SEWAGE AND ENVIRONMENTAL TECHNOLGY

Technical part about sewage pipe systems

FRANK


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About this catalogue

This catalogue provides an overview of the applications and installation options available with our quality pipe systems. The data and recommendations in this document are based on recognised technical standards and our extensive experience in the field of plastic pipe systems. The catalogue thus serves as a comprehensive reference handbook that assists you in your planning and installation tasks.

Technical expert advice

Our technical expert advice service focuses on the application of our products, based on best technical practice. All information provided is to our best knowledge and does not constitute a binding guarantee of specific properties. Our recommendations do not absolve you from the obligation to examine the suitability of the products for your specific purposes.

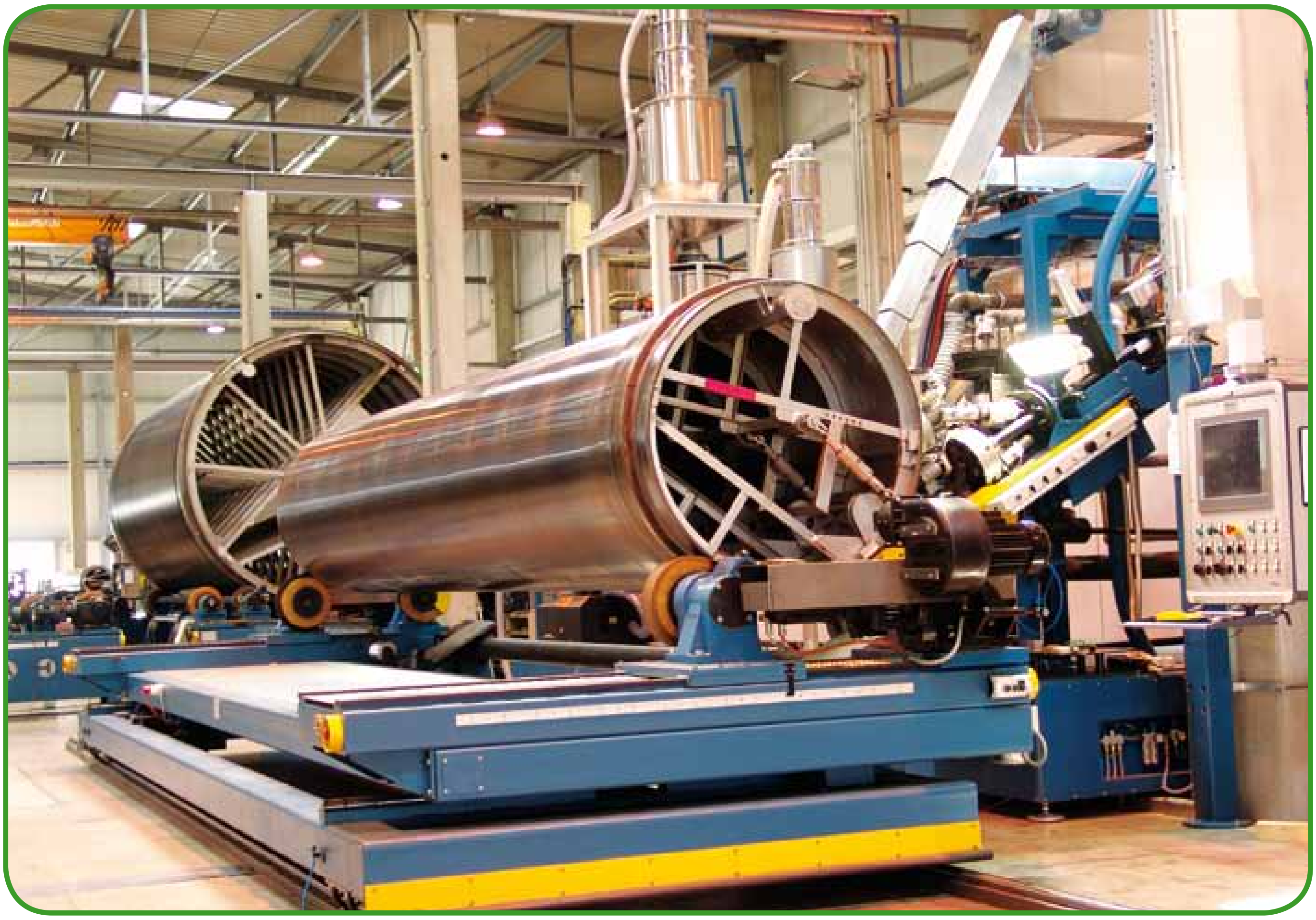

Fig. 1 - Spiral pipe production at FRANK & KRAH Wickelrohr GmbH

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Sewage Catalogue

Plastic pipe systems for sewage

FRANK GmbH has been involved since 1965 in the production and installation of plastic pipe systems. The company has been one of the main contributors to the development of modern PE and PP pipes for all types of applications.

Fig. 2 - Headquarters of FRANK GmbH at Mörfelden, Germany

Plastic pipe systems from FRANK GmbH are used for a wide range of applications:

- Sewage pipe systems
- Storm water systems
- Ventilation ducts
- Landfill gas extraction and drainage systems
- Waste incineration
- Process pipes for aggressive substances
- Double containment pipes and vacuum systems
- Pressure drainage
- Power plants
- Biogas systems
- Drainage/perforated pipes
- Special pipes for installation without sand-embeding

For all applications, the pipes as well as the connection technology and the fittings need to be tested and certified in advance. FRANK GmbH was involved as a competent partner in all these tasks from the very beginning.

Based on this experience, FRANK GmbH has been able to develop a comprehensive range of products for a variety of applications.

FRANK GmbH also offers welding technology for pipeline systems, connecting parts for manholes, connectors to other pipe types and a complete range of fittings.

FRANK GmbH is your competent partner for plastic pipe systems.

To find out more, simply give us a call!

Your FRANK GmbH team

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1. System information

1.1 Introduction

For many decades, sewage systems consisted mainly of rigid pipe structures with socket connections that are prone to damage. Excessive stress on rigid pipes can cause cracks or fragmentation of the pipe material, resulting in infiltration of ground water and exfiltration of contaminated wastewater into the environment. For more than 40 years, RANK GmbH has been using plastic pipe systems in a range of high-demand applications. Pipes made from flexible materials with tight, welded socket connections have many advantages over rigid, push-fit pipe systems. The experience of the last decades has lead to the development of the PKS® profiled sewage pipe system made in PE 100. The PKS® system allows for uniform, permanently tight sewage systems with pipes of all conventional dimensions. The installation of storm water storage sewers, rain water tanks, landfill manholes, perforated pipes and leachate reservoirs made from PE 100 pipes is a technically advanced yet affordable solution. The components can be made to measure and fitted at the factory. This allows for fast installation on site, so that construction costs can be minimised.

Polyethylene and polypropylene

Polyethylene (PE) and polypropylene (PP) are thermoplastic materials with a low specific weight. They are very easy to process, weld and form. Both materials are also resistant to aggressive media. Thanks to their molecular composition of carbon and hydrogen, they are 100% recyclable and thus environmentally friendly.

Polyethylene (PE) is characterised by low permeation, good UV resistance (carbon black stabilised), excellent chemical resistance and physiological safety. PE is the ideal material for use in sewage systems in buildings and underground installations. It has also been used for many decades in drinking water systems and for the transport of chemicals and gases (e.g. natural gas). For all these applications, high-grade PE 100 is the material of choice. FRANK GmbH has been using PE 100 of the third generation for many years in its components and pipes as standard.

Fig. 3 - PKS® sewage pipe made in PE 100

Polypropylene (PP) has a higher heat distortion resistance than most other thermoplastics. It offers great mechanical strength, excellent chemical resistance and physiological safety. PP is widely used in the chemical industry, where high temperature resistance is a must.

Fig. 4 - Ventilation shaft made in PP-R

System	Material	Dimension																				
		300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600	1800	2000	2300	2400	2700	3000	3500
PKS® sewage pipe	PE 100*	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
TSC-Pipe	PE 100/ PP	√	√	√	√	√	√	√	√	√	√	√	√	√	√							
PKS® Secutec pipe	PE 100*	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
PKS® underground ventilation pipe	PE 100*	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√

System	Material	SDR class	Outside diameter d								
			160	180	200	225	250	280	315	355	400
Sureline pipe	PE 100 RC	SDR 11, SDR 17	√	√	√	√	√	√	√	√	√
SURE INSPECT RC	PE 100 RC	SDR 26	√	√	√	√	√	√	√	√	√

** option/available in PP or PE on request*

Table 1 - Available dimensions for FRANK plastic pipe systems

1. System information

1.2 PKS® sewage pipe system

PKS® profiled sewage pipe system

The PKS® profiled sewage pipe system consists of light-weight, dimensionally stable profiled pipes conforming to DIN EN 13476, part 2 and 3 in sizes DN 300 to DN 3500, plus associated fittings, manholes and connection parts such as house connection saddles for new buildings. PKS® sewage pipes are profiled on the outside and feature a white lining for easy inspection. All components are made from durable PE 100. Alternatively, the pipes and fittings are available in PP-R (polypropylene), which might be required for sewage pipelines that might withstand high temperatures.

For smaller diameters (DN 150 to DN 300), we offer co-extruded PE solid wall pipes according to DIN 8074/8075 with separate electrofusion fittings. From DN 300, we offer pipes equipped with an integrated socket and electrofusion wire at one end, for on-site electrofusion welding (up to DN 2400). Pipes larger than DN 2400 are ready for electrofusion welding according to DVS 2207-4.

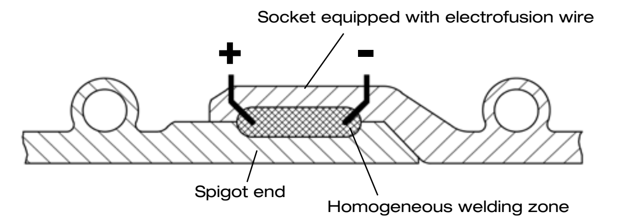

Fig. 5 - PKS® pipe welding zone

All pipe, manhole and fitting components are specifically designed for use in sewage systems and underground installations. Our PKS® sewage pipes are high-quality products made in modern spiral pipe production plants, where we use advanced technology such as co-extrusion.

As polyethylene is a flexible material, short-term overloads of the pipe system can normally be compensated without any lasting effect. The components can be made to measure and fitted at the factory. This ensures short installation times on site.

For the development of the profiled sewage pipe system, we aimed at combining the advantages of profiled PE 100 pipes with tight, uniform pipe connections, in order to allow for easy installation. The electrofusion socket of our PKS® sewage pipe systems from DN 300 to DN 2400 and our advanced spiral pipe production technology allow for the installation of permanently tight, durable and thus economically viable pipelines systems.

Advantages of PKS® pipes

- Light weight for easy handling
- Strong, permanently tight and uniform connection produced by electrofusion welding
- Electrofusion welds can be produced quickly and easily
- Electrofusion welded connections for DN 300 to DN 2400,
  extrusion welding possible for sizes 300 to 3500
- Made for easy pipe welding under site conditions
- Flexible pipe material ensures permanently tight pipelines even in the event of subsequent ground settlement
- Easy inspection thanks to bright inside lining
- Anti-adhesive surface provides excellent resistance to abrasion and chemicals
- Expected service life: minimum 100 years
- Recyclable

Applications of PKS® pipes

- Ideal for all conventional and heavy-duty sewage and manhole systems
- Storm water pipes, rain water tanks
- Pump shafts and landfill manholes
- Perforated pipes and leachate reservoirs

Fig. 6 - Pipe stock at Wölfersheim site

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1. System information

1.3 TSC sewage pipe system

TSC-Pipe - Twin Seal Connection-Pipe

For the drainage of surface and rain water, we offer a pipe system with push-in connections. The pipes are available in polyethylene or polypropylene. Both materials are flexible so that TSC pipes can be deformed to a certain degree without breaking. This means that they can withstand considerable loads without damage. The integrated, non-shifting and certified double sealing technology prevents infiltration as well as exfiltration at the joints, even under extreme loads.

TSC includes all components that are required for gravity pipelines. In addition, we offer a complete range of fittings such as branch sections, bends, slope drainage fittings, manholes, etc. specially adapted for pipe systems.

Thanks to the light weight of the pipes and the push-fit connections, installation is quick and cost-effective. The pipes are black on the outside to ensure permanent UV resistance, while the grey co-extruded inner lining allows for easy camera inspection. The pipes are however also available with a black or grey inner surface.

TSC-Pipe come in sizes DN 600 to DN 1200 and with a grey inner lining as standard. Other options are available on request.

Fig. 7 - TSC pipe

Advantages of TSC-Pipe

- Easy to install, cost-effective and environmentally friendly
- Sturdy and durable
- Tight (exceeding DIN 4060 requirements) thanks to non-shifting double sealing system
- Strong pipe of low weight, thanks to profiled pipe wall according to DIN 16961
- Resistant against aggressive media and corrosion by contaminations or bacteria, with anti-adhesion surface that prevents deposits
- Abrasion and impact proof, resistant to UV light
- Excellent hydraulic performance due to smooth inner surface finish (k < 0.05 mm)
- Easy inspection thanks to bright inside lining
- Expected service life: minimum 100 years
- Recyclable

Applications of TSC-Pipe

- Drainage of surface and rain water
- Drainage of wastewater
- Gravity pipeline systems
- Culverts

1. System information

1.4 Sureline® sewage pipe system

Sureline® - optimised safety

Sureline® pipes are co-extruded solid wall pipes made from high-quality PE-100-RC (RC = resistance to crack). Thanks to the co-extrusion production process, Sureline® pipe are of excellent, uniform quality across the entire wall thickness. PE 100-RC exceeds the test requirements laid down in PAS 1075, such as FNCT and point load test according to Hessel. Thanks to the use of top-quality, non-crosslinked plastic, FRANK Sureline® pipes provide excellent safety as they are resistant to point loads, crack initiation, slow crack propagation and external impact.

High-quality pipe designed for cost-effective installation

Due to their excellent properties, polyethylene pipes are becoming the preferred substitute for more traditional materials such as cast iron and ceramics. This is not least due to the ever more stringent statutory requirements that force operators of pipeline systems to fix leaks and problems as quickly as possible. In many cases, existing metal pipelines are repaired with PE pipes. As trenchless installation methods such as relining, burst lining, ploughing or horizontal hydraulic drilling are extremely cost-efficient, they have also become very popular for the installation of new pipes.

Fig. 8 - Sureline® pipes

Advantages of Sureline® pipes

- Sureline® pipes are resistance to
  - damage to surface (grooves) caused during transport or installation
  - point loads from rocks and stones
  - Stress in pipe wall due to deformation (ground settlement, dips in trench)
- Easy handling thanks to low weight: one DN 150 section (d 160, SDR 17; length 6 m) weighs for example only approx. 27 kg (ductile cast pipe DN 150: weight approx. 171 kg) and can be easily handled and moved on site by one or two workers
- Available in sizes d 160 to d 400
- High-strength connections (electrofusion or butt welded)
- Reliable connections that remain tight even under extreme conditions (e.g. temperature)
- Permanently tight pipelines thanks to flexible material (no leakage even with subsequent settlement)
- Unrivalled resistance to abrasion and chemicals
- Expected service life: minimum 100 years
- Recyclable
- Compatible with other commonly used PE pipes and fittings

Sureline® pipes can be used for a number of installation methods

- Installation without sand-embedding
- Ploughing in of pipe
- Milling
- Relining of existing pipelines (long pipe relining)
- Burst lining
- Installation with drilling rocket
- Horizontal hydraulic drilling

1. System information

1.5 PKS® Secutec sewage pipe system

PKS® Secutec - pipe system designed for monitoring

Installations such as drinking water supply systems and chemical pipelines through groundwater protection zones require permanent monitoring. For this purpose, entire pipelines systems must be tested by vacuum or permanent overpressure. Using the defined hollow space method, PKS® Secutec pipes allow for the continuous monitoring of the entire pipeline system. In underground pipelines, it is possible to include manholes in the monitored system (see also chapter 10, "Manhole constructions").

The system can be monitored by means of an approved leakage detector, a mobile testing unit or a leakage check system accessible from the operating room. Monitoring can extend across the entire pipeline system or to isolated sections only.

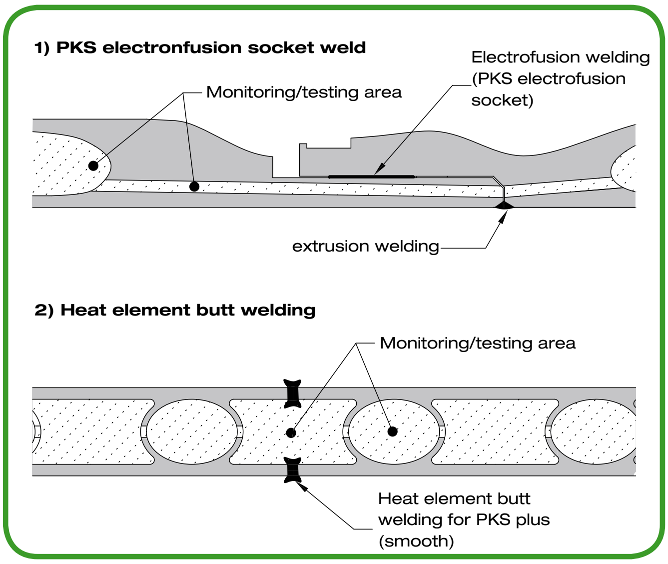

Fig. 9 - Joining methods available with PKS® Secutec

PKS® Secutec pipes are designed for joining by electrofusion welding and come with an integrated electrofusion socket. The monitoring area is produced by means of an additional extrusion weld at the inside of the pipe, This section is connected to the monitoring area of the adjoining pipe. Alternatively, it is possible to join the pipes by means of an inner and an outer extrusion weld, doing away with electrofusion welding. PKS® Secutec pipes can also be joined by butt welding. All joining methods guarantee homogenous and permanently tight connections of the PKS® Secutec pipes.

