the pipe inside wall roughness, m

The choice of pipe diameter is dependent on the pipe gradient, the volumetric flow rate and the average flow velocity. This is aided by a nomogram, which is shown in Figure 1. This nomogram was created using Colebrook-White's equation (1) on the condition that the pipe is entirely full, the viscosity of water v= 1.03 10-6 m2/s and the pipe's inside wall roughness k = 0.007 10-3 m. In cases where there is a partially full pipe, in equation (1) diameter D shall be replaced with 4Rh.

Figure 1. Nomogram
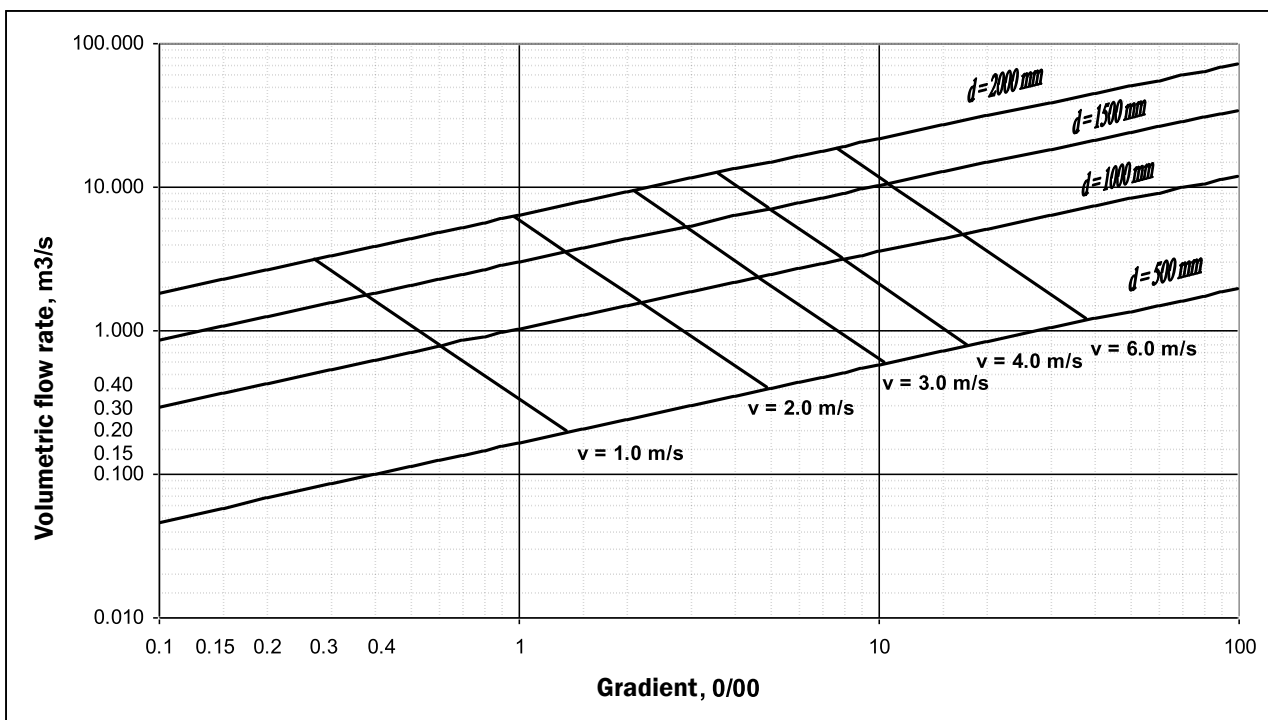
3.2. Static calculation of pipes for underground installation

A significant advantage of Krah pipes is that they can be easily tailored to the needs of various types of projects. In accordance with the different norms and standards, the pipes must be selected in accordance with their class of nominal ring stiffness (SN), as SN2 (only for pipes DN> 500), SN4, SN8 or SN16 (in accordance with the standard ISO9969), or in accordance with any other stiffness standard (DIN16961, ASTM F894, NBR 7373 etc) notwithstanding the testing methods (at constant speed or constant load).

In addition to this, in accordance with Article 9.1 of the standard EN 13476-3, the manufacturers are allowed to produce pipes DN/ID > 500 that fall between the above listed SN-classes. To qualify for this admission the producer must be able to prove this solution with static calculations. With Krah pipes, we are able to provide any project with pipes of the precise stiffness that the project demands.