The PKS® Secutec system is DIBt-approved and available in diameters from DN 300 to DN 3500. The core wall thickness is defined according to the project-specific requirements and with regard to special customer requests.

Advantages of PKS® Secutec pipes

- DIBt approval for pipe system and welding method
- Excellent safety thanks to double-wall structure and integrated monitoring system
- Pressure/leakage monitoring
- Simultaneous butt welding of inside and outside pipe.
- Available in DN 300 to DN 3500
- Excellent chemical resistance
- Easy handling and installation thanks to low weight
- Unrivalled resistance to abrasion and chemicals
- Expected service life: minimum 100 years
- Recyclable

Applications

- Sewage pipelines through groundwater protection zones
- Underground pipelines for water polluting substances
- Leachate drain lines in landfills
- Process lines for hazardous chemicals
- Other pipelines that require special leakage monitoring

Fig. 10 - PKS® Secutec sewage pipe

1. System information

1.6 Plastic pipe production

DIN 16961 / DIN EN 13476 spiral pipes

The pipes are produced by means of the winding method as specified in DIN 16961 / DIN EN 13476. The homogeneous, thermoplastic band (profiled or solid form) is thereby wound around a steel mandrel and connected by overlapping. The profile pattern is aligned with the overlaps to ensure a uniform wall thickness. The steel mandrel guarantees that the inside diameter (DN) is the same in all sections, irrespective of the wall thickness or stress applied to the pipe. This ensures that each pipe consists of a homogeneous, high-density wall from the socket to the spigot end.

The discontinuous production method allows for the manufacture of individual pipes with special length and diameters. The profile construction is adjusted to suit the actual operating conditions as specified in the project documentation. FRANK GmbH is therefore able to produce sewage pipes that meet your specific requirements and provides the necessary safety tolerances.

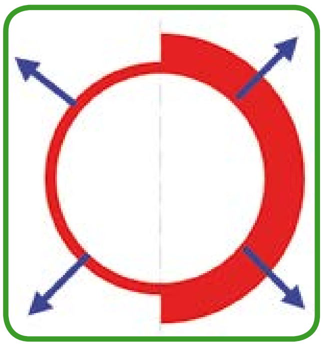

Fig. 11 - Production method for DIN 16961 / DIN EN 13476 spiral pipes

Sewage pipes for underground installation are produced with special regard to the necessary long-term ring stiffness. In PKS® /TSC- and PKS® Secutec sewage pipes, this is achieved by choosing a suitable profile construction. We are thus in a position to manufacture light-weight sewage pipes that offer high long-term ring stiffness.

Fig. 12 - Production machine at FRANK & KRAH Wickelrohr GmbH

DIN 8074/8075 pressure pipes

Pressure pipes according to DIN 8074/8075 are produced by extrusion. With this continuous production method, the material is extruded through a nozzle. With co-extrusion, two or more melted plastics of the same type are mixed together before they leave the profile nozzle.

The material to be extruded/co-extruded is melted and homogenized in a heated extruder. The process is aided by internal friction. The extruder produces the pressure required for the proper extrusion of the plastic. After the plastic has been pressed out through the nozzle, the resulting continuous pipe section is calibrated and cooled.

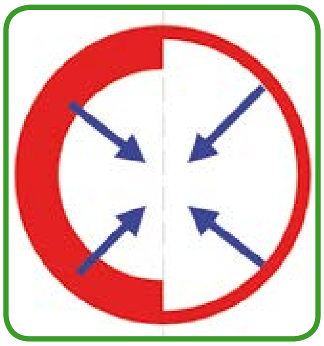

Fig. 13 - Production method for DIN 8074/8075 pressure pipes

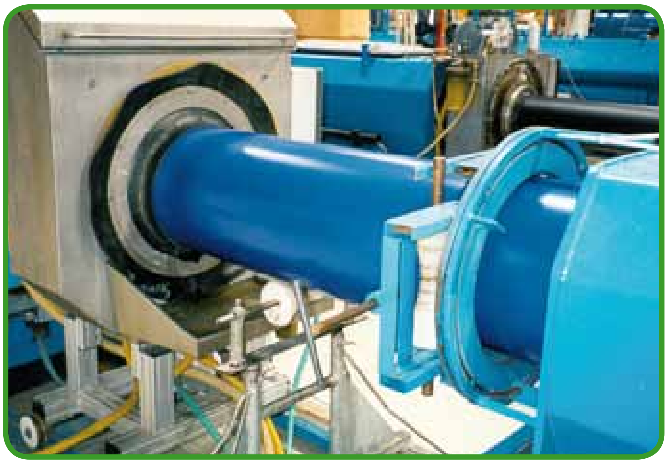

Fig. 14 - Extrusion plant for pressure pipes at AGRU-FRANK GmbH

After cooling, the extruded pipe is cut to size.

1. System information

1.7 Spiral pipe profile types

PKS® solid wall profile type

The PKS® solid wall pipes can be produced with various wall thicknesses and with a co-extruded light-coloured inside lining according to the static strength specifications or the needs of the customer. Thanks to the homogeneous structure of the pipe wall and the smooth inside and outside surfaces, the solid wall pipes are particularly suitable for the production of manholes, bends and other similar installations. For upright tanks, we offer solutions with a graduated wall thickness that conforms to the relevant standards. Our products are available with a wall thickness of up to 400 mm.

Solid wall pipes are available with standard or electrofusion sockets and spigot ends as well as with smooth ends. Pipes up to DN 2400 are connected by means of electrofusion welding. From DN 300 to DN 3500, extrusion welding can be used.

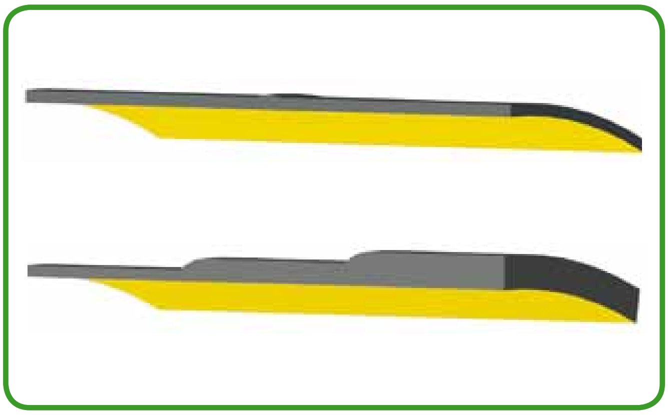

Fig. 15 - Top: solid wall profile; bottom: graduated solid wall profile

PKS® profile type PR, PRO (DN 300 to DN 3500)

The PKS® profiles of the PR type offer excellent ring stiffness combined with extremely low pipe weights. The PR pipes are mainly used for underground sewage systems up to size DN 3500. Where installation is difficult or pipes are exposed to extreme loads, we recommend using pipes of the PKS® Pro profile. With this pipe type, connections are made by electrofusion welding up to a nominal diameter of DN 2400. As an alternative to electrofusion welding, pipes from DN 300 to DN 3500 can also be joined by extrusion welding. The pipes come with integrated sockets and spigot ends.

The PKS® system range also includes extruded PE 100 pipes conforming to DIN 8074/75 in sizes from D 160 SDR 17/SDR 11 to D 400.

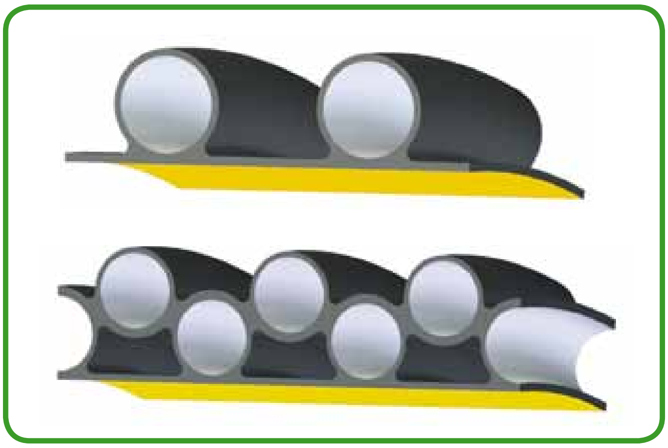

Fig. 16 - Top: PR profile; bottom: PRO profile

PKS® profile type PKS®$_{plus}$, SQ (DN 300 to DN 3500)

PKS® profiles of the PKS®$_{plus}$ or SQ type offer particularly high long-term ring stiffness, thanks to their compact profile structure with smooth and fully sealed outer surfaces. They are the preferred option for systems that are exposed to exceptionally high stress.

As the outside surface is smooth, this pipe type is particularly suitable for the production of manholes and similar applications in pipeline systems.

The PKS® pipes of this type can be produced according to customer requirements regarding ring stiffness and core wall thickness. Up to DN 2400, the individual pipe sections can be joined by electrofusion welding. From DN 300 to DN 3500, extrusion welding can be used, and pipes of this size come with spigot ends and sockets as standard, similar to profile type PR.

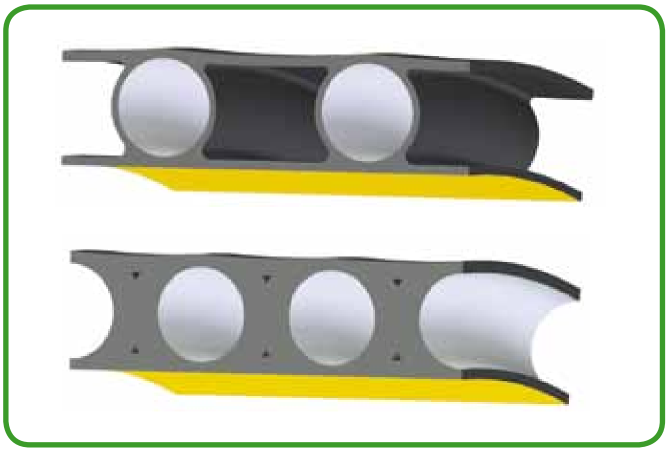

Fig. 17 - Top: PKS$_{plus}$ profile; bottom: SQ profile

1. System information

1.8 Flexible sewage pipe system and stress loads

Advantages of flexible sewage pipes

During their lifetime, underground pipes are exposed to various and changing loads. In many areas, sewage pipes that were installed nearly 100 years ago are still in use. During this period, the traffic load increased dramatically due to the increase in motor traffic and urbanisation. Today's stress loads are thus much higher than several decades ago. We can only guess what loads newly installed sewage systems must withstand in 50 years time from now. As sewage systems are to last for several decades, it is important to choose pipes and fittings that will not fail under increased stress.

Pipes made in traditional materials, which are still prevalent in our sewage systems, are prone to cracking, fragmentation, collapse and socket disconnection. Such damage is generally due to settlement of the surrounding ground, which causes excessive stress at the top of the pipe. Other causes of leakage are tree roots near house connections and socket joints. Future-proof sewage systems must be made of pipes that are not prone to such failures.

Fig. 18 - Flexible sewage pipe

Moving with the force

We know from nature that the thin branches and leaves of a tree are in constant motion when there is wind. At a closer look, we can see that they move with the wind until its impact is minimised. In other words, they move with the force. Would it not be perfect if such deformation under load could be incorporated into sewage pipe systems? This is exactly what the PKS® system does. Made from flexible polyethylene or polypropylene, the pipes allow for a certain degree of deformation under load. As a consequence, the stress load in the material is reduced. The risk of overload and rupture is therefore minimised. As soon as the load is reduced, the PKS® pipes return to their initial shape. PKS® pipes thus introduce flexibility into the sewage system,

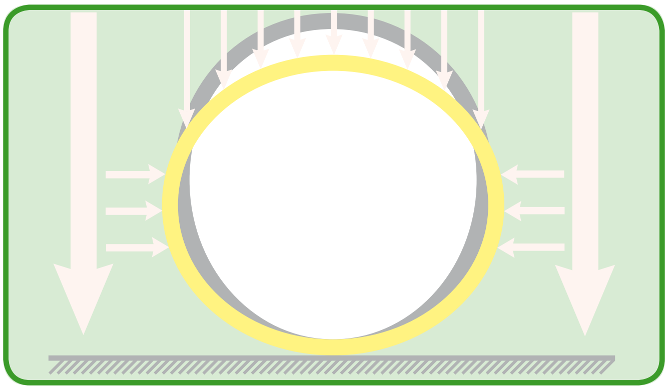

Fig. 19 - Forces acting on flexible sewage pipe

Making use of the load-bearing capacity of the surrounding soil

In contrast, rigid pipes made in stoneware or concrete are not able to compensate for changing loads and are thus at all times exposed to the full traffic load and weight of the soil cover. With PKS® pipes, the loads are transferred to a wider area as the pipe bends slightly. As the top of the pipe is lowered, the load concentration above the pipe is reduced. The desired deformation shifts the flanges slightly outwards, which results in additional bedding pressure so that the pipe is supported at both sides. Thanks to the deformation of the PKS® pipe, a new equilibrium of the forces acting on the pipe is achieved. The PKS® pipe can thus withstand even heavy loads, despite its light-weight construction.

Fig. 20 - PKS® sewage pipe

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1. System information

1.9 Commercial advantages of plastic pipes

Cost-efficient and sustainable solutions

According to the latest survey by the German Association for Water, Wastewater and Waste DWA, local authorities are facing costs in the region of billions for the replacement of leaking and outdated sewage systems. As the public purse is empty, new solutions must be found to reduce the running costs in the public sewage treatment sector. On the one hand, citizens want to keep wastewater charges low, while operational safety of the system is of course a major priority.

A survey carried out by the Technical University Darmstadt in 2006 among German sewage system operators, the cost reduction potential of high-quality sewage pipe systems made in PE was analysed. For the study, 83 operators of public sewage systems were interviewed. This group serves 18% of the population in Germany. With over 56,600 kilometres of sewage pipelines, the above operators look after nearly 12% of the German public sewage network.

The study revealed that the key cost factors for wastewater system operators are network maintenance and repairs (approx. 25%) and depreciation (approx. 29%), see figure 21. By reducing these costs, operators would be able to lower the wastewater treatment charges.

The depreciation figures are mainly determined by the expected service life of the fixed assets. Around 70 to 80% of funding required for the installation of a wastewater treatment system is spent on the sewage pipelines. By choosing a pipe material that has a long service life, it is thus possible to significantly reduce the depreciation rates. Even if the initial installation would be slightly more expensive, such advanced systems will reduce the overall lifetime costs and thus the wastewater treatment charges for customers.

Taking into account the overall investment, the actual material costs for the pipe are a relatively small expense, so that the decision for or against a particular material should not be based on its price, but rather on technical criteria. Of main concern here are the service life of the pipe and the connections and other quality properties as well as installation site conditions (see figures 22 and 24).