It is useful to perform static calculations for Krah pipes taking into consideration the specifications of each particular project. In 99% of cases the pipes selected for a particular project are over-dimensioned in the original project design documentation. Using the calculations it is possible to prove that it is sufficient to install a pipe with less stiffness but the correct profile, including the required safety factor which is also cheaper and faster to install. In addition to this, first of all, the actual quality of the pipes depends on the correct wall thickness, the raw materials used and reliable jointing technology – but not on stiffness.

3.3. Pipe fittings

The Krah pipe can be provided in the complete range of diameters and stiffness classes but also fittings, manholes and other components are deliverable to accomplish the mission of a homogenous and reliable pipe system.

All fittings are fabricated from pipes of the type VW or SQ. Generally the ittings are designed corresponding to the required stiffnesses and in consideration of the welding factors. Every fitting can have any kind of pipe end and can be assembled with the existing pipe system with any jointing technique.
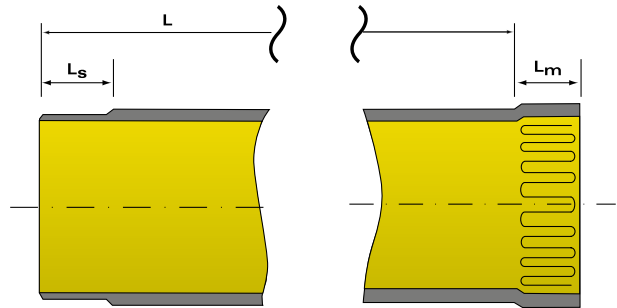
All pipe end dimensions fuli ll the requirements of the standard EN 14376, like the minimum lengths and stiffnesses. The standard spigot length (Ls) is 140mm and the standard socket length (Lm) is 140mm.

3.4. Branches

Branches can be manufactured and delivered in every type and form. The angle can be adapted individually from 15° to 90° as well as the ends and the respective segment lengths.

3.5. Bends

Bends can be manufactured and segmented in different angles and the related radius of the bend to pipe diameter can be selected independently.

α	Number of segments
15°	2
30°	2
45°	3
60°	3
75°	4
90°	4

Number of segments

The figure presents the angles of the standard bends in accordance with the DIN 16961 standard. Other solutions are in accordance with the customer's requirements.

3.6. Reductions

Reductions can be made both centric and eccentric so that the reductions will always meet the requirements. For standard reductions the maximum difference in diameter is 200mm, other differences on request.
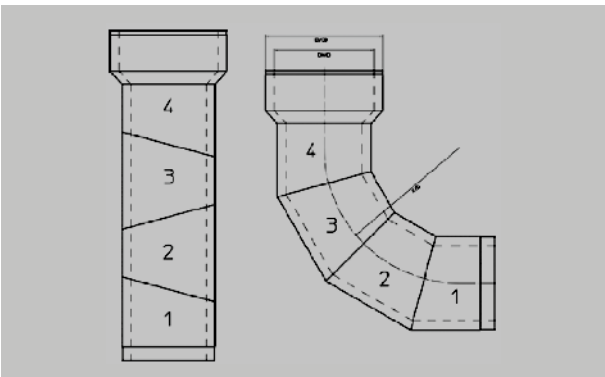
Devision and new arrangement of the pipe segments to create a 90° angle.

3.7 Manholes

Krah Pipes produces manholes in accordance with the designer's specifications. Manholes are made of polyethylene and they are in accordance with all the international regulations and standards. The materials used are environmentally friendly and durable. Therefore, they are the best choice for producing pipes, manholes and tanks.

Krah's product portfolio includes a wide choice of manholes for water and sewage pipelines. According to the customer's requirements they can either have a hatch made of cast iron or plastic. Hatches can be joined to the manholes in one of two ways: either fixed rigidly or by using telescopic pipe which allows them to move. We produce manholes with solid and grated hatches, both of which can be round or square.

The diameter of a manhole depends on its purpose. Normally the diameters of the jointing ends and where they are placed in relation to each other will be the most important factor. Also, the size of the equipment used for cleaning the sewage system must be considered.

Diameters of most common manholes (body/telescope):
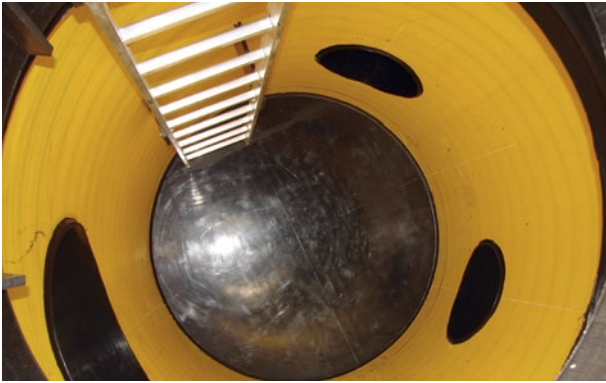
OD200/OD160 mm

OD400/OD315 mm

OD560/OD500 mm

ID800/OD500 mm

ID1000/OD630 mm

To make it easier to inspect them, all Krah manholes have a yellow inside surface.