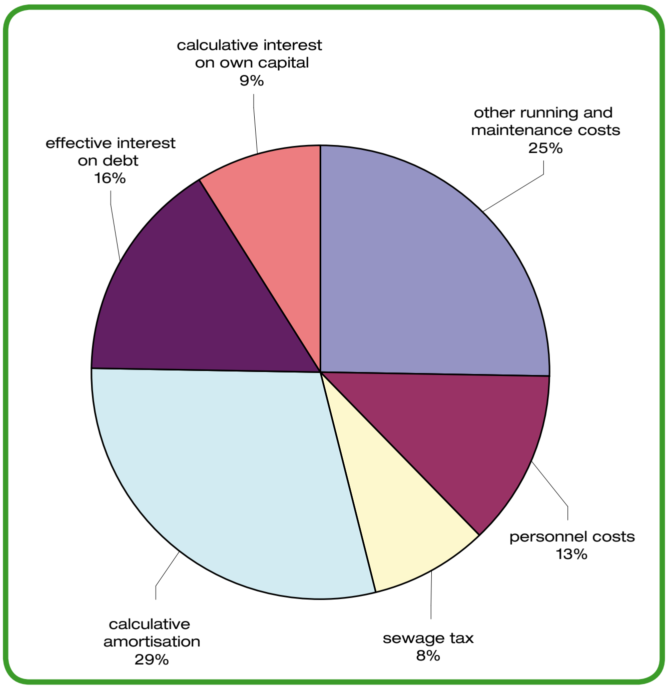

Fig. 21 - Cost analysis of German sewage system operators (Source: TU Darmstadt - Empirical study, 2006)

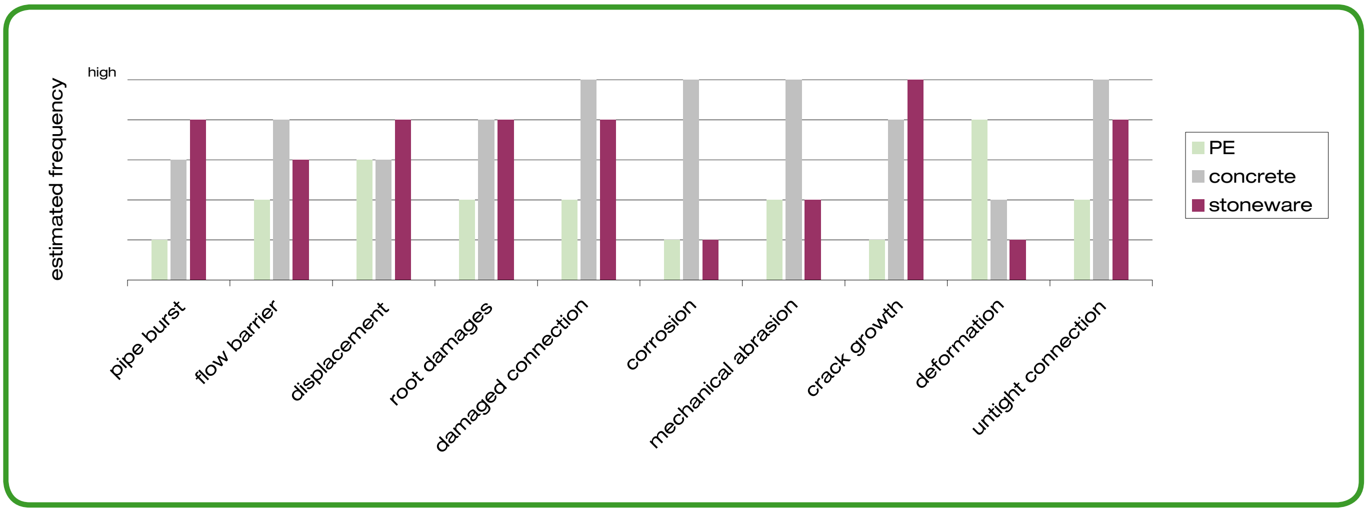

Fig. 22 - Frequency of common damage (source: empirical study by TU Darmstadt, 2006)

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1.9 Commercial advantages of plastic pipes

Saving money by reducing repair costs

Sewage system operators see significant cost savings in the field of repairs, if the occurrence of relatively expensive damage such as pipe fracture/collapse and defective connections (generally associated with extensive work in open trenches) could be reduced. This can be achieved by proper installation of the pipes and the use of a pipe material that is appropriate for the job. By using PE 100 pipes in sewage pipe networks, operators can save money, as the above expensive problems are less likely (see figures 22, 23, 24).

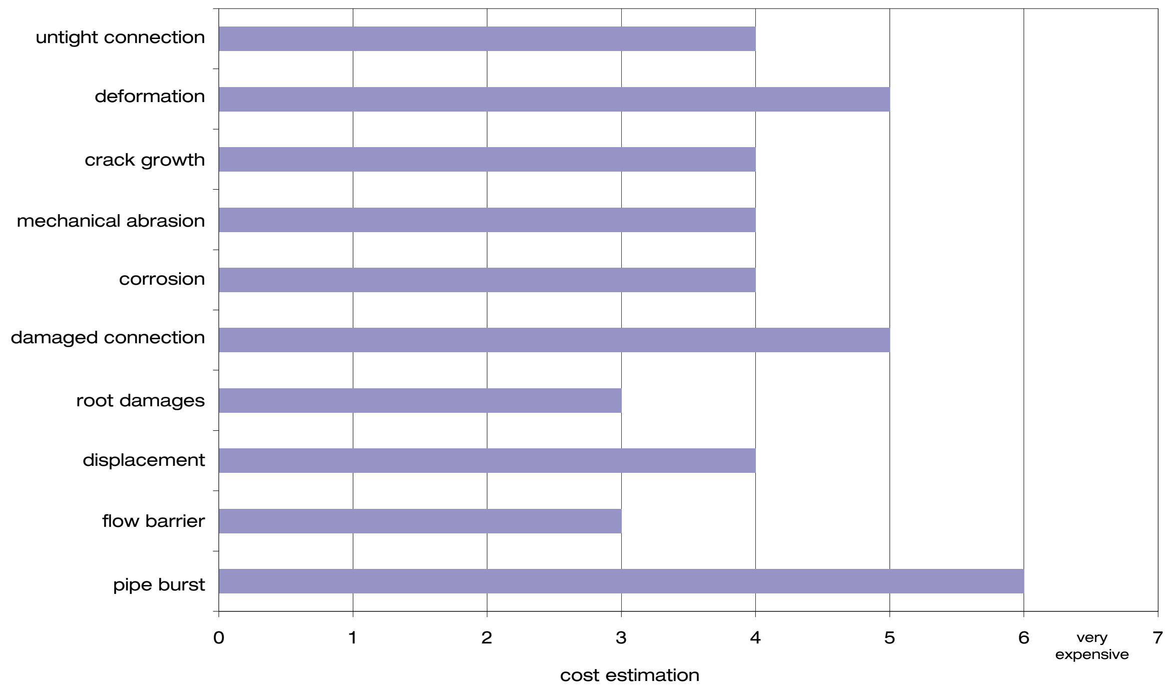

Fig. 23 - Estimated costs for the repair of certain types of damage (source: empirical study by TU Darmstadt, 2006)

When comparing the types of damage (figures 22 and 24) with the associated repair costs (figure 23), it becomes obvious that PE has significant advantages over rigid pipe material, especially in relation to the most costly repairs.

The only exception here is deformation. Flexible pipes show a deformation damage rate of 0.7 per kilometre of sewage line. It remains however unclear whether such deformation should actually be considered a defect. According to ATV-DVWK-A 127, deformation is permitted to a certain degree and actually taken into account for the static calculations of flexible pipe systems.

Such deformation does not have an adverse effect on the function of the pipe system. In addition, extreme deformation is normally not caused by the material but by poor installation or significant overloads, which can be eliminated by proper planning and engineering.

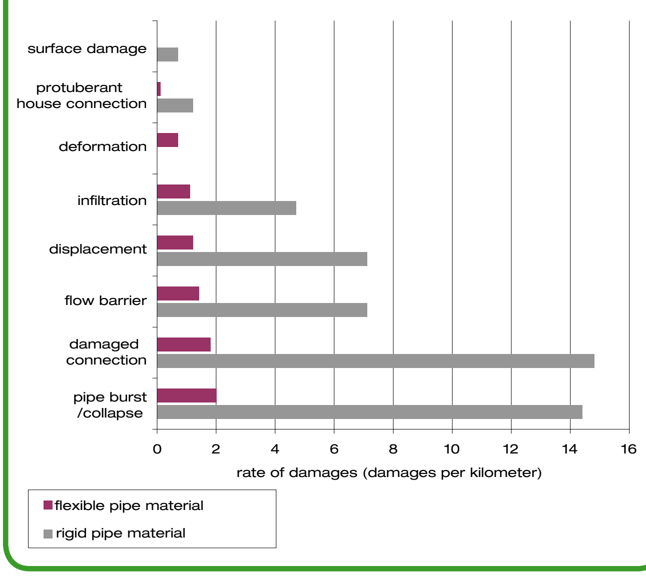

Fig. 24 - Occurrence of damage in pipe systems made from rigid and flexible materials (source: empirical study by TU Darmstadt, 2006)

1. System information

1.9 Commercial advantages of plastic pipes

Reasons behind increased use of plastic pipes in sewage networks

For the study by TU Darmstadt, sewage network operators were asked about the criteria they consider when choosing a specific pipe material. The public company managers were asked to state the five pipe properties they consider most important (figure 25).

A long service life of the pipe was mentioned by 72 of the surveyed companies, putting it to the top of the table. Nearly 90% considered a long service life the main requirement to be met by a pipe material. More than 40% thought that resistance to corrosion, tightness of the connections, low operating and repair costs as well as a minimum risk of installation errors were important factors. These properties actually have a significant effect on depreciation and operating expenses (see figure 21).

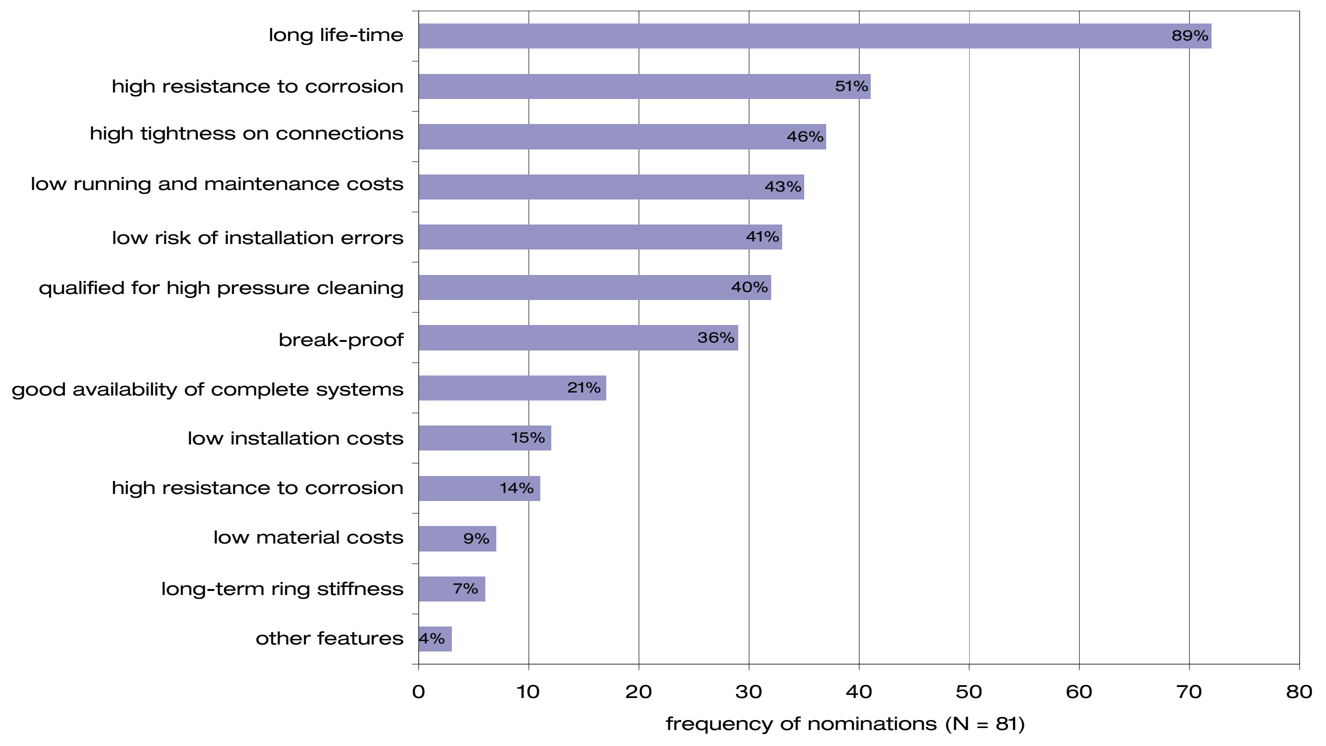

Fig. 25 - Rating of pipe properties by sewage system operators (source: empirical study by TU Darmstadt, 2006)

When purchasing a sewage pipe system made in PE 100, system operators are looking for a solution that requires only minimum maintenance, remains operational for a period of 100 years or more and can be repaired and maintained at low costs. As sewage pipe systems made in PE are welded throughout, irrespective of the pipe diameter, they are exceptionally tight and durable. In contrast, rigid pipes made from conventional materials tend to be prone to leakage at the push-fit connections, which can lead to significant repair costs.

When comparing flexible and rigid pipe materials with regard to pipe break/collapse, which has been identified as the most frequent cause of costly repairs, it becomes clear that flexible pipes made in a material such as PE 100 are significantly less likely to break or collapse. Based on their practical experience, sewage system operators estimate that the overall maintenance and repair costs for PE sewage pipes are clearly below 10% of the overall costs. According to DIN 8074/8075, the expected service life of PE pipes is at least 100 years, which means that indirect costs arising from depreciation are also significantly reduced. For operators who are looking for an economically viable and lasting solution when upgrading their sewage system, the only obvious future-proof option are pipes made in polyethylene.

2. Identification

2.1 Spiral pipes (DIN 16961 / DIN EN 13476)

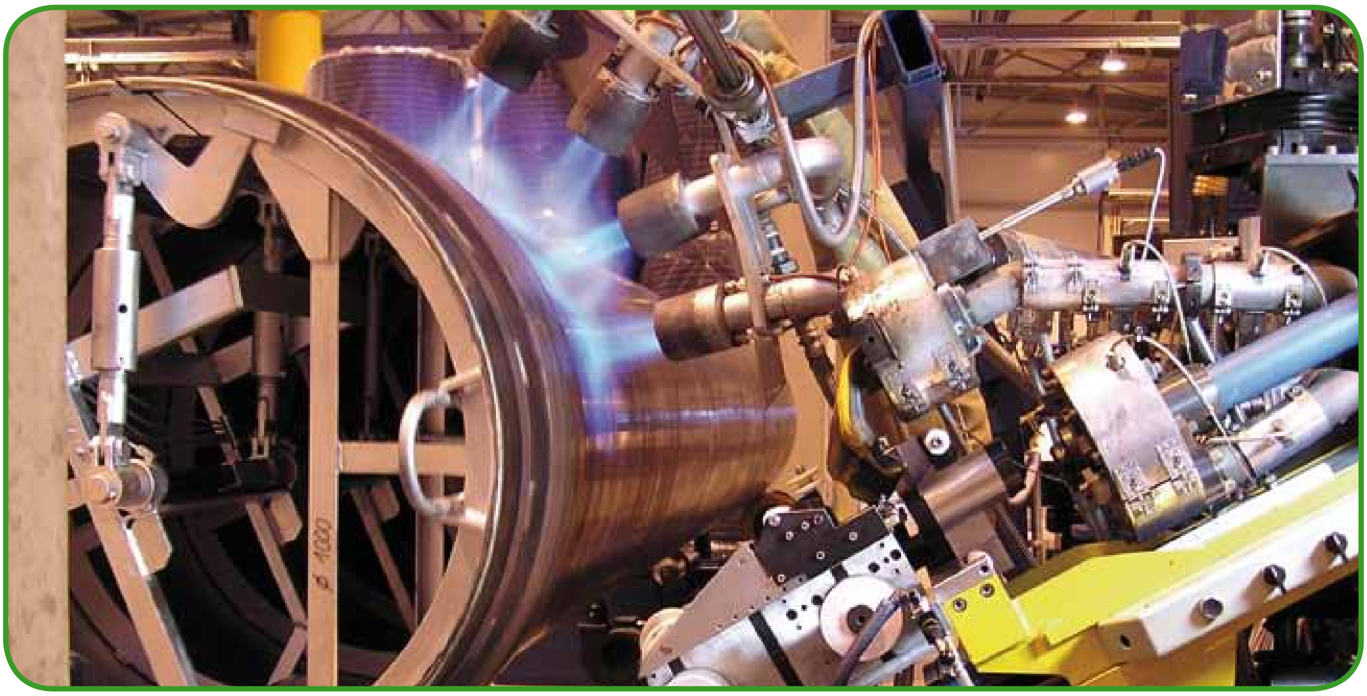

Fig. 26 - Production machine of FRANK & KRAH Wickelrohr GmbH

Standard identification

The standard identification mark is produced during production by means of an embossing punch that is adapted to suit the pipe diameter. It contains all relevant pipe specifications. For spiral pipes, the standard identification mark allows for complete traceability of the batch and contains the following details:

- DIN 16961 / DIN EN 13476
- Manufacturer
- Type of profile (e.g. PR 75-17.4)
- Material class
- Dimensions (inside diameter)
- MFR group
- Date of manufacture
- Pipe series
- Consecutive pipe number

Fig. 27 - Pipe identification mark

2. Identification

2.2 Pressure pipes (DIN 8074/75), pipes with high crack resistance (PAS 1075)

During production, the pipes are marked at distances of one metre by means of embossing.

The identification mark indicates the pipe material. Each standard mark contains the following details:

- Manufacturer
- Material code
- Dimensions (outside diameter x wall thickness)
- Pipe series (ISO , SDR code)
- Rated pressure (PN ...)
- Year of manufacture
- Applied standard
- Factory batch code

The marks for all pressure rating classes are applied in a colour that differs from that of the pipe material, whereby the size of the writing varies, depending on the pipe diameter.

Fig. 29 - Identification mark on extruded sewage pipe

2.3 Fittings (DIN 16963)

The fittings are marked during production by means of special inserts placed in the injection mould.

Each identification mark contains the following details:

- Manufacturer
- Abbreviation and classification of material
- Dimensions (outside diameter x wall thickness)
- ISO or SDR code
- Factory serial number (indicating year of manufacture)

The electrofusion fittings and other fittings with long welding ends from D 110 also bear the welding code and the component traceability code. This barcode (128 type C*) contains all details of the fitting batch.

Fig. 28 - Component traceability code

Fig. 30 - DA 160 and DA 560 electrofusion socket

* barcode conforms to ISO/FDIS 1276-4 (November 2003)

3. Quality assurance

3.1 General information

Raw materials

Prior to the launch of a new product, all tests laid down in the requirement specifications are carried out and documented. Before the materials are used in serial production, a trial manufacturing run is completed and the pipes and fittings undergo long-term tests. If our factory standards and criteria, which are significantly more stringent that the standard requirements, are met, we enter into a supply quality agreements with the raw material suppliers that are binding for all future deliveries.

A material is only approved for serial production after an extensive production trial phase has been completed successfully. In the meantime, a number of material tests are performed by an independent external lab in order to verify the results.

All incoming raw materials and semi-finished products are carefully inspected before they are released for use in production. In the inspection process, the suitability of the goods for the intended purpose is verified.

Fig. 32 - Pendulum impact tester

Products

Underground pipes for the transport of wastewater and sewage need to withstand media that tend to contain ever more aggressive components. At the same time, the requirements regarding the protection of the environment have become much more stringent than in the past. This means that modern pipe systems must meet extremely high quality standards as regards their production, development and installation.

As part of our internal quality assurance system, all in-process tests and inspections that are required by the relevant standards are performed at regular intervals by qualified staff. Our laboratory technicians take samples from each production batch, which are used for more detailed physical tests. All these procedures are performed according to the relevant product standards.

Fig. 31 - Ultrasonic measuring device

The following routine tests are carried out as part of our internal quality assurance system:

- Incoming inspection of raw material batches
  - Melt flow index
  - Homogeneity of material
  - Moisture content
  - Material density
  - Colour
- In-process control
  - Colour
  - Identification
  - Surface properties
  - Delivery condition
  - X-ray examination (injection-moulded fittings)
  - Dimensions
- Quality inspection of extruded solid wall pipes
  - Dimensions
  - Melt flow index
  - Homogeneity of material
  - Behaviour after heat treatment
  - Internal pressure creep test
- Quality inspection of profiled sewage pipes
  - Dimensions
  - Melt flow index
  - Ring stiffness
  - Tensile strength of pipe connections
  - Tensile strength of pipe between profiles
- Pre-delivery inspection
  - Packaging
  - Delivery condition
  - Dimensions
  - Electrofusion wire resistance

3. Quality assurance

3.2 Internal quality monitoring

Fig. 33 - Melt flow rate

MFR - melt flow rate according to ISO 1133

The viscosity of the various polyethylene melts is determined by means of a MFR meter. This parameter is determined during the incoming inspection and at regular intervals during the production process. For PE, the melt flow rate is normally determined at a temperature of 190° C and a load of 5 kg (MFR 190/5).

Fig. 34 - Measurement of moisture

Moisture content

During the incoming inspection, the moisture content (volatile component) of each raw material batch is determined by means of an infra-red measuring device. This is done according to the internal inspection instruction. The results of the upstream drying unit are taken into account for the production.

Fig. 35 - Material density

Density according to DIN EN ISO 1183

The density of plastics is a parameter that is easy to measure and that allows for the detection of physical and chemical changes in the material. The density determines the mechanical properties of the material and is therefore measured during the incoming inspection.

Fig. 36 - Tensile strength testing system

Tensile strength test according to ISO 6259

Tensile tests can be used to determine a number of mechanical properties of a material. The most common parameters are the yield strength, the failure stress and the elongation at break.

3. Quality assurance

3.2 Internal quality monitoring

Fig. 37 - Internal pressure creep testing device

Internal pressure creep tests according to DIN 8075

To determine the expected service life of a pipe, each batch undergoes an internal pressure creep test. For each material class, the testing parameters laid down in the applicable regulations and standards are used.

Fig. 38 - SR/SN ring stiffness testing system

Testing of SR ring stiffness (DIN 16961 / DIN EN 13476)

The constant load test is performed in order to verify the calculated SR ring stiffness. In this process, a constant linear load is placed on the top of the pipe.

Testing of SN ring stiffness (ISO 9969)

In the constant speed test, the spiral pipe to be tested is deformed vertically by 3 % (relative to its inside diameter). The deformation force required to achieve this is then used to calculate the corresponding SN value of the pipe.

Fig. 39 - Ultrasonic examination

Ultrasonic testing of wall thickness according to factory standard

As part of the internal quality assurance system, the wall thickness of the profiled sewage pipe is measured by means of ultrasound. This test is performed in order to ensure that the pipe has the minimum wall thickness at all points between and below the profiles.

Fig. 40 - Tensile testing machine

Tensile test of profile according to DIN EN 1979

This test determines the short-term tensile strength of an overlap seam and is especially suitable for thermoplastic spiral pipes with profile walls. A test sample cut perpendicularly from the overlap seam is placed in the tensile testing device. The force in N (Newton) at which the seam breaks corresponds to the tensile strength of the overlap seam.

3. Quality assurance

3.3 External testing complementing the internal quality assurance system

Introduction

Over long periods of stress and/or at high temperatures, even minute defects such as notches in the material can lead to brittle failure of PE/PP pipes. This failure is due to slow crack propagation. In the past, a number of test methods have been developed that are able to simulate brittle failure. Based on the relevant test results, a material can be improved to show high resilience against slow crack propagation. The most common test methods used today are the notch test and the FNCT (full notch creep test).

Depending on the installation and operating conditions, pipelines can be exposed to extremely high stress. The resistance to the various stress factors can be determined in the lab by means of accelerated test.

These tests take into account that pipes laid by alternative methods tend to become damaged when coming into contact with stones, rock and similar hard material. While such damage normally affects only the surface of the pipe, they might be rather deep (e.g. grooves) with sharp edges. This results in a stress concentration on top of the "normal" stress (e.g. internal pressure, traffic load, settlement).

To guarantee safe operation of polyethylene pipes that are installed by means of alternative techniques, the pipes must meet certain minimum requirements, in particular as regards creep resistance. For a definition of these properties, please refer to PAS 1075. This publicly available specification complements the existing standards and regulations. It describes the technical requirements and test procedures for pipe materials and pipe systems.

Point load test according to Hessel for extruded solid wall pipes (PA PLP 2.2-2 2004.05)

This test method has been approved by Deutsches Akkreditierungssystem für Prüfwesen GmbH and essentially combines an internal pressure test with an external point load test. The test simulates the stress that might occur on a buried pipe that rests on a pointed stone in the sand embedding (simulated in the lab by a 10 mm punch).

The test is performed at an increased temperature (80°C) and with a wetting agent (e.g. Arkopal N-100). The strength requirements for point loads are based on the need for a pipe to withstand such additional loads without showing stress cracks with subsequent failure.

Notch test (DIN EN ISO 13479)

The notch test is performed to test extruded solid wall pipes. It can best be described as a modified internal pressure creep test, whereby the failure point is predefined by a notch (opening angle 60°, notch depth = 20 % of wall thickness). Four such notches are produced at equal distances along the circumference of the pipe. The test is performed at 80°C with 4.6 N/mm².

The minimum standard requirement for PE 100 pipes is > 500 h (DVGW GW 335-A2). For protective pipes, it is > 5000 h. The latest test results are shown below:

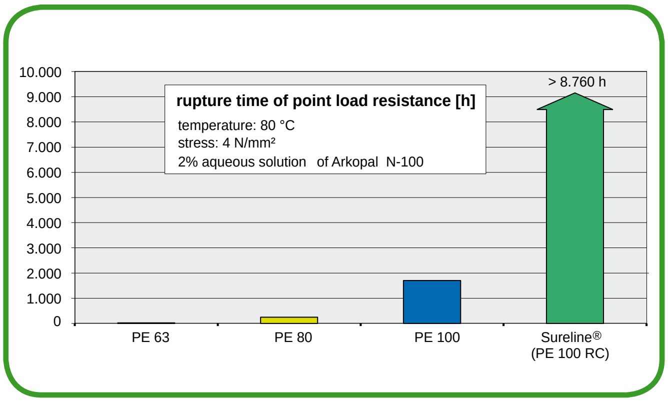

Fig. 41 - Point load resistance

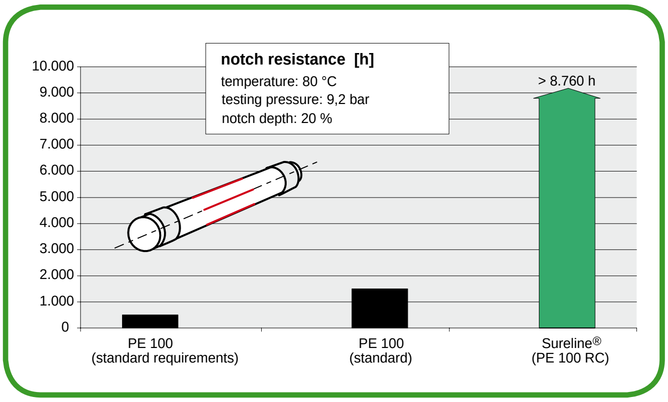

Fig. 42 - Notch resistance

3. Quality assurance

3.3 External testing complementing the internal quality assurance system

FNCT (full notch creep test) according to DIN EN 12814-3; DVS 2203-4 Supplement 2

For this test, rods (i.e. specimens cut in radial direction from the pipe wall) are prepared with a circumferential notch. These rods are then tensile-tested with wetting agents (e.g. Arkopal N-100) at an increased temperature (80 or 95°C). With this testing method, clearly differentiated results can be achieved for the various moulding materials with relatively short testing times. The stronger the material, the longer it takes to break them.

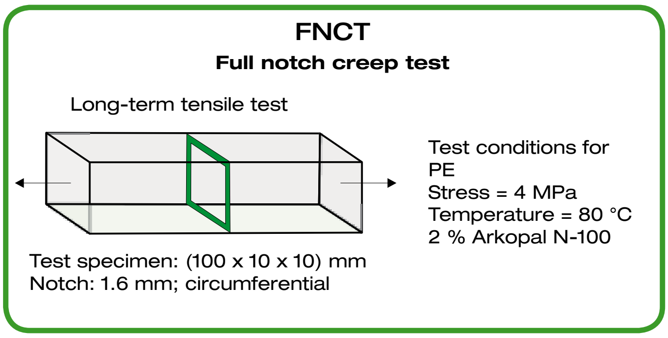

Fig. 43 - FNCT

Test results at 80°C MPa in water		
Material	without wetting agent	with Arkopal 100-N wetting agent
PE-HD*		n/a
PE 80	600 h	≥ 100 h
PE 100	1900 h	≥ 300 h

Table 2 - FNCT minimum requirements according to DIBt

*High-density polyethylene (PE-HD) pipes are only suitable for use as cable duct pipes. There are therefore no specific test criteria for long-term internal pressure creep testing. Given the general approach of only using high-quality materials for sewage pipes, raw materials labelled simply "PE-HD" are never deemed suitable.

Special properties of PE 100-RC

Through optimisation of the manufacturing process of polyethylene materials by copolymerisation with suitable alpha olefins, producers have been able to come up with PE-100 raw materials that offer exceptionally high creep resistance. These PE-100 compounds are generally known as PE 100-RC and are mentioned in PAS 1075 in connection with the use of alternative installation techniques. "RC" stands for "resistance to crack", as FRANK Sureline® pipes are made from this material and are therefore particularly suitable for conventional laying techniques according to PAS 1075. The PKS® sewage pipe with light-coloured inside surface made in F100+ is also classified as a PE-100-RC product (DIBt certificate Z40.25-399). The advantages of a light-coloured inside surface that allows for easy inspection made in a high-quality material are obvious: long service life, high abrasion resistance and minimised surface roughness (K_b) or exactly what is required for the transport of sewage and wastewater.

According to PAS 1075, each batch must undergo a full notch creep test in order to be classified as a PE 100-RC material. For this purpose, FRANK has commissioned Hessel Ingenieurtechnik GmbH to perform accelerated tests at increased temperatures.

Results of external tests

The tests carried out by independent testing institutes (notch test, internal pressure creep test, point load test) confirm the excellent physical and chemical properties of the moulding material used by FRANK. Of special importance here are the properties of PE 100-RC, as this material makes the Sureline pipes particularly suitable for laying by means of alternative techniques, as is documented in PAS 1075.

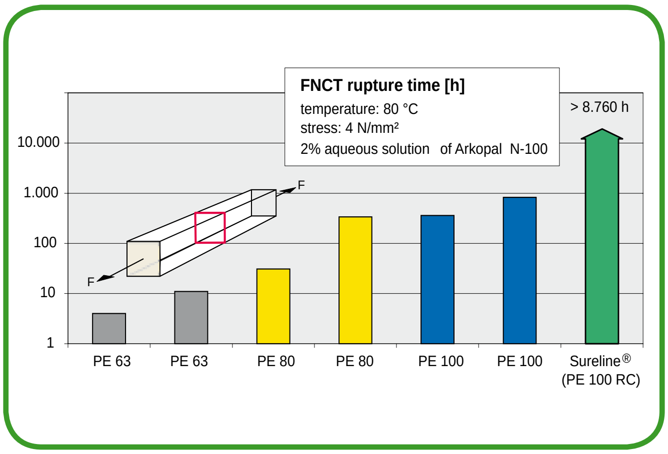

Fig. 44 - Full notch creep test results of different materials

3. Quality assurance

3.3 External testing complementing the internal quality assurance system

Tensile testing of weld

To verify the safety of electrofusion welds, FRANK commissions an independent lab for the long-term tensile testing of electrofusion wire connections. The load is thereby applied at right angles to the joining plane. These tests are performed according to DVS standard 2203-4, Supplement 1 at 80°C and with a test load of 3.0 N/mm² (standard requirement: 2.0 N/mm²).

These tests have been performed for all available pipe dimensions, whereby failures only occurred in the plane of the electrofusion wire. Welds in PKS® pipes reached test times of up to 500 hours. This means that these welding connections meet the test requirements, and that welding is a suitable method to achieve lasting tightness even under long-term stress.

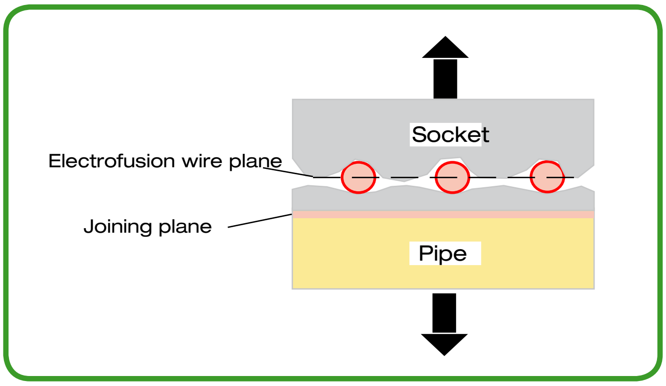

Fig. 45 - Tensile test in electrofusion wire plane

Fig. 47 - Specimen with tensile test failure pattern

HESSEL
Ingenieurtechnik

Bericht Nr.: R06 04 1107

Thema: Prüfungen an der Schweißverbindung eines PKS-Rohres mit gelber Innenschicht

Auftraggeber: Frank & Krah Wickelrohr GmbH
Dieselstraße 11
61200 Wölfersheim

HESSEL Ingenieurtechnik GmbH
Am Vennstein 1a
D-52159 Roetgen

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Fax: +49 2471/920 2219
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Net: www.hessel-ingtech.de

Amtlich anerkannte Prüf-, Überwachungs- und Zertifizierungs-Stelle für Behälter, Rohre und Abdichtungsbahnen aus Thermoplasten (NRW 37).

Deutscher Akkreditierungs Rat
DAR
DAP-PL-3760.00

Nach DIN EN ISO/IEC 17025 durch die DAP Deutsches Akkreditierungssystem Prüfwesen GmbH akkreditiertes Prüflaboratorium.

Datum: 17.03.2006

Zeichnungsberechtigter: Dr.-Ing. Joachim Hessel

Die in diesem Bericht enthaltenen Prüfergebnisse beziehen sich ausschließlich auf die Prüfgegenstände.

Dieser Bericht darf ohne schriftliche Genehmigung der HESSEL Ingenieurtechnik nicht auszugsweise vervielfältigt werden.

Dok. Nr.: R06 04 1107 Seite 1 von 7

Fig. 46 - Hessel certificate - electrofusion weld testing

Conclusions

Given the failure pattern along all the electrofusion wire plane in the electrofusion socket welds, it is reasonable to conclude that the strength of the joining plane is greater than that of the electrofusion wire plane.

The durability of these connections is thus determined by the notch cavities around the electrofusion wires and the notch sensitivity of the material of the socket during machining.

In contrast to electrofusion welds in gas and water pipes made in conventional PE, PKS® welds can withstand forces that are higher by a factor of approx. 3.

3. Quality assurance

3.4 External quality testing

Our products are tested regularly according to the relevant standards and certificates by approved test laboratories with which we have entered into long-term quality assessment contracts.

The following specialist test labs are currently involved in the external testing of our production of pressure pipes and PKS® pipes:

- State Material Testing Institute, Darmstadt (MPA)
- Hessel Ingenieurtechnik GmbH, Rötgen

The high quality standard of our products is documented by a number of approvals and certificates.

As a rule, we only process moulding materials that have been approved by DIBt. Of special importance here are high oxidation stability (OIT value) of the material and a high resistance to slow crack propagation.

By applying test criteria that are more stringent that those laid down in the relevant standards, and by performing tests that are beyond the scope of the current regulations, we can guarantee high system safety.