Inspection manhole for rainwater DN/ID1600

Pipelines from a diameter of DN/ID800 mm and upwards we recommend, if possible (curvature manholes, flowing-through manholes) the more economical saddle manholes.

Saddle manhole OD560mm, for ID1000 mm pipe

Main functions of manholes:

Rainwater and drainage manholes

These manholes are meant to divert rainwater. In most cases these manholes have a smooth base, and are between 200 mm and 1000 mm in diameter. Grated manholes are also produced, which are normally used to divert water from parking lots to the piping.

Inspection manhole for rainwater DN/ID1500

Sewage manholes

These are used for the inspection and maintenance of sewage piping. Manholes are made with a flowing channel to provide a steady flow of refuse liquids. The recommended size for the flowing channel is 1/3 – ½ from the diameter of the main line. This means that there is a channel at the base of the manhole to ensure the better flow of refuse liquids.

Inspection manhole for sewage DN/ID800

NB! If possible, please avoid using square angle turns in the flow channel. To prevent a turn with a square angle we recommend the use of a manhole body with a suitable diameter into which a gently sloping flow channel can be built.

A turn inside manhole ID800

Rainwater manholes

Gate valve manholes

To open and close sections of water and sewage piping. A gate valve manhole facilitates all-year-round maintenance of the piping.

Air release manholes

These are used to release air that emerges from water and sewage piping where there are significant height differences.

Water meter manhole

These are used to measure the amount of fluids which pass through the water and sewage piping.

Inspection manhole

The inspection manhole is used to inspect the quality of the fluids that flow in the sewage piping.

Flow reducing manhole

This is used to reduce the flow speed in rainwater and sewage piping.


Saddle manhole

Rainwater manholes with electro-fusion fittings

4. Jointing methods for KRAH pipes

4.1. Jointing pipes using integrated electro-fusion fittings

A complete pipe system is always just as secure as its weakest component. The weakest component is the joint. Therefore it is important to choose the most suitable and permanent one. The welding of small diameter plastic pipes and fittings with the help of electro fusion has been a common method in the market for years. Above all because this jointing technique is very favourable, simple and secure, which has caused Krah to develop this technique for big pipes according to DVS 2207-1.

A fusion wire is included into the socket of the pipe. After putting the socket and spigot of the two pipes, that shall be jointed, together, the wire is heated with the help of a special fusion device whereby the two pipe ends (the socket and the spigot) are welded together. This jointing technique allows pipes to be installed in such a short period of time never achieved before. With only one welding device it is possible to install a pipeline of 72m with a diameter of 1200mm inbetween 8 hours. The installation speed is now depending on the trench works.
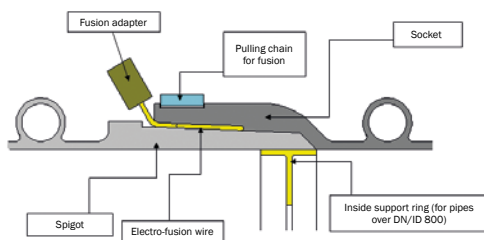
Jointing and fusing instructions for KRAH pipes with electro-fusion socket

1. Power source: The power of the generator must be at least 15 kVA. Ensure the stable characteristics of the current!
2. Fusion can only be performed by authorized personnel.
3. The fusion areas must be free from dirt andhumidity and be out of direct sunlight.
4. If the outside temperature is below +5°C, additional measures must be used, such as a tent and heating fan.
5. Check the sockets and spigots for possible damage during transportation.
6. Remove the protective film only when you are ready to start cleaning the pipes and are going to joint immediately.
7. Install the pipe in a way that the welding wire is easily accessible.
8. The sockets and spigots must be cleaned with detergent and paper which is not fluffy or colored.
9. Mark the spigot with waterproof marker on the length of the pipe which enters the socket (at least 120mm).
10. Joint the pipes and make sure that the spigot goes into the socket as far as the previously marked line. Make sure that there is no moisture between the sockets and spigots.
11. In cases where the pipes are larger than DN/ID 800, an internal support ring for the spigot must be installed (ca 20 mm from the end of the pipe).
12. After finishing these preparations start immediately with the fusion process.

Items 13 and 14

13. Place the KRAH pulling chain into the special channel at the end of the socket. The tensioner must be placed at least 25 cm away from the welding wire.
14. Pull the chain until the value of the tightening torque is reached, as presented in the chart below.

15. In cases where the pipeline is short make sure the sockets and spigots are fixed properly and cannot move.
16. Joint the fusion equipment with the welding wire using the adapter. If necessary, bend and cut the ends of the welding wire for the adapter so it is as close as possible to the socket. Make sure the welding wires won't touch each other (short circuit).
17. Enter the fusion parameters (read from the barcode with special equipment or enter manually). Begin the fusion process.
18. At the beginning of the last third of the fusion, pull the pulling chain again until the required value of the tightening torque is reached in the chart below.
19. When the fusion time is over mark the fusion with waterproof marker (No. of fusion, date, voltage used, time, name of operator).
20. Remove the adapter from the welding wires.
21. Do not move the pipe during the cooling period.
22. After the cooling period (about 35 – 45 mins) remove the pulling chain and the inside support ring.
23. Checking and testing of the drainage and sewage piping joints is regulated with the standard EN 1610:200.


item 14
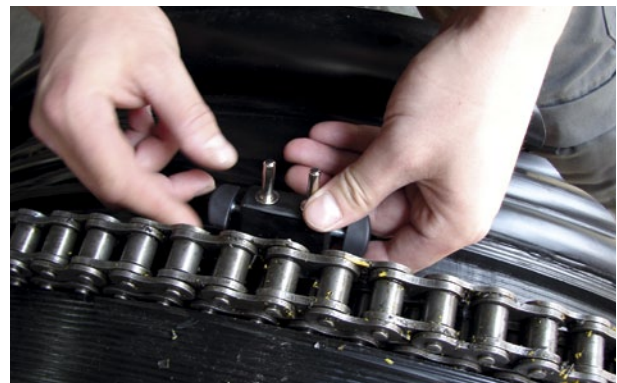
item 16

DN/ID (mm)	Voltage (V)	Time (sek)	No. of fusion equipment	Tightening torque at the beginning of fusion	Tightening torque for over-tightening after 2/3 of fusion period
500	20	900	1	50 Nm	60 Nm
600	24	1020	1	50 Nm	60 Nm
800	33	1020	1	55 Nm	65 Nm
1000	40	1080	1	55 Nm	70 Nm
1200	43	1260	1	60 Nm	70 Nm
1400	28	1020	2	60 nm	70 Nm
1500	32	1020	2	65 Nm	75 Nm
1600	32	1080	2	65 Nm	78 Nm
1800	40	880	2	75 Nm	90 Nm
2000	39	1200	2	80 Nm	90 Nm
2200	41	1260	2	85 Nm	95 Nm

Fusion parameters for KRAH pipes for manual input and tightening torques for pulling chain.
Send an enquiry for the parameters for bigger diameter.

4.2. Jointing KRAH pipes using gasket
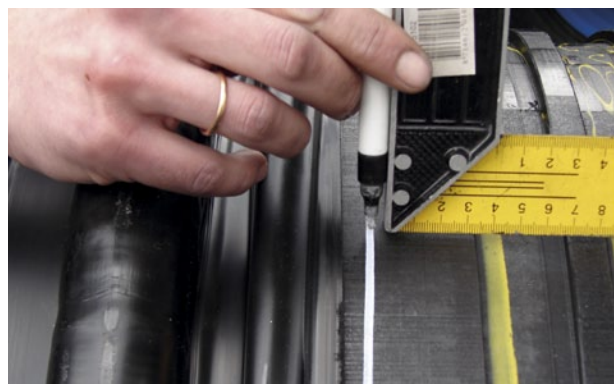

Gaskets

- Two gaskets per joint
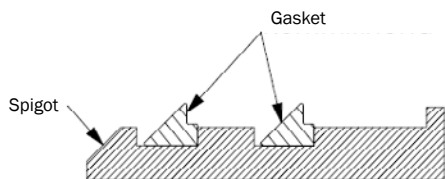
- Install the gaskets as shown in the figure

- To facilitate the installation, it would be good if the ground around one of the pipes to be jointed could be partially backfilled as this ensures proper support during the jointing and prevents the pipeline from waving.

- Mark the spigot with waterproof marker on the length of the pipe which will enter the socket (at least 125mm).

Marking

- Cover the sockets and spigots with PLENTY of lubricant.

- The spigots and sockets must be kept clean during the lubrication as well as the jointing process.

- Joint the pipes up until the marked line on the spigot has been reached.

- During the jointing period a mechanical aid is needed. If you joint by pushing, a device to spread the pressure must be used (e.g. a wooden sheet), to prevent the socket from being damaged.