Our PE and PP products are DIBt-approved under the following certificate numbers:

HESSEL

Prüfnummer 02 534 Ü

Seite 1 von 7

Überwachungsvertrag

Zwischen

Frank & Krah Wickelrohr GmbH
Dieselstraße 11
61200 Wölfersheim – Berstadt
Tel.: 06036 – 98 98 541
Fax: 06036 – 98 98 579

als Hersteller des in § 1 bezeichneten Bauprodukts - im folgenden Hersteller genannt - und der

HESSEL Ingenieurtechnik GmbH
Am Vennstein 1a
D-52159 Roetgen
Tel.: 02471 - 920 220
Fax: 02471 - 920 22 19
Kennziffer: NRW 37

als bauaufsichtlich anerkannte Überwachungsstelle für die Fremdüberwachung - im folgenden Überwachungsstelle genannt - wird folgender Überwachungsvertrag geschlossen:

§1

Gegenstand der Überwachung

Bauprodukt: - im Extrusionswickelverfahren hergestellte Rohre und Formstücke mit und ohne verfahrensspezifischen inneren und äußeren Hohlprofilen und glatten Innenwänden nach DIN 16961 Teil 1 und Teil 2 sowie

- im Extrusionswickelverfahren hergestellte Vollwandrohre und Formstücke,

beide aus PE-HD und PP Formmassen, die für die Behälterherstellung beim Deutschen Institut für Bautechnik (DIBt) zugelassen sind.

Der Anwendungsbereich dieser Wickelrohre umfaßt Behälter und ähnliche Bau- und Anlagenteile mit Gütenachweisen.

Herstellwerk: Frank & Krah Wickelrohr GmbH
Dieselstraße 11
61200 Wölfersheim – Berstadt
Tel.: 06036 – 98 98 541
Fax: 06036 – 98 98 579

Fig. 48 - Hessel - continuous quality assessment contract

Material/ product	Pipes	Fittings
PE	Z-40.23-231	Z-40.23.232
PP	Z-40.23.233	Z-40.23.234
F100+	Z-40.25.399	
PE spiral pipe	Z-40.26.359	
PP spiral pipe	Z-40.26.343	

Table 3 - DIBt approval numbers

DIBt

Allgemeine bauaufsichtliche Zulassung

21.08.2013

Z-40.26-359

31. August 2013
31. August 2018

Frank & Krah
Wickelrohr GmbH
Dieselstraße 11
61200 Wölfersheim

Frank & Krah Wickelrohre aus Polyethylen (PE 100) und
Frank & Krah Wickelrohre aus Polyethylen (PE 100-RC)

Der oben genannte Zulassungsgegenstand wird hiermit allgemein bauaufsichtlich zugelassen.
Diese allgemeine bauaufsichtliche Zulassung umfasst sechs Seiten und drei Anlagen mit acht Seiten.
Der Gegenstand ist erstmals am 3. November 2004 allgemein bauaufsichtlich zugelassen worden.

DIBt

Fig. 49 - DIBt approval for PKS® Secutec and PE 100 spiral pipe

FRANK

3. Quality assurance

3.5 QM system according to DIN EN ISO 9001

For many years, all relevant procedures and processes at FRANK GmbH are covered by a quality management system according to DIN EN ISO 9001. The quality management system is regularly audited by TÜV Rhineland and aims at meeting the expectations of customers at every level.

It therefore does not only cover the quality of our products and the further development of our product range, it also helps us improve our customer services. Through regular staff training and a number of continuous improvement measures, we are taking all the necessary steps to further improve our delivery performance and expertise in the field of plastic pipe systems.

Our high quality standards must of course also be met by our suppliers. The operation of a quality management system according to DIN EN ISO 9001 is only one of many requirements that our supply partners must fulfil. Through the careful choice of our suppliers and continuous supplier verification, we have been able to establish long-term partnerships with a number of reliable moulding material producers.

Our production plants are equipped with the latest technology. Testing and measuring equipment that is directly integrated into the manufacturing process ensure the consistent high qualify of our pipes and fittings.

Das Kunststoff-Zentrum SKZ

Zertifikat

Die SKZ-Cert GmbH Zertifizierungen bescheinigt dem Unternehmen

FRANK Der Vorsprung.
Starkenburgstrasse 1
64546 Mörfelden-Walldorf

mit den Standorten:

AGRU-Frank GmbH, Dieselstraße 1 - 7, 61200 Wölfersheim – Berstadt
XORELLA-FRANK AG, Hardstraße 41, CH-5430 Wettingen
FRANK & KRAH Wickelrohr GmbH, Dieselstraße 11, 61200 Wölfersheim - Berstadt

die Einführung und Anwendung eines Qualitätsmanagementsystems gemäß
DIN EN ISO 9001:2008

Geltungsbereich: siehe Anlage 1

Der Nachweis wurde durch ein Qualitätsaudit erbracht.

Dieses Zertifikat ist gültig vom: 01.12.2011 bis: 30.11.2014
Zertifikat Nr.: 1958/11.N

Würzburg, 24.11.2011
Zertifizierungsstelle

IAF

Fig. 50 - DIN EN ISO 9001 certificate

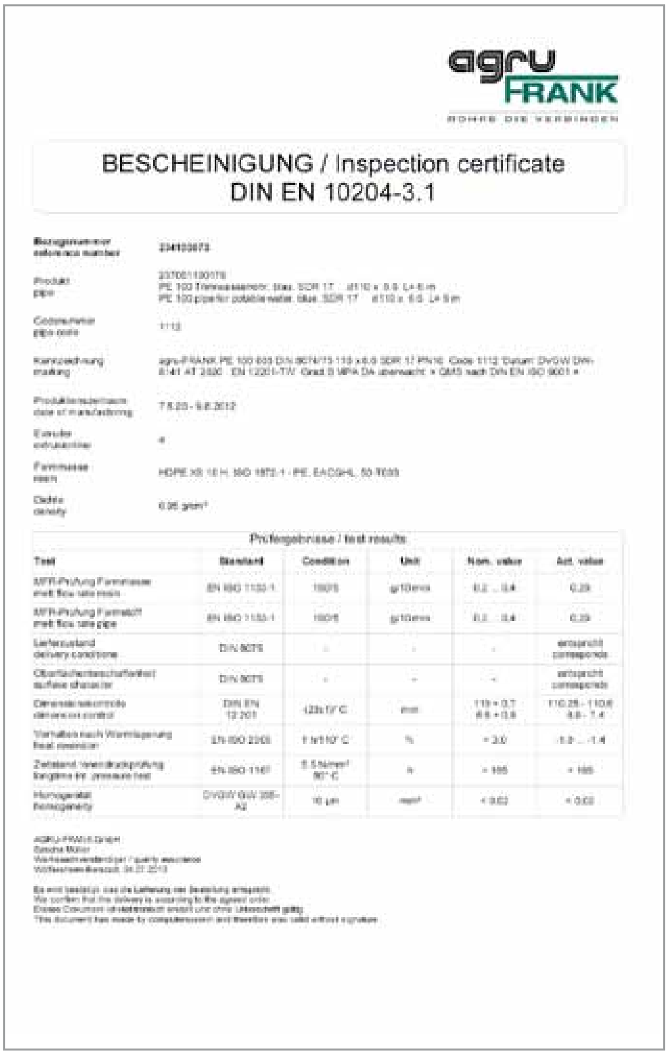
3. Quality assurance

3.6 Inspection certificates according to DIN EN 10204

As each pipe and fitting is equipped with a serial number, it is possible to trace it back to the original raw material batch. All tests and inspections performed from the incoming inspection to the pre-delivery check are documented in inspection certificates according to DIN EN 10204.

These certificates are available on request from our QA department.

Due to more than 40 years of experience in the manufacture of semi-finished products made from polyolefins and our rigorous internal quality assurance system, the quality of our products far exceeds the relevant international minimum standards.


BESCHEINIGUNG / Inspection certificate
DIN EN 10204-3.1

Prüfergebnisse / test results

Fig. 51 - Inspection certificate from AGRU-FRANK GmbH


Abnahmeprüfzeugnis 3.1 nach DIN EN 10204
Inspection Certificate 3.1 according to DIN EN 10204

Prüfergebnisse/ test results

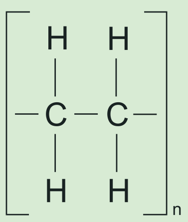
Fig. 52 - Inspection certificate from FRANK & KRAH Wickelrohr GmbH

4. Moulding material

4.1 Polyethylene

General properties of polyethylene

Structural formula of PE



Thanks to the continuous development of enhanced PE moulding material over the last few years, the quality of PE pipes and fittings has been significantly improved.

Previously, polyethylene (PE) has been classified according to its density (PELD, PEMD, PEHD). Today, the materials are classified according to ISO 9080 based on their hydrostatic strength (PE 63, PE 80, PE 100).

Moulding materials previously known as PEHD are no longer relevant for technical applications and are now classified in PE 80.

In contrast to other thermoplastics, PE offers excellent chemical resistance and has been used for many years for the safe transport of sewage and wastewater.

Other key advantages of this material that is normally died black are its UV stability and flexibility.

PE 100

PE 100 is often referred to as a polyethylene of the third generation, or MRS-10 material. It has been developed from standard PE by means of a modified polymerisation method and adapted molecular weight distribution. PE-100 materials therefore do not only feature a higher density, but offer also improved mechanical properties such as increased stiffness and hardness. The durability and resistance against slow and fast crack propagation has also been improved significantly.

This material is therefore ideally suited for the production of large-diameter sewage pipes.

FRANK GmbH is committed to best material and production quality. We therefore decided several years ago to use only PE 100 for the production of our sewage pressure and PKS® pipes and fittings.

Physiological safety

Polyethylene (and polypropylene) are food-grade materials that meet the relevant standards (BGA and KTW regulations). PE pipes and fittings are therefore approved for use in drinking water distribution networks.

Advantages of PE

- Low specific weight of 0.95 g/cm³ (resulting in low pipe weight)
- Easy to transport (e.g. in bundles)
- Excellent resistance to chemicals
- Weather-proof
- Radiation resistant
- Extremely easy to weld
- Excellent abrasion resistance
- No risk of deposits or blockage
- Low pressure drop due to low friction factor (in contrast to metal pipes)
- Frost-resistant
- Ideal for thermoplastic forming (e.g. deep-drawing)
- Rodent-proof
- Resistant to microbiological corrosion
- Suitable for media temperatures up to 60°C

UV resistance

Pipes made in PE are weather-resistant and do not become damaged by UV light (black PE pipes). Black PE pipes can therefore be stored and installed outdoors, as the material does not deteriorate when exposed to the elements.

Radiation resistance

Pipes made in polyethylene are resistant to high-energy radiation. PE pipes have for example been used for many years for the transport of radioactive wastewater from specialist labs and as cooling water lines in nuclear power plants.

Normally radioactive wastewater emits beta and gamma radiation. Tests have shown that PE pipelines do not become radioactive, even after having been in use in nuclear plants for years. Provided that they are not exposed to a uniformly distributed dose of more than 10^4 gray over its service life, PE pipes can also be used in areas with higher radiation activity.

4. Moulding material

4.1 Polyethylene

Hydraulic properties

The hydraulic properties of PE pipes are primarily determined by the smooth, anti-adhesive inside surface of the pipe, whereby the pipe cross-section can be calculated on the basis of a surface roughness of k < 0.01 mm.

Abrasion resistance

Wastewater often contains substantial amounts of abrasive substances such as sand and grit. PE 100 (as well as PP) offer great resistance to abrasion. This has also been demonstrated in abrasion tests performed according to the Darmstadt method (see chapter 5.3 "Abrasion resistance", page 35).

Resistance to chemicals

As PE is a non-polar polymer, it is highly resistant to chemicals in water and other media. PE does not react in any way with aqueous solutions of salts, and non-oxidising acids or alkaline substances.

Up to a temperature of 60° C, PE is also resistant to most solvents. For detailed information, please refer to our catalogue for plastic pipe systems or contact our technical department.

Fig. 53 - SURE INSPECT RC - sewer pipe made in PE 100-RC with yellow inner lining for easy inspection

Modified polyethylene PE-el

(electrically conductive polyethylene)

Pipes used to transport dust or other highly flammable substances must be earthed to prevent electrostatic charging. By equipping pipes with a special co-extruded inside layer, it is possible to produce PKS® sewage pipes (PE 100) that are electrically conductive at the inside. Both the surface and volume resistivity are within the limits generally required for electrically conductive surfaces.

The actual earthing connections for PKS®-el pipes must be determined in cooperation with our technical department.

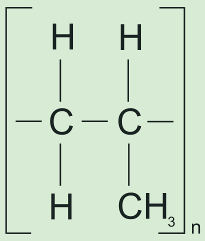
Fig. 54 - PKS® pipe with electrically conductive inside layer

4. Moulding material

4.2 Polypropylene

General properties of polypropylene

Structural formula of PP



When transporting media at a high temperature, polypropylene might be more suitable than polyethylene.

Pipes made in polypropylene (PP) are high heat stabilised and therefore particularly suitable for sewage systems where temperatures up to 95°C might occur.

Radiation resistance

Polypropylene can be affected by long-term exposure to high-energy radiation.

Such radiation might lead to temporary brittling of the material as its molecular structure becomes more closely crosslinked. Long-term exposure to radiation however results in the breakup of the molecular chains and a permanent weakening of the polymer structure. This effect can be taken into account by applying a reduction factor that must be determined empirically.

Absorbed doses of less than 10^4 gray cause however no significant reduction in the strength of polypropylene.

Resistance to chemicals

PP is normally resistant to a large number of acidic and alkaline substances, including phosphoric acid and hydrochloric acid. Hydrocarbons can however damage PP pipes, as the material tends to swell by up to 3 % when in contact with such substances. Polypropylene pipes are therefore not suitable for the transport of petrol and other petrochemicals. The material also reacts with free chlorine and ozone.

Thanks to its high temperature resistance, PP is widely used in pickling units, chemical processing plants and for the transport of highly aggressive effluents.

As the chemical resistance of a material is always determined by the actual operating temperature, operating pressure and other external influences, its suitability for a particular application must always be determined with these factors in mind.

If you have any queries regarding the suitability of PP for a specific application, please contact our technical department for advice.

Advantages of PP

- Low density of 0.91 g/cm³ (PVC: 1.40 g/cm³) (resulting in low pipe weight)
- High durability
- Excellent resistance to chemicals
- Dyeable with TiO_2 pigments
- High resistance to ageing
- Easy to weld
- Excellent abrasion resistance
- Smooth inside surface preventing deposits
- Low pressure drop due to low friction factor (in contrast to metal pipes)
- Non-conductive, no damage to molecular structures from leakage current
- Ideal for thermoplastic forming (e.g. deep-drawing)
- PP is a poor thermal conductor, which means that there is normally no need for insulation around hot water pipes
- Suitable for media temperatures up to 95°C
- Rodent-proof
- Resistant to microbiological corrosion

UV-resistance of PP

Pipes made in grey polypropylene are not UV-stabilised and must therefore be protected against direct sunlight. PP pipes for underground installation do not require any special protection against UV radiation, in contrast to overground installation, where special protective measures must be taken. When storing PP pipes outdoors for a prolonged period of time, they must be covered with light-tight foil.

TSC pipes are black at the outside, which makes them UV-resistant.

4. Moulding material

4.3 Material properties

Materials used in the production of sewage pipe systems must have the following properties (guide values):

	Property	Standard	Unit	PE 100	PE 100 RC	PE-el	PP-R	PP-B
Mechanical properties	Density at 23°C	DIN EN ISO 1183	g/cm³	0.96	0.96	0.99	0.91	0.91
	E modulus (tensile test) Short-term Long-term (50 years)	DIN EN ISO 178	N/mm²	1100 200	1100 200	1400 -	900 287	1850 290
	Tensile stress at yield	DIN EN ISO 62:2008-05	N/mm²	23	23	26	25	33
	Tensile strength at break	DIN EN ISO 62:2008-05	N/mm²	38	-	30	-	-
	Elongation at break	DIN EN ISO 62:2008-05	%	> 600	-	-	-	-
	Ball impression hardness	DIN EN ISO 2039	N/mm²	46	-	40	-	-
	Notched impact strength at 23°C (Charpy test)	DIN EN ISO 179/ DIN EN ISO 180	kJ/m²	-	22	5	20	50
	Creep resistance (FNCT)	DIN EN 12814-3	h	> 300	> 8760	-	-	-
Thermal properties	Melt flow index MFR 190/5 (°C/kg) MFR 190/21,6 (°C/kg) MFR 230/2.16 (°C/kg) MFI group	DIN EN ISO 1133 Code T Code G Code M	g/10 min	0.3 - - T005	0.25 - -	- 4.5 - M003	- - 0.25	- - 0.30
	Coefficient of elongation	DIN 53752	k-1 x 10-4	1.8	1.8	-	-	-
	Fire class	UL94 DIN 4102	-	94-HB B2	94-HB B2	94-HB B2	94-HB B2	94-HB B2
	Thermal conductivity (at 20 °C)	DIN 52612	W/mK	0.38	0.38	0.43	0.24	-
Electrical properties	Specific volume resistivity	DIN IEC 60093 DIN IEC 60167	Ohm cm	$> 10^{15}$	$> 10^{15}$	$> 10^{5}$	-	-
	Surface resistivity	DIN IEC 60093 DIN IEC 60167	Ohm	$> 10^{13}$	$> 10^{13}$	$> 10^{4}$	-	-
	Colour	-	-	Black/yel-low	Black	Black	Grey (RAL 7032)	Black/grey
	MRS rating	DIN EN ISO 9080	N/mm²	10	10	-	-	-
	Electric strength	DIN EN VDE 0303	kV/mm	70	70	-	-	-

Table 4 - Material properties of plastics (guide values)