Grooves for gaskets on the pipe

- Avoid dragging the pipe ends.

- Krah pipes with a gasket jointing are for use in straight pipelines. In cases where there is a curvature in the project, a pipe bend must be used.
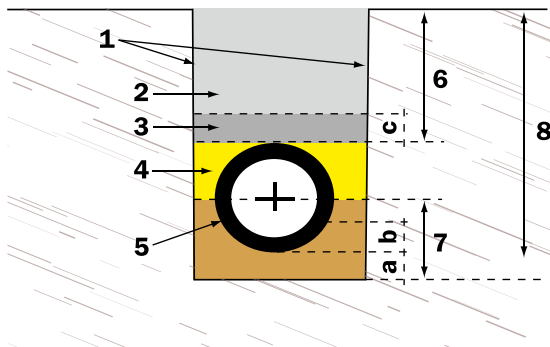
5. Installation of KRAH pipes

5.1. Trench

1. Trench walls
2. Final backfill
3. Initial backfill
4. Sidefill
5. Bed
6. Depth of cover
7. Depth of bed
8. Depth of trench

a – depth of lower bed layer
b – depth of higher bed layer
c – depth of initial backfill

b=k x OD (see chapter "fill and support")

where:
k – a factor without unit, ratio between depth of higher bed layer b and OD

OD – outer diameter of pipe in millimeters

Note 1.

For minimal values for a and c see chapter "fill and support"

Note 2.

In some national standards k x OD replaces the determination of the bed angle. The bed angle is not the same as the reaction angle of the bed used in the construction design documentation.

Trenches must be designed and excavated in a way that guarantees an installation which is safe and which fits the requirements.

If the underground constructions, e.g. manholes, need to be accessed from the side, a protected working zone with a minimum width of 0.5 m must be provided. If two or more pipes are going to be installed into the same trench or embankment, the minimal horizontal inter-pipe working area must be observed. If it has not been stated otherwise, it must be: for pipes up to and including DN700 0.35 m and pipes over DN700 0.5 m.

Installation of Krah pipes DN/ID1000 at a construction site

5.1.1 Width of a trench

5.1.1.1 Maximum width of a trench

The maximum width of a trench cannot exceed the maximum width as provided in the construction design drawings.

If this is not possible, the designer must be contacted.

5.1.1.2 Minimum width of a trench

The minimum width of a trench must exceed the values provided in Figures 1 and 2, except in the cases covered in Section 5.1.1.3.

DN	Minimum width of trench (OD+x) m		
	Supported trench	Unsupported trench	
		ß > 60°	ß ≤ 60°
≤ 225	OD + 0.40	OD + 0.40	
> 225 to ≤ 350	OD + 0.50	OD + 0.50	OD + 0.40
> 350 to ≤ 700	OD + 0.70	OD + 0.70	OD + 0.40
> 700 to ≤ 1200	OD + 0.85	OD + 0.85	OD + 0.40
> 1200	OD + 1.00	OD + 1.00	OD + 0.40

Figure 1 – Minimum width of trench with respect to nominal size (DN). In the equation OD+x, x/2 equals the minimum working space between the pipe and the wall of the trench or supports, where: OD is the external diameter in meters and ß designates the angle of the unsupported wall of the trench, measured with respect to the horizontal (see Figure 2).

Depth of trench m	Minimum width of trench m
< 1.00	No minimum width required
≥ 1.00 ≤ 1.75	0.80
≥ 1.75 ≤ 4.00	0.90
> 4.00	1.00

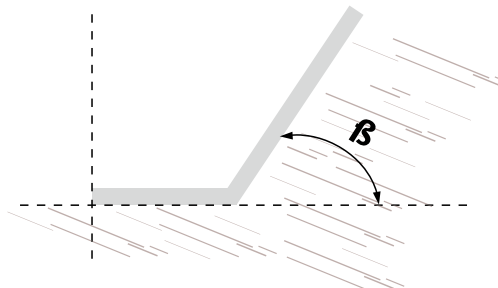*Table 2 – Minimum width of trench with respect to depth of trench*

Figure 2 - angle of unsupported wall of trench ß

5.1.1.3

The minimum width of the trench based upon Tables 1 and 2 can be amended in the following circumstances:

- If the staff must never go into the trench;
- If the staff must never go between the piping and the wall of the trench;
- In unavoidable limited situations.

In all these cases special precautions must be considered during the design and construction.

5.1.2 Removal of water

During installation the excavations must be kept free of water. Methods for disposing water must not damage the filling material or piping. After the water has been disposed of, all the temporary drains must be closed properly.