FRANK

5. Resistance to pressure and wear

5.1 Creep rupture curves - DIN 8075 PE 100 pipes

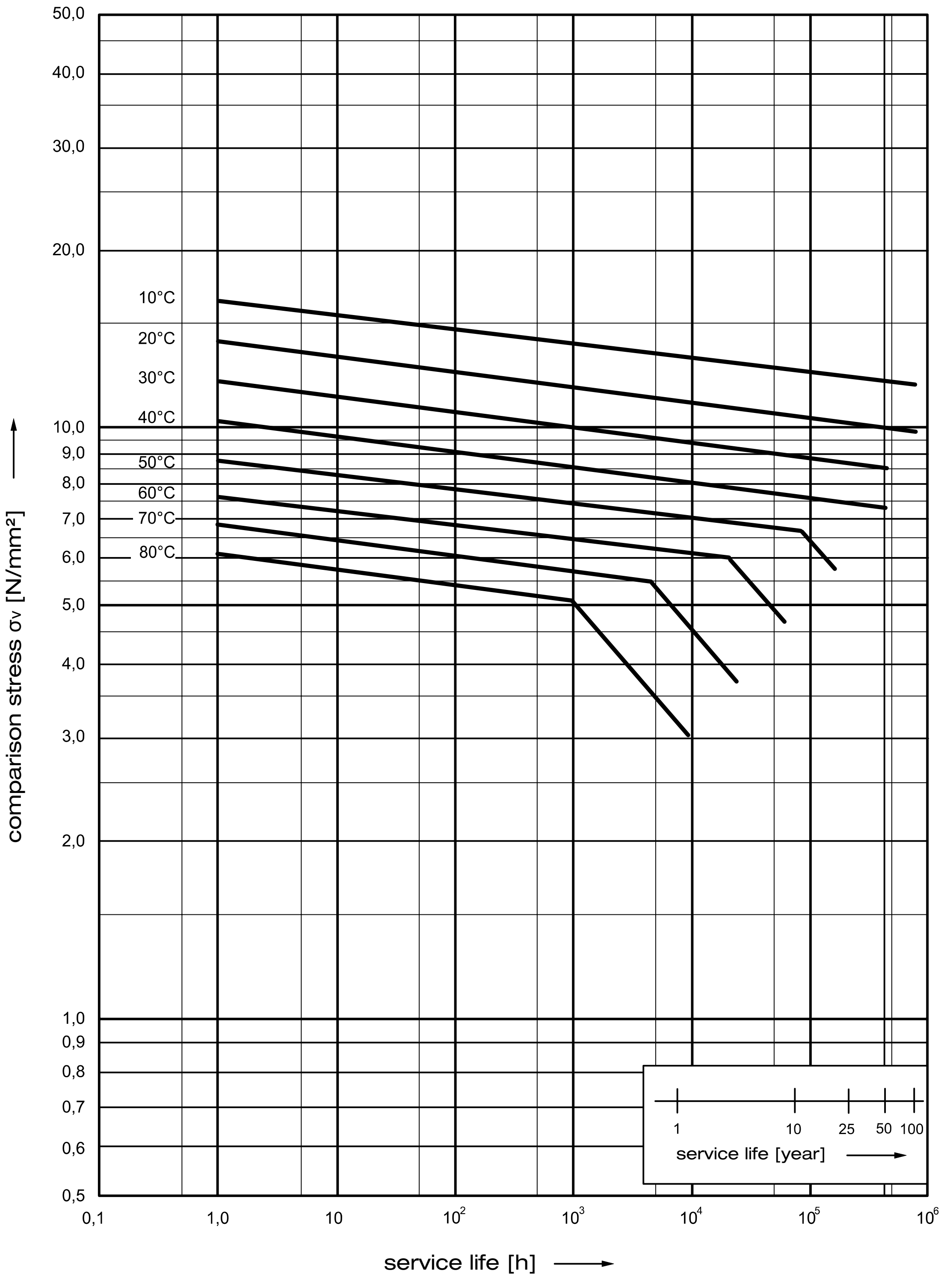


Fig. 55 - Creep rupture curve - PE 100

5. Resistance to pressure and wear

5.2 Creep rupture curves - DIN 8078 PP-R pipes

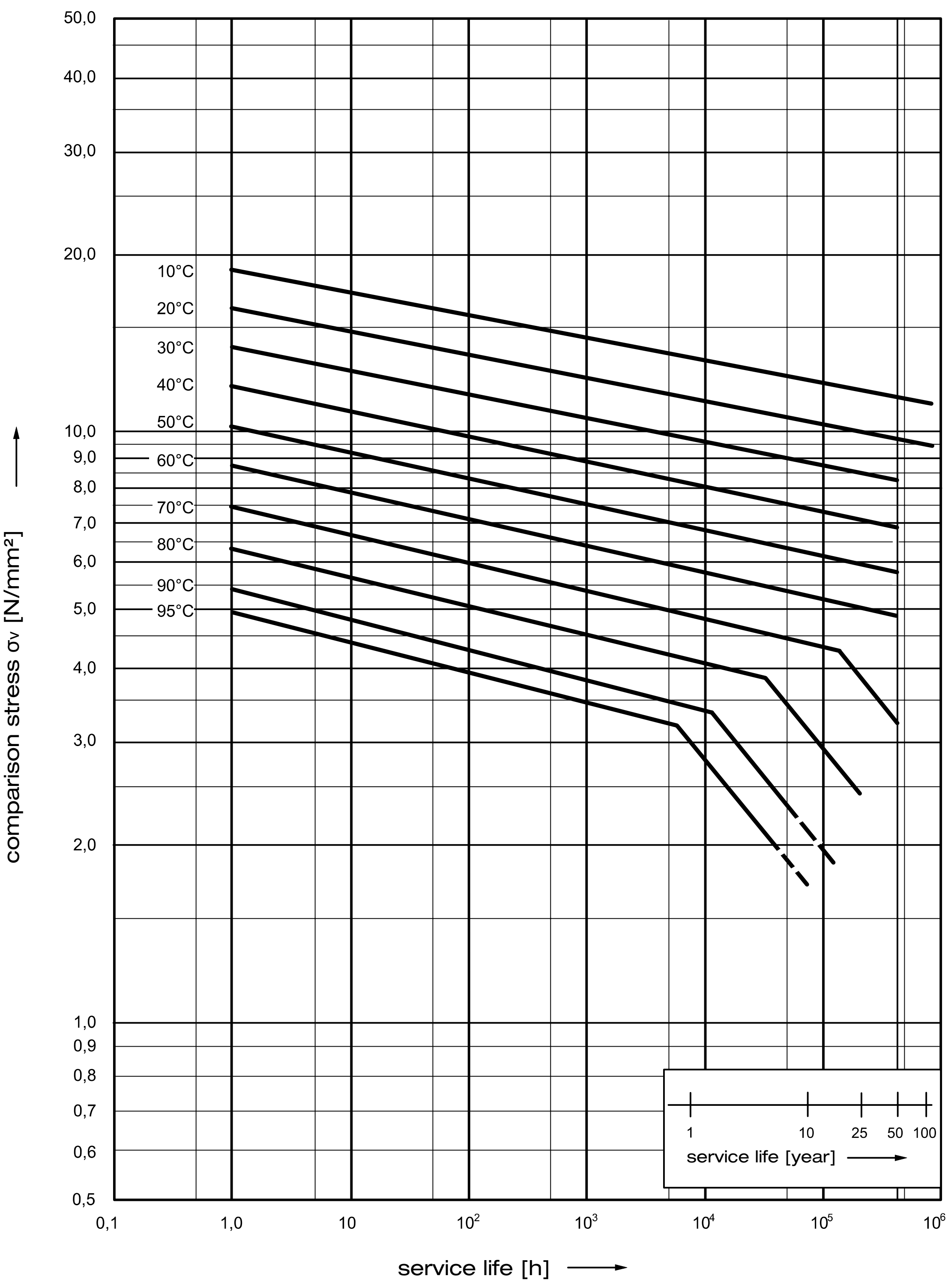


Fig. 56 - Creep rupture curve - PP-R

5. Resistance to pressure and wear

5.3 Abrasion resistance

General

Sewage pipe systems carry wastewater and rain water, which contain abrasive substances such as sand and grit. As wastewater systems are crucial for the protection of the environment and are costly investments they must work properly and reliably for a long period of time. This can be achieved by opting for permanently tight pipe systems made in high-quality materials and by regular cleaning and maintenance.

To withstand the impact of solids, pipes must be made from a material that is resistant to abrasion, as premature wear of the pipe tends to lead to leakage. FRANK pipes are made from PE 100 and PP that have a high resistance to abrasion as has been proven in abrasion tests performed according to the Darmstadt method.

Testing according to the Darmstadt method

The Darmstadt method has been devised for the abrasion testing of pipes and conforms to the relevant standards.

Test layout:

With the Darmstadt method, a 1000 mm half-pipe section is mounted in the testing device. The ends of the section are closed with end plates and filled with a mixture of sand and gravel. To conform to the standard, the test must be performed with natural, unbroken, round-grained quartz gravel. The half-pipe is then closed with a lid and tilted alternatively by 22.5° along its transverse axis so that the sand/gravel mixture is moved along the inside surface of the pipe.

For the test, an average of 400,000 tilting cycles must be performed.

Evaluation:

The abrasion is measured with a dial gauge (scale 0.01 mm) along the base of the pipe. The depth of the abrasion is thereby measured along a length of 700 mm, as the two 150 mm sections near the ends of the pipe are not taken into account. The measurements are taken at distances of maximum 10 mm and the average abrasion depth is calculated. This value thus represents the average difference between the new pipe wall thickness and the actual wall thickness after testing. The excellent abrasion resistance of PE and PP compared with other pipe materials is shown clearly in the diagram below:

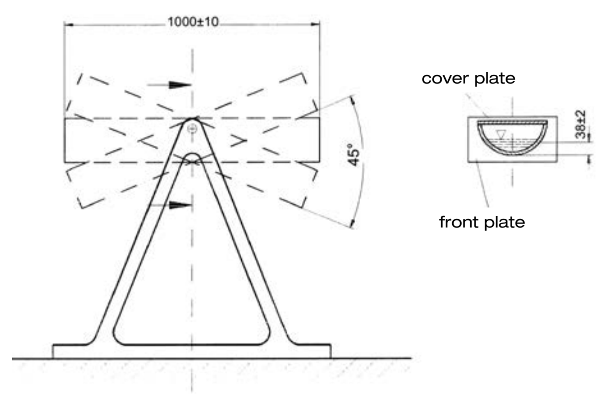


Fig. 57 - Test layout for abrasion testing

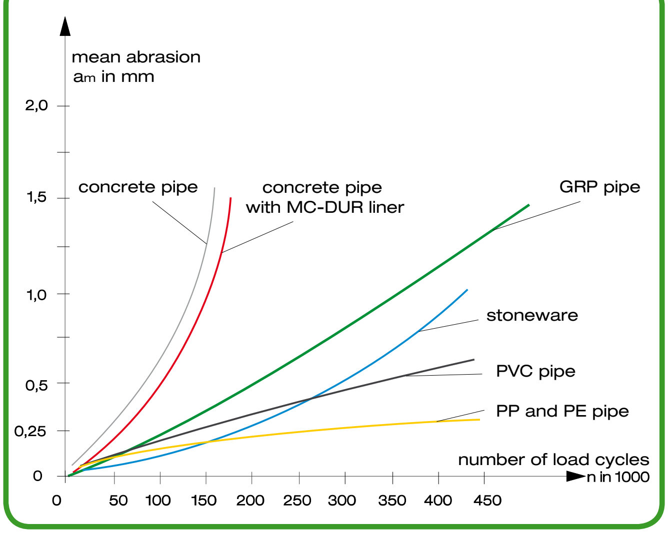


Fig. 58 - Diagram of mean abrasion

5. Resistance to pressure and wear

5.3 Abrasion resistance

As part of our quality assurance systems, we perform internal tests and also have our products tested by independent testing bodies. One of the test parameters is the abrasion resistance of our raw/moulding materials. The specimens are normally DN 300 sections taken from a normal production run at one of our plants.

For the evaluation of the results, the values are adjusted to 100,000 test cycles. This corresponds to the actual abrasion in an installed pipe over a period of 25 years.

Results

PKS® sewage pipes according to DIN 16961 / DIN EN 13476, FRANK & KRAH

The abrasion test was performed with a profiled sewage pipe (PE 100), size DN 300. The discolouration at the bottom of the pipe indicates minor abrasion.

PP pipes according to DIN 16961 / DIN EN 13476, FRANK & KRAH

In other tests, a pipe made in PP, size 300 was examined. The picture to the right shows minor abrasion (discolouration at the bottom of the pipe).

Fig. 59 - PKS® pipe (PE 100), DN 300 in abrasion test, FRANK & KRAH Wickelrohr GmbH

Fig. 60 - PP pipe, DN 300 in abrasion test, FRANK & KRAH Wickelrohr GmbH

Abrasion caused during the tests appear as lighter coloured sections inside the pipe halves.

The results of the two tests show that the actual abrasion depth is more or less proportional to the number of test cycles. The measurements of the two tested pipes show a mean abrasion depth of 0.09 mm after 100,000 test cycles. This value is significantly below those measured in other materials.

5. Resistance to pressure and wear

5.4 Resistance to high pressure cleaning

Introduction

As wastewater is not a homogeneous solution and the flow rate in most sewage pipes fluctuates, deposits are to be expected and might differ greatly in composition and structure. Normally, deposits in pipes consist of a mixture of mineral and organic matter, including small stones. That is why sewage pipe system operators regularly clean their pipelines. A number of different methods have been devised for this task over time. Today, most operators use high pressure cleaning, as this is the most economical method. However, high pressure cleaning places a high load on the sewage pipe system. To ensure that a pipe system is suitable for high pressure cleaning, a standardised test method known as the Hamburg model has been devised.

During high pressure cleaning, pipe systems must withstand a number of stresses and impacts. Pipes can become mechanically worn by the nozzle and high-pressure hose that pass along the bottom of the pipe during the cleaning process. As deposits are moved along the bottom of the pipe is normally, abrasion from solids is increased.

To determine the effect of high pressure cleaning on the pipe material, a number of tests have been devised. In order to obtain results that reflect the actual conditions during high pressure cleaning, the pipes are tested following the Hamburg model. In 2004, Institut für Unterirdische Infrastruktur GmbH (IKT) in Gelsenkirchen published a scientific study that examined various pipe materials as regards high pressure cleaning resistance. The study report is available from IKT.

High pressure system test - layout

The tests were performed using conventional cleaning vehicles, flushing hoses and cleaning nozzles and with a pressure of 120 bar at the nozzle and a flow rate of 320 l/min. The nozzle was moved through the pipe system at a rate of 1 m/s (forward) and 0.1 m/s (return). These parameters are at the upper end of load that might occur during standard pipe cleaning. In addition, grit was added at each test cycle. This material is accelerated by the water jet and the propelled air, impacts on the pipe wall, connections and inlets and eventually escapes at the other end. This was done to simulate the effect of deposits in the pipe.

All pipe strings also underwent a stationary test with a point load. In this test, three points along the pipe were selected and the nozzle was placed for three minutes above these points to produce a point load.

All nozzle point load tests were performed with the same type of nozzle (circumferential, eight-jet nozzle with a jet angle of 30° (test nozzle D1 8 x 30°)) and for the same time period. The test was performed over 50 cleaning cycles (forward and return movement of the nozzle). This corresponds to the number of cycles that are normally expected over the service life of a sewer line of 100 years (cleaning every two years).

Results of tests

For the high pressure cleaning test, IKT used PKS® pipes with a smooth, extruded solid wall made in PE 80 and light-coloured inside layer, size DN 300/da 355.

Reference high pressure cleaning tests carried out without grit show only minor marks along the bottom of the PE pipes near the connections, caused by the moving nozzle jet. Subsequently, a volume of 5 litres of grit was added at each cleaning cycle. The bottom of the pipe and the connections now showed more prominent abrasion marks and the pipe surface became rougher. The actual abrasion depth remained however below 1 mm.

The pipe strings also underwent stationary tests whereby the nozzle was pointed for 3 minutes to the same point in the pipe. This load did have no discernible effect on the material.

The test results show that PE pipes can withstand normal loads and abrasion over a lifespan of 100 years without any significant damage. The wear resistance of PE is therefore considerably higher than that of conventional pipe materials, some of which showed significant abrasion.

6. Calculations

6.1 Determination of pipe cross-section for gravity pipelines

Thanks to the outstanding properties of plastic pipes, they can be used for the construction of sewer lines with a very small angle of inclination. For the hydraulic dimensioning of PE pipes, follow the DWA guidelines. The waxy, smooth inside surface of the PE pipes prevents sediments.

Pipes might be partially or fully filled. Normally, the maximum possible flow rate in fully filled pipelines is taken into account.

Operational roughness k_b

Following the DWA guidelines, the calculations for sewer lines must be based on the operational roughness k_b, as it includes the effect of manholes and fittings on the flow rate. For PE pipes, the recommended value k_b = 0.1 mm provides an adequate safety margin.

The maximum drainage rate **v** is determined according to **PRANDTL** and **COLEBROOK:**

$$v = \left(-2 \cdot \lg \left[\frac{2{,}51 \cdot \nu}{d \cdot \sqrt{2 \cdot g \cdot J_E \cdot DN}} + \frac{k_b}{3{,}71 \cdot DN} \right] \right) \cdot \sqrt{2 \cdot g \cdot J_E}$$

v	...	Flow rate	[m/s]
J_E	...	Energy gradient	
k_b	...	Operational roughness	[mm]
g	...	Gravity	[Nm/s²]
n	...	Kinematic viscosity	[m²/s]
		(1.31 x 10^{-6}, for sewage at 12°C)	
DN...		Inside diameter	[mm]

The maximum **discharge Q** of a fully filled pipeline is:

$$Q = v \cdot A$$

Q	...	Discharge	[l/s]
A	...	Flow cross-section area	[mm²]
v	...	Flow rate	[m/s]

General mean roughness k_b for various operating conditions

The k_b values include the effects of pipe joints, deviations from the planned pipe position, wall roughness, inlet fittings and man-hole structures.

Operating conditions	Recommended for PE k_b	according to DWA-A 110 k_b
Throttle sections, pressure pipelines, culverts and relined sections without manholes	0.10 mm	0.25 mm
Transport pipelines with manholes according to DVWK M 241 section 1.1.5, e.g. PKS® tangential manhole made in PE 100	0.25 mm	0.50 mm
Main sewers and pipelines with manholes according to DVWK M 241 section 1.1.5 up to DN 1000; with form-fitted manholes according to DVWK M 241 section 8.1.2.3 for all DN; transport pipelines with special or integrated man-holes for all DN	0.50 mm	0.75 mm
Main sewers with supply pipes, special manholes and spe-cial angles	0.75 mm	1.50 mm

Table 5 - Mean roughness k_b for PE

6. Calculations

6.2 Stress resulting from insulation and groundwater above pipe level

In certain exceptional cases, a pipeline system might be exposed to an external underpressure:

- If it is installed in water (culvert) or in the ground below the groundwater horizon
- During the insulation of a relined pipe
- If a pump is installed at the suction side of the pipeline (underpressure in pipe)

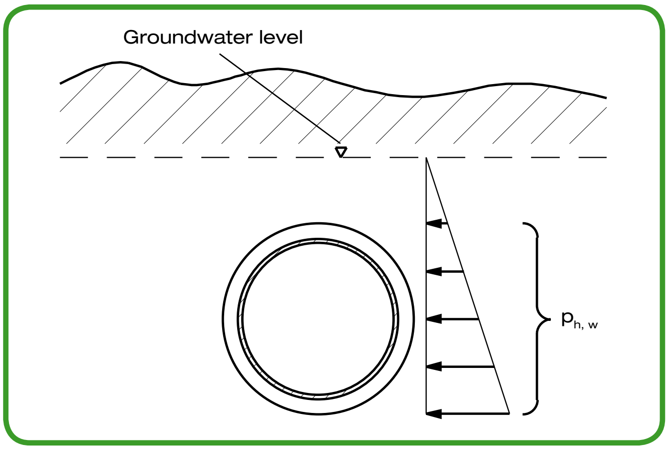


Fig. 61 - Load resulting from hydrostatic pressure resulting from groundwater above pipe level (e.g. for pipes installed below groundwater horizon)

In insulated pipes, the insulation supports the pipe, so that its buckling pressure is higher than that of a non-insulated pipe. The static stress on a sewer pipeline restored by means of PE pipes can be calculated using the p_k equation:

For PE pipes the **buckling pressure p_k** is:

$$p_k = \frac{10 \cdot E_C}{4 \cdot (1-\mu^2)} \cdot \left[\frac{s}{r_m}\right]^3$$

p_k ... Critical buckling pressure [bar]
E_C ... Creep modulus (see page 41) [N/mm²]
m ... Transverse contraction coefficient (for thermoplastics: generally 0.4)
s ... Equivalent wall thickness [mm]
r_m ... Mean pipe radius [mm]

The effects of eccentricity and unroundness must be taken into account by applying a reduction factor f_r, which is normally between 0.9 and 0.95.

For stability calculations, for example to calculate the buckling pressure, a minimum safety factor of 2 must be applied.

The **permissible buckling pressure** is:

$$p_{k,\,zul} = p_k \cdot \frac{f_r}{S}$$

$p_{k,\,zul}$ Permissible critical buckling pressure [bar]
f_r ... Reduction factor (0.9 to 0.95)
S ... Safety coefficient (≥ 2)

The **buckling stress** can subsequently be calculated as follows:

$$\sigma_k = 0{,}1 \cdot p_k \cdot \frac{r_m}{s}$$

s_k ... Buckling stress [N/mm²]
p_k ... Permissible critical buckling pressure [bar]
r_m ... Mean pipe radius [mm]
s ... Wall thickness [mm]

Where PE pipes are insulated, there is a risk that the pipe might become buoyant so that it is not in the envisaged position. To prevent this, pipe sections can be equipped with spacers that prevent the pipe from floating. In this case, the loads on these spacers must be calculated. The spacer distance must be chosen so that the maximum permissible deflection is not exceeded.

Lifting force acting on empty PE pipes:

$$F_V \approx \frac{\pi \cdot da_R^2}{400} \cdot l_R \cdot \gamma_D$$

Lifting force acting on PE pipes filled with water:

$$F_V \approx \left[\frac{\pi \cdot da_R^2}{400} \cdot l_R\right] \cdot \gamma_D - 1$$

F_V ... Lifting force [N]
da_R... Outside pipe diameter [mm]
DN... Inside pipe diameter [mm]
γ_D ... Specific weight of insulation [kg/dm³]
l_R ... Support span [m]

Maximum distance between support points

$$L_A = f_{LA} \cdot \sqrt[3]{\frac{E_C \cdot J_R}{q}}$$

L_A ... Maximum support span [mm]
f_{LA} ... Deflection factor (0.80)
E_C ... Creep modulus (see page 41) [N/mm²]
J_R ... Pipe moment of inertia [mm⁴]
q ... Buoyancy load [N/mm]

6. Calculations

6.3 Calculations for underground sewage pipes according to ATV-DVWK-A 127

ATV-DVWK-A 127

Plastic pipes made in polyethylene or polypropylene are normally installed underground. As the loads on the pipe can be varied and changing, the stability calculations are normally performed by means of specialised computer software. As a rule, the calculations must be carried out according to the instructions in ATV-DVWK-A 127 "Static Calculations of Drains and Sewers". In order to perform accurate and complete calculations for underground PKS® pipes, it is necessary to know the actual installation conditions.

To determine these, please refer to the questionnaire in chapter 7, pages 44 ff. On request, FRANK GmbH shall perform verifiable calculations based on your information provided in the questionnaire.

Loads

For calculations according to ATV-DVWK-A 127, a number of different loads might need to be considered, including:

- Road traffic loads
- Rail traffic loads
- Top covering loads
- Surface loads from buildings
- External water pressure

Road traffic loads

Apart from the top covering load, road traffic loads are the most common loads on underground sewage pipes, as most pipelines are driven over by road vehicles. According to ATV-DVWK-A 127, it is therefore necessary to assume a road traffic load of minimum of CV 12 even for pipes that are not strictly speaking in a road traffic area.

For the determination of the load, ATV-DVWK-A 127 uses the following standard vehicles:

Standard vehicle	Total load	Wheel load	Wheel footprint	
	[kN]	[kN]	Width [m]	Length [m]
HGV 60	600	100	0.6	0.2
HGV 30	300	50	0.4	0.2
CV 12	120	front 20 rear 40	0.2 0.3	0.2 0.2

Table 6 - Load assumptions for standard vehicles

Installation

For the calculation, the type of installation must be taken into account in addition to the outer and inner stress factors. The deformation of underground sewage pipes is greatly affected by the structure and material of the bedding. As a rule, the bedding angle should be as large as possible. Possible bedding angles are 120° and 180°.

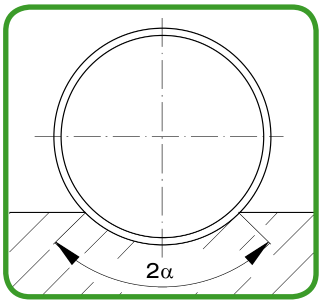


Fig. 62 - Bedding angle

Most underground sewage pipes are installed in a trench. Depending on the site conditions and requirements, different trench types and shapes are used. For the calculation of the pipe stress, the shape of the trench must be determined (see examples below).

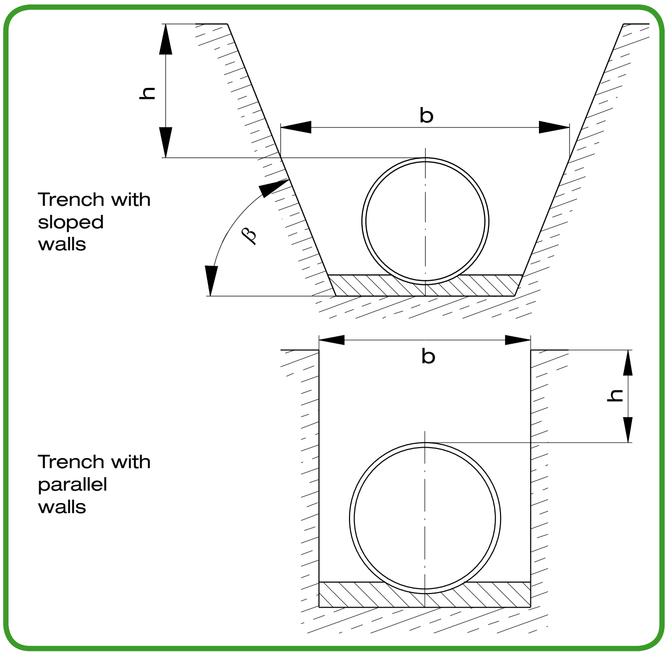


Fig. 63 - Trench installation

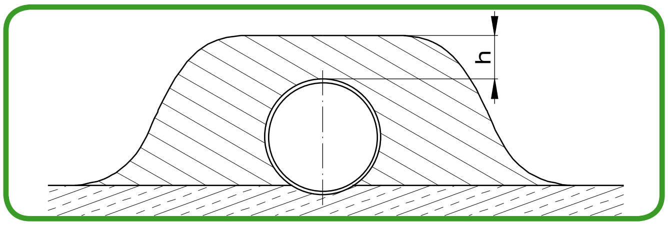


Fig. 64 - Installation in bank

6. Calculations

6.3 Calculations for underground sewage pipes according to ATV-DVWK-A 127

Covering and embedding conditions

For the embedding of the pipe zone and the backfilling of the trench above the pipe zone, ATV-DVWK-A 127 distinguishes between 4 covering conditions (A) and 4 embedding conditions (B):

A1/B1. Compacted embedding in layers against the natural soil or in the embanked covering (without verification of degree of compaction); applies also to beam pipe walls ("Berlin shuttering").

A2/B2. Vertical shuttering in the pipe trench using trench sheeting or lightweight piling profiles, which is only removed after backfilling. Shuttering plates or equipment are gradually removed as the trench is being filled. Uncompacted trench backfilling. Hydraulic installation of backfilling/embedding material (only suitable for soil group G1).

A3/B3. Vertical shuttering in the pipeline zone, using sheet piling or lightweight piling profiles, wooden planks, riveting plates or similar equipment, which are only removed after backfilling; no effective re-compaction after removal of the above equipment.

A4/B4. Compacted embedding in layers against the natural soil or in the embanked covering, with verification of degree of compaction (Proctor density) as required according to the German Technical Terms and Conditions of Contract and Guidelines for Earthworks in Road Construction ZTVE-StB; applies also to beam pipe walls ("Berlin shuttering"). Covering/embedding condition A4/B4 is not permissible for soils of group G4.

Soil classes

The soil groups required for the calculation are laid down in DIN 18 196:

G1: Non-cohesive soils (gravel, sand)
[GE, GW, GI, SE, SW, SI]

G2: Slightly cohesive soils (mixtures of gravel and sand with clay and silt)
[GU, GT, SU, ST]

G3: Cohesive mixed soils, coarse clay (cohesive sand and gravel, cohesive stony residual soil)
[GU, GT, SU, ST, UL, UM]

G4: Cohesive soils (clay, loam)
[TL, TM, TA, OU, OT, OH, OK, UA]

Trench zones

The pipeline trench consists of the following zones:

Zone 1: Trench filling above the top of the pipe

Zone 2: Pipe zone to the side and below the bottom of the pipe

Zone 3: Ground adjacent to the trench or soil installed beside the pipe zone

Zone 4: Ground below the pipe (trench base)

For the calculation according to ATV-DVWK-A 127, it is necessary to determine compaction rate (Proctor density) and the soil type of the above zones (see questionnaire page 45).

Fig. 65 - PKS® sewage pipe installed in pipe trench

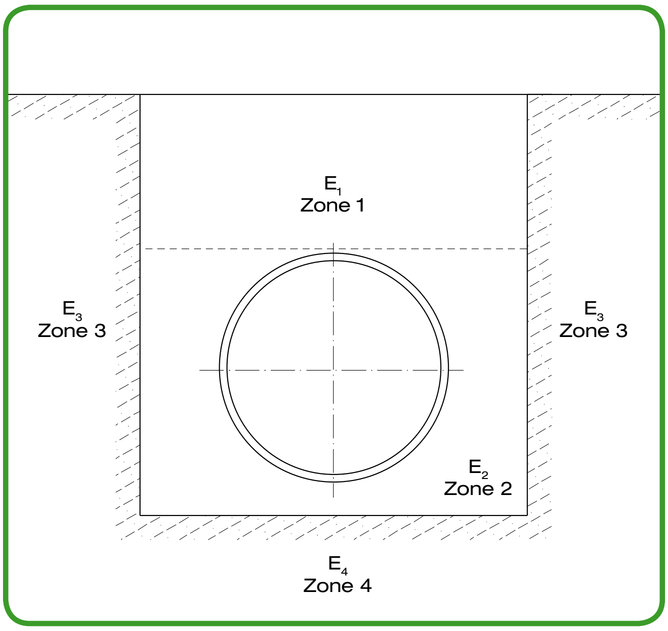


Fig. 66 - Pipe trench zones

6. Calculations

6.4 Calculation of pipe wall thickness s_{min} based on operating pressure

The wall thickness is calculated with the **boiler formula**. To determine the **design stress (σ_{zul})**, use the reference stress (σ_V) shown in the respective service life curves (pages 31, 32) and divide it by the safety coefficient C (according to DIN 8077). Depending on actual application, it might be necessary to include a system reduction coefficient (0.8). This additional safety coefficient enables you to take into account additional stresses at joints (e.g. welded connections):

$$\sigma_{zul} = \sigma_V \cdot \frac{1}{C}$$

For hazardous media, the permissible stress must be reduced by the associated reduction coefficients.

The **minimum wall thickness** can be calculated with the following formula:

$$s_{min} = \frac{p \cdot d}{20 \cdot \sigma_{zul} + p}$$

s_{min}	Minimum wall thickness	[mm]
p	Operating pressure	[bar]
d	Outside pipe diameter	[mm]
σ_{zul}	Design stress	[N/mm²]

If required, the above values allow for the calculation of the actual **stress σ_{tat}** or the **maximum operating pressure p** at a given wall thickness s:

$$\sigma_{tat} = \frac{p \cdot (d - s_{min})}{20 \cdot s_{min}} \qquad p = \frac{20 \cdot \sigma_{zul} \cdot s_{min}}{d - s_{min}}$$

For rigidly secured sewage pipe systems, the required **minimum wall thickness s_{min}** must be calculated with the following formula:

$$s_{min} = \frac{p \cdot d}{20} \cdot \sqrt{\frac{1}{\sigma_{zul}^2 - (E_C \cdot \varepsilon)^2}}$$

E_c	Creep modulus *(see page 41)*	[N/mm²]
ε	Elongation = $\Delta L / L_0$	
ΔL	Elongation	[mm]
L_0	Pipe length	[mm]

6.5 Stress due to external overpressure (buckling pressure)

In certain exceptional cases, a pipeline system might be exposed to an external overpressure:

- Pipeline installed below water level or below the groundwater horizon
- Underpressure pipelines, e.g. suction lines

The **permissible underpressure** is determined as follows:

$$p_B = \frac{10 \cdot E_C}{4 \cdot (1 - \mu^2)} \cdot \left[\frac{s}{r_m}\right]^3$$

p_B	Permissible buckling pressure	[bar]
E_c	Creep modulus *(the creep modulus must be determined from the diagrams on page 41; the value determined from the diagram must be divided by 2)*	[N/mm²]
μ	Transverse contraction coefficient *(for thermoplastics: generally ~0.4)*	
s	Wall thickness	[mm]
r_m	Mean pipe radius	[mm]

The **minimum wall thickness** is calculated as follows:

$$s_{min} = \sqrt[3]{\frac{p_B \cdot 4 \cdot (1 - \mu^2)}{10 \cdot E_C}} \cdot r_m$$

p_B	Permissible buckling pressure	[bar]
E_c	Creep modulus *(the creep modulus must be determined from the diagrams on page 41; the value determined from the diagram must be divided by 2)*	[N/mm²]
s_{min}....	Minimum wall thickness	[mm]
r_m	Mean pipe radius	[mm]

The **buckling stress** is calculated as follows:

$$\sigma_B = 0{,}1 \cdot p_B \cdot \frac{r_m}{s}$$

σ_B	Buckling stress	[N/mm²]
p_B	Permissible buckling pressure	[bar]
r_m	Mean pipe radius	[mm]
s	Wall thickness	[mm]