5.2. Filling material and support

Materials, base layer, support and thickness of the filling layer must be in accordance with the design documentation. The filling material and its fractional composition together with the support must take the following into consideration:

- Size of pipe;
- Material of pipe and wall thickness;
- Characteristics of the ground.

The width of the base layer must be equal to the width of the trench, if it has not already been determined otherwise. The width of the base layer for the piping installed into the embankment must be four times OD, if it has not been determined otherwise.

The depth of the initial backfill, c (see Figure 1) must be 150 mm over the cylinder and 100 mm over the joints.

All soft ground under the base of the trench must be removed and replaced with material suitable for the base layer.

5.3. Backfill

Placing the sidefill and backfill can only be started if the pipe joints and the base layer allow loading.

Backfill, including placing the filling material and the final backfill, the removal and packing of the closing wall of the trench must be carried out in a way that ensures the loading capacity of the piping in accordance with the project documentation.

The filling material must be placed in a way that prevents the existing ground from falling in or the filling material being mixed with the existing ground. In special cases, especially if ground water is present, geotextiles or an inverted rectifier may be needed to keep the filling material in place.

Suitable precautions must be observed in locations where the flow of groundwater may replace small ground particles or where the level of ground water may be reduced.

Should parts of piping need to be anchored, this must be done before the filling material is put in place.

5.4. Packing

While installing Krah pipes, the side- and initial backfill must be packed at least up to 90% of the standard density - Proctor density.

If required, the initial backfill, which is directly over the pipe, must be packed manually. The final backfill, which is directly over the pipe, cannot be packed mechanically until the total depth of the filling material over the pipe is 300 mm. The total depth of the cover directly over the pipe before mechanical packing depends on the type of packing equipment. While deciding upon the packing equipment, the number of passing throughs and the depth of the layer to be packed, the material to be packed and the pipe to be installed must be considered.

5.5. Leakage test

According to the requirements pipe systems have to be tested for leakage. There exist different kinds of test procedures.

The first alternative is the section test, where the total pipe sections (between two manholes) are tested in all. Air hoses are blown up and they lock the pipes at both ends. Then, water with a certain nominal pressure is pumped into the tightened section. This overpressure is tested after a certain period of time which gives information about the leakage of the section.

The other alternative is the jointing test (only possible with diameters greater than DN/ID 600mm), where only the pipe joints are tested as it is assumed that the pipes themselves are tight. A leakage testing device is used but the testing principle is the same applied in the section test, the only difference is that the test area is the joint.

6. Pipe-in-pipe-method renovation

The reconstruction of damaged sewage pipes using the restoration "Pipe-in-pipe-method" is very important. Krah pipes are perfect for restoring broken pipes. The stiffness of the pipes is calculated using actual loads. Also, in order to restore short pipes, Krah provides suitable solutions. Welding will take place within the pipe. Pipes are available in lengths of 1 m to 6 m. With Krah pipes it is possible to restore the static throughput capacity of a sewage piping system without digging it out. In cases of longer trenches, it is possible to use up to 18 m of pre-produced pipes. In cases of DN 800 pipes or with pipes that have larger diameters, it is possible to insert single pipes into the existing sewage piping and to joint them using internal extrusion welding.

7. Transportation

It is very easy to transport Krah pipes, as the pipes are lightweight. During transportation the pipes must be secured to prevent them from moving. In special cases, if the pipes are delivered in a container, the space should be used efficiently and the lengths of pipe must be adjusted to the transportation conditions.

8. Storage

While storing pipes and pipe fittings it is important to ensure that the ground is smooth and to avoid point loads. Further, it must be made sure that there are no stones or any other objects with sharp ends. Then, it is important to check that the spigots and sockets of the pipes loaded on each other are in different directions.

This means that each layer of pipes shall be in the opposite direction to the next layer – the socket is side-by-side with the spigot. Sockets cannot be in contact with the sockets in the next layer.
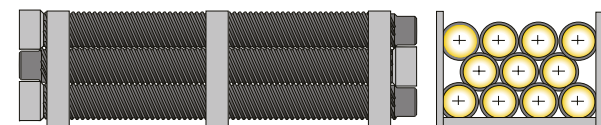
A sample about storing Krah pipes

9. Quality control

Total quality management

The quality of the pipes and the pipe products is the criterion for all developments of Krah AG and companies using the Krah technology. As the international requirements vary because of the different norms and standards, there exists a multiplicity of test procedures for the quality assurance. The whole production process is included in an extensive Total-Quality-Management-System. There are two main fields, the one is the internal quality control and the other is the external (third-party) quality control.

Generally the internal quality control is divided into three different steps:

1. BEFORE PRODUCTION CONTROL

The raw materials and any other input are tested regarding the melting flow ratio, moisture and colour. Usually any new delivery of material is tested before it is stored. Every test is documented, analysed and filed.

2. DURING PRODUCTION CONTROL

During the production the individual working steps are continously supervised and documented. Moreover the most important dimensions are measured and if necessary, corrected.

Inspection of ring stiffness

3. AFTER PRODUCTION CONTROL

After the production, the final product is tested and compared with the requirements of the customer. The final minute is written and the documentation is finished. In order to guarantee that the static theoretic values are conform to the reality pipes are continuously taken out of the production and they are tested with the help of a ring stiffness test according to DIN 16961 or ISO 9969.

Measuring the width of the pipe wall

The quality assurance demands a great know-how and therefore the Krah AG has created a Quality handbook in which all the important tests including the necessary machines are described. In order to give the customer an impression of the quality control it is possible to have a look into the handbook.

Marking

Depending on the used pipe standard, the marking can be different. A minimum marking is: The pipes shall be marked at intervals of maximum 2m, at least once per pipe.

The marking must include at least the following:

- **No. of standard** (e.g. EN13476)
- **Nominal dimension** (e.g. DN/ID 1000)
- **Producer** (e.g. Krah Pipes)
- **Ring stiffness class** (e.g. SN8 in accordance with the standard EN13476)
- **Ring elasticity** (e.g. RF30 in accordance with the standard EN13476)
- **Material of pipe** (e.g. PEHD)

Marking

Quality certificates

In general the whole production is constantly supervised by a third party inspection. The quality control exceeds by far the ISO 9000 certifications because in our case the quality of the final product is tested. As result we are in the position to issue quality certificates for every delivery of pipes from the most simple quality certificate 2.2 to the first class certificate 3.1b according to EN 10204.

The recent certificates given to Krah pipes are always available on our website: www.krah-pipes.ee in the sub-directory: Certificates.

DIN 16961-2:2010-03

Annex B (INFORMATIVE)
Methods of assessing the load capacity of pipes

B.1 General

One of the most frequent uses of profiled pipes is in buried piping systems. Before these are installed, proof of their load bearing capacity is required to be provided.

This proof can be provided in the form of structural design calculations or computational graphs or tables based on practical experience and comparative calculations.

Structural design based on analysis or computation is not generally necessary in thermoplastic pipe design. In practice, each calculated prediction of the behaviour of a pipe is heavily dependent on the conditions assumed for the purposes of the calculation corresponding to actual conditions on-site. With this in mind, in critical cases it is recommended that the input data be carefully checked and verified by carrying out soil analyses and monitoring pipe-laying operations.

In standard installation situations (see Table B.1), predictions of the behaviour of underground pipes can be made on the basis of practical experience.

**B.2. Structural design based on practical experience**

On the strength of decades of experience, and provided the pipes used are at least of the minimum quality-required by this standard and are properly laid, most construction work involving underground pipes can be carried out without any need for complicated structural design calculations (see CEN/TS 15223, DIN EN 13476-1).

The limiting values specified in Table B.1 shall be observed in respect of the installation conditions and the installation quality.

Studies at the European level (see Bibliography [1]) and extensive research into the deflection behaviour of

pipes in existing European pipe systems (see Bibliography [2]) have investigated the subject of deflection of underground pipes. In the latter study, actual deflection was measured several times over a period of 25 years. The findings of the two studies have resulted in the empirical values shown in Figure B.1.

Figure B.1 illustrates the expected maximum long-term deflection of buried pipes as a function of the laying quality and the ring stiffness of the pipes.


Key
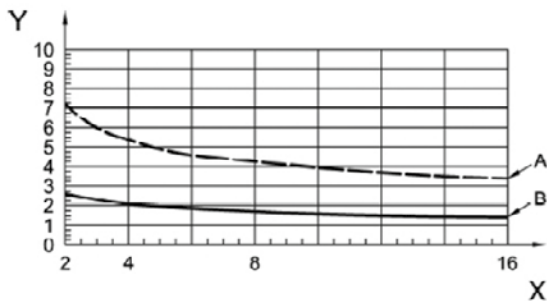
X Ring stiffness SN, in kN/m^2
Y Long-term deflection, in %
A Compaction "AVERAGE"
B Compaction "GOOD"

Joonis B.1 – Long-term pipe deflection: maximum values

The ring stiffness of a pipe or fitting cannot be directly converted from the S_{R24} to the SN value and vice-versa. Due to the influence of various factors: the modulus of elasticity of the respective material, the nominal size of the pipe, the various methods of testing stiffness and the differing durations of the tests, the value of ring stiffness is required to be determined individually by testing. Practice has shown that these factors do not have any measurable influence on the actual deflection of pipes once they are laid.