6. Calculations

6.6 Creep rupture curves for PE 100 according to DVS 2205-1

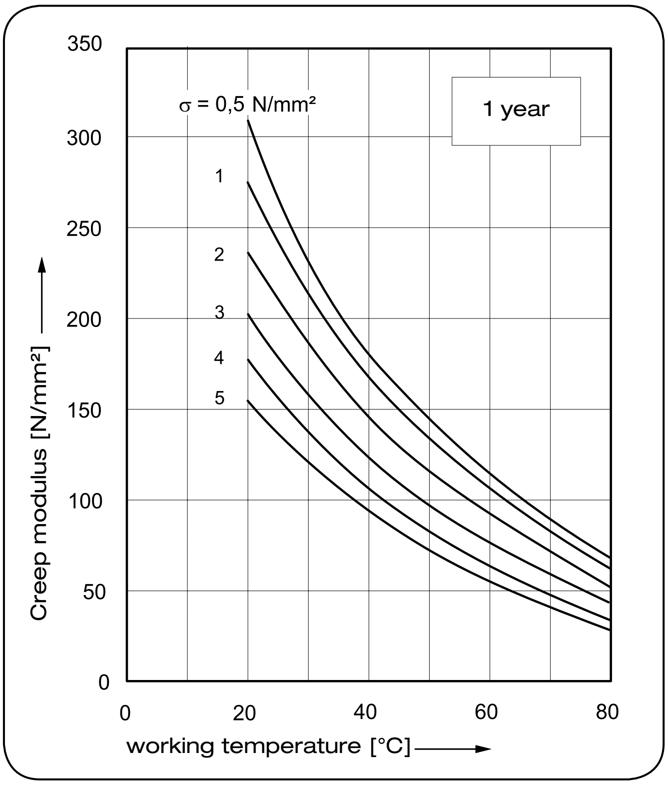


Fig. 67 - Creep rupture curve for PE 100, service life 1 year

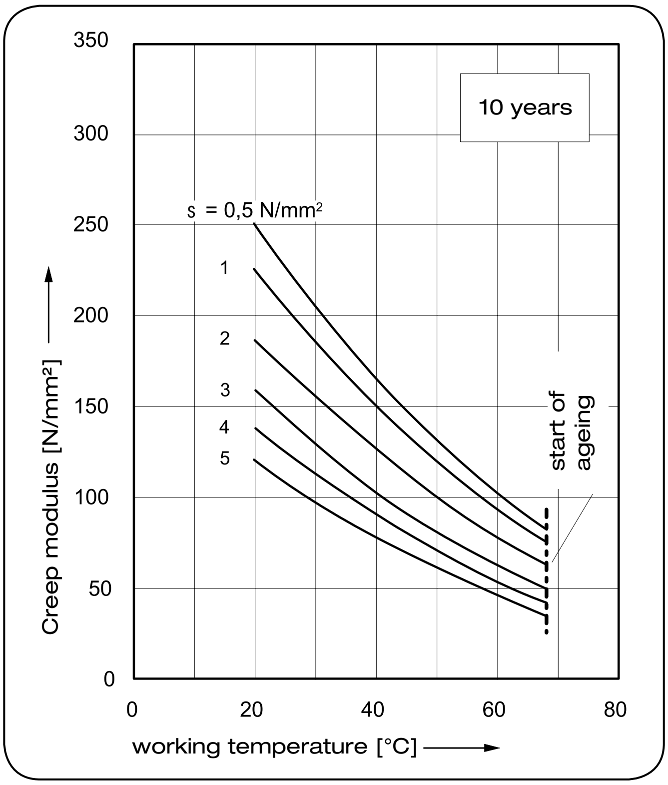


Fig. 68 - Creep rupture curve for PE 100, service life 10 years

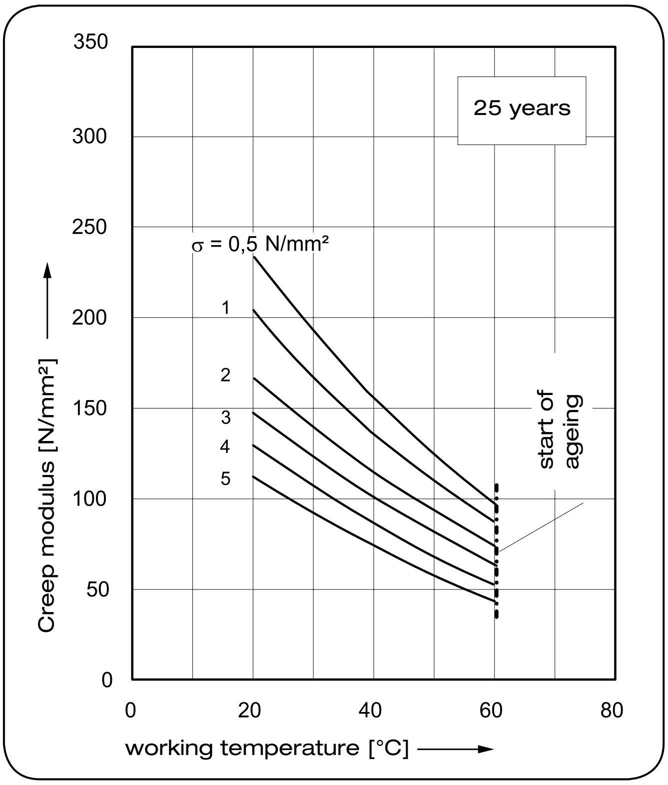


Fig. 69 - Creep rupture curve for PE 100, service life 25 years

Reduction of creep modulus

For stability calculations, the creep modulus determined from the diagrams shown here must be reduced by a safety coefficient of $\geq$ 2. The effects of chemical influences, eccentricity or unroundness must be taken into account separately.

Creep rupture curves for PP

The creep modulus is mainly determined by the materials used in the pipe. For pipes made in PP, special raw materials that have a higher creep modulus than specified in DVS 2205-1 are used. For a rough calculation, the value stated in DVS 2205-1 can be applied. Exact creep modulus figures are available on request.

6. Calculations

6.7 Calculation of elongation

Elongation due to changes in temperature

The elongation of the pipe resulting from changes in temperature is calculated as follows:

$$\Delta L_T = \alpha \cdot L \cdot \Delta T$$

ΔL_T....	Elongation due to change in temperature	[mm]
α	Linear coefficient of expansion	[mm/m·K]
L	Pipe length	[m]
ΔT	Temperature difference	[K]

Δ**T** is the difference between the installation temperature and the highest (lowest) operating temperature.

Mean value for α:

PP ~ 0.16 mm/m·K = 1.6·10-4	1/K
PE ~ 0.18 mm/m·K = 1.8·10-4	1/K

The actual coefficients of expansion depend on the temperature and are listed in our catalogue of plastic sewage pipe systems.

Note:
The elongation values and associated bending leg lengths are shown in the nomograms in our catalogue of plastic sewage pipe systems.

Elongation due to internal pressure

The longitudinal expansion caused by internal overpressure in a sealed pipeline that has no friction is:

$$\Delta L_p = \frac{0{,}1 \cdot p \cdot (1 - 2\ \mu)}{E_C \cdot (d^2 / d_i^2 - 1)} \cdot L$$

L ...	Pipeline length	[mm]
p	Operating pressure	[bar]
μ	Transverse contraction coefficient	
E_C ...	Creep modulus	[N/mm²]
d	Outside pipe diameter	[mm]
d_i ...	Inside pipe diameter	[mm]

Elongation due to chemical influences

Chemicals (e.g. solvents) transferred through the pipe can lead to elongation (due to swelling) of the pipe and an increase of its diameter. This is accompanied by reduced mechanical strength.

For solvents, the expected elongation can be determined with reasonable accuracy using a swelling coefficient. Based on the extensive research regarding the behaviour of PE and PP sewage pipes filled with solvents, we recommend using a swelling coefficient of:

L ...	Pipeline length	[mm]
f_{Ch} ...	Swelling coefficient	

$$f_{Ch} = 0.025 \ldots 0.040$$

The elongation due to swelling can thus be determined as follows (approximate calculation):

$$\Delta L_{Ch} = f_{Ch} \cdot L$$

Note:
For the exact calculation, the applicable swelling factor must be determined by means of material tests.

6. Calculations

6.8 Fixed points in exposed pipelines

Fixed points are designed to prevent the pipe from moving in any direction. They also absorb reactive forces in systems where compensators, plug sockets or sliding sockets are used. The fixed point must be suitably dimensioned to withstand all occurring forces:

- Forces generated by obstructed elongation
- Weight of vertical pipeline sections
- Specific weight of medium in pipe
- Operating pressure
- Intrinsic resistance of expansion compensators

Fixed points must be positioned in such a way that bends in the pipeline can be utilised for the purpose of elongation compensation.

The edges of sockets of fittings and special fixed point fittings have proven must suitable for this task. In profile sewage pipe systems, the profiles at the outside of the pipe can serve as fixed point structures (e.g. with concrete counter bearing).

Rigidly secured systems

Systems where elongation of the pipeline is prevented are referred to as rigidly secured systems. The rigid or rigidly secured pipeline section does not include any compensation elements and must be dimensioned accordingly as a special construction.

The following system parameters must be calculated:

- Fixed point load
- Permissible guide bearing distance, taking into account critical buckling length
- Occurring tensile and pressure stress

Pipes made of the special materials PE-el and PP-s-el can only be used in rigidly secured systems, if the tensile stress is minimal. For all other materials, we recommend using expansion bends to compensate the elongation.

Fixed point load in rigidly secured systems

The fixed point load is highest along straight, rigidly secured pipeline sections. It can be calculated with the following formula:

$$F_{FP} = A_R \cdot E_C \cdot \varepsilon$$

F_{FP} ...	Fixed point force	[N]
A_R ...	Inside wall surface area	[mm²]
E_C ...	Creep modulus	[N/mm²]
ε ...	Prevented elongation caused by thermal expansion, inside pressure or swelling	

6.9 References

For additional information and formulas for the calculation and dimensioning of plastic pipes, please refer to our catalogue of plastic sewage pipe systems.

It contains the details regarding:

- Permissible component operating pressures p_B for PE 100 and PP with reference to temperature and service life
- Comparison of application limits for pipelines made in PE 100 and PP over a service life of 25 years
- Application coefficients f_{AP} for water pollutant media and reduction coefficient A1 for media that become viscous at low temperatures (following DVS 2205-1)
- Media list with chemical resistance coefficients f_{AZ}=1 (according to DVS 2205-1)
- Chemical resistance coefficients f_{AZ} for chemicals flow (according to DVS 2205-1)
- General chemical resistance with special reference to acidic and alkaline substances
- Calculation of pipe cross-sections for pressure pipelines
- Calculation of hydraulic loss
- Resistance coefficient of pipe fittings
- Flow nomogram (for water) for the rough calculation of the flow rate, pressure drop and discharge rate

7. Static strength questionnaire/manhole data sheet

7.1 Static load questionnaire for the calculation of underground sewage pipes according to ATV-DVWK-A 127

Project details:

Project:

Location:

Client:

Contact person: Phone:

Pipe:

PKS® profiled sewage pipe:	Inside pipe diameter	DN:	mm
Extruded solid wall pipe:	Outside pipe diameter	da:	mm
	Wall thickness	s:	mm
Length of pipeline			m
Pipe material:	☐ PE 100	☐ PP-R	

Loads:

Flow medium:		
Specific weight:		g/cm^3
Medium temperature:	during operation T_B:	°C
	maximum T_{max}:	°C
Operating pressure $p_ü$:		bar
Service life:	☐ 50 years or years:	
Road traffic load:	☐ none ☐ HGV 60 ☐ HGV 30 ☐ CV 12	
Additional surface load		N/mm^2
Groundwater level above bottom of trench:		mm
Filled with water (e.g. storage capacity system):	☐ yes ☐ no	

Comments:

FRANK

7. Static load questionnaires/manhole data sheet

7.1 Static load questionnaire for the calculation of underground sewage pipes according to ATV-DVWK-A 127

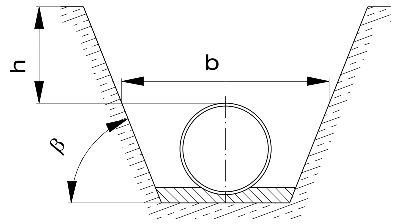
Installation:

☐ Trench

Trench width (w): ____________ mm

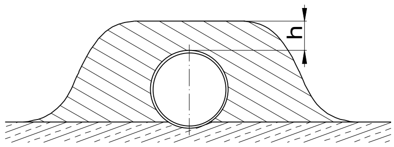
Slope angle (β): ____________ °

Covering height (h): ____________ mm



☐ Bank

Covering height (h): ____________ mm

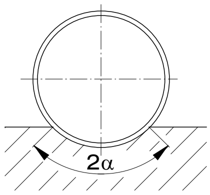


Covering and embedding conditions:

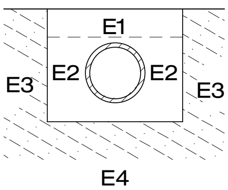
Covering	Embedding
☐ A1	☐ B1
☐ A2	☐ B2
☐ A3	☐ B3
☐ A4	☐ B4

Support:

Bedding angle 2α: ☐ 120° ☐ 180°



Soil:

Soil	Soil type	E1	E2	E3	E4
Zones: 	Group: G1 - non-cohesive soils (sand, gravel)	G1 ☐	G1 ☐	G1 ☐	G1 ☐
	G2 - slightly cohesive soils (sand, gravel)	G2 ☐	G2 ☐	G2 ☐	G2 ☐
	G3 - cohesive mixed soils, coarse clay	G3 ☐	G3 ☐	G3 ☐	G3 ☐
	G4 - clay, loam	G4 ☐	G4 ☐	G4 ☐	G4 ☐
	Note: In zone E2, sand (G1) should be used!				
	Specific weight [g/cm³]	....	....	....	....
	Degree of compaction (85 % to 100 %), % D_{pr}, preferably > 97 %	....	....	....	....
	E modulus E_B [N/mm²]	....	....	....	....

7. Static load questionnaires/manhole data sheet

7.2 Static load questionnaire for the calculation of underground plastic manholes following ATV-DVWK-A 127

Project details:

Project: ______________________

Location: ______________________

Client: ______________________

Contact person: ______________________ Phone: ______________________

Installation:

Manhole diameter (DN): ________ mm

Installation depth (h_1) ________ mm

Length of manhole pipe (h_2) ________ mm

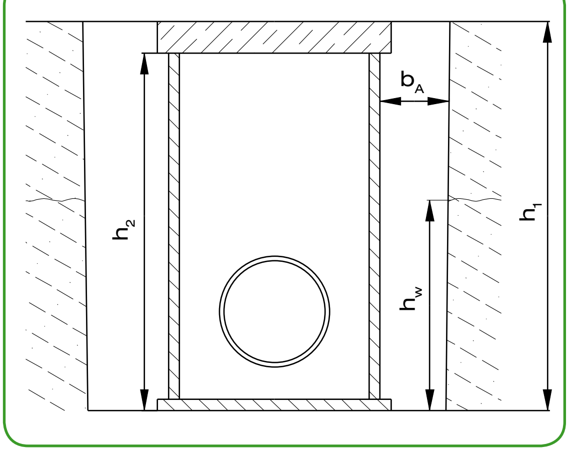
Height of groundwater level (h_w) ________ mm

Casing area (b_A) ________ mm

Density of embedding material: ________ g/cm³

Slope of terrain: ________ °

Manhole sleeve material: ☐ PE 100 ☐ PP-R



Soil:

	Embedding	Natural soil
Soil group	☐ G1 ☐ G2	☐ G1 ☐ G2 ☐ G3 ☐ G4
Proctor density	________ %	________ %
Known E modulus	________ N/mm²	________ N/mm²

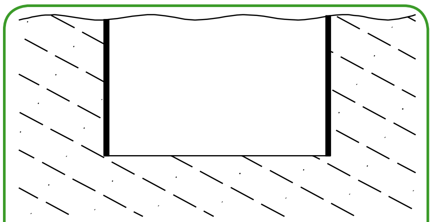
Road traffic load:

	On cover	Adjacent to manhole
no traffic load	☐	☐
HGV 30	☐	☐
HGV 60	☐	☐
other	________ kN	________ kN
Impact factor		

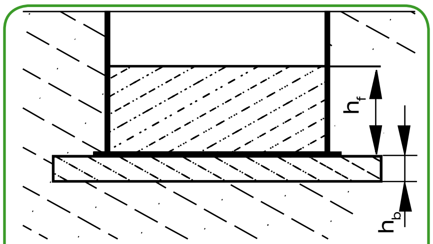
7. Static load questionnaires/manhole data sheet

7.2 Static load questionnaire for the calculation of underground plastic manholes following ATV-DVWK-A 127

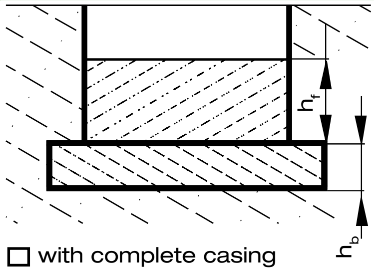
Manhole floor:



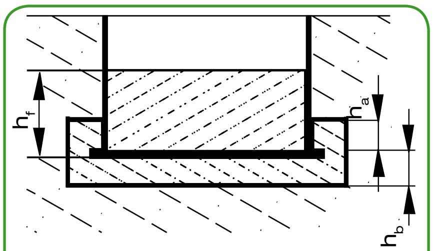
☐ without bottom plate



☐ with