The ring stiffness values < SN 4 (S_{R24} 16) shown in the diagrams are most frequently found in large pipes.

Key
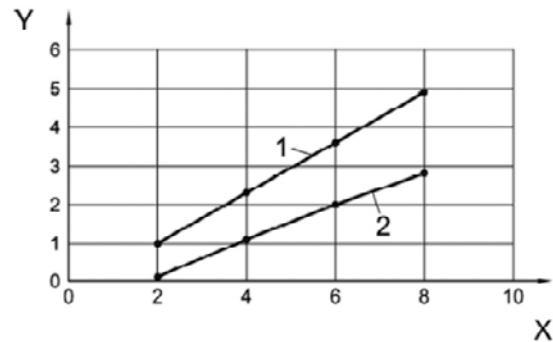
X Ring stiffness SN, in kN/m^2
Y Groundwater level above the invert, in m
1 Compaction "GOOD"
2 Compaction "AVERAGE"

Joonis B.2 – Maximum permissible groundwater level above the invert (GW) as in ATV-DVWK-A 127 (DWA-A 127 Code of practice)

NOTE 1 The relationship between SN and SR24 as shown in Figure B.2, based on polyethylene, is intended for guidance. The curve has been calculated assuming a laying depth of 6 m and good laying quality (see Table B.1). Higher ground water levels are permitted for pipes laid at a depth less than 6 m.

NOTE 2 "Good" and "average" compaction with 95 % and 90 % standard Proctor density respectively are used for all types of ground in which pipes are installed (i.e. including natural ground). Only installation case I as in ATV-DVWK-A 127 is considered. Mixed soils of groups 1 and 2 as in ATV-DVWK-A 127 (DIN 18196) are assumed.

According to CEN/TS 15223, piping systems of stiffness classes   SN 4 or SR24 16 designed to be used underground are sufficiently resistant to external water pressure. The more stringent requirements of ATV-DVWK-A 127 (DWA-A 127) [3] with regard to external water pressure can be checked in Figure B.2 as a function of the ring stiffness of the pipe.

Tabel B.1 – Conditions on which the graphs in Figure B.1 are based

Pipe system	Systems intended to be installed underground and complying with the requirements of DIN 16961 Parts 1 and 2

Depth	0,8 m – 6,0 m
Traffic load	included
Trench width	as in DIN EN 1610
Ground water	see Figure B.2 and Notes
Laying quality	as in DIN EN 1610

Compaction "GOOD"
Granular soil to be used as bedding is carefully placed in the embedment and compacted, after which the soil is placed in layers not more than 30 cm thick and each layer carefully compacted. The pipe shall be covered with a layer at least 15 cm thick. The trench is then filled with (any type of) soil and compacted.
Proctor density of embedment   95 %

Compaction "AVERAGE"
Granular soil to be used as bedding is placed in layers not more than 30 cm thick and each layer carefully compacted. The pipe shall be covered with a layer at least 15 cm thick. The trench is then filled with (any type of) soil and compacted.
Proctor density of embedment ! 90 %

Timbering	Prior to compaction, the timbering shall be removed as recommended in DIN EN 1610.

The proven flexibility of the pipes is such that failure will not occur, even when the pipes are subjected to unforeseen loads or are improperly installed. Deflections of up to 15 % do not adversely affect the correct functioning (i.e. the durability, hydraulic properties and leak tightness) of the pipe system.

B.3 Structural design based on design calculations

If structural calculations are necessary (for instance because the laying conditions are other than those given in Table B.1), a method specified in DIN EN 1295-1 should be used. In Germany, method ATV-DVWK A 127 (DWA-A 127) is generally used. Recommended deflection values can be found in CEN/TS 15223.

B.4 Suitability of methods for large pipes

The specifications of CEN/TS 15223 and DIN EN 13476-1 are limited to pipes up to 1 200 mm in diameter. However, the interaction between pipe and the ground surrounding it is always largely the same, irrespective of the diameter of the pipe. The reason for this is the dominance of the surrounding ground. Calculations in accordance with ATV-DVWK-A 127 (DWA-A 127) show that the pipe diameter hardly affects the results of the stress and deflection analyses. This is also confirmed in Figure B.1. The main factor is the excellent soil and laying quality that is recommended for large pipes.

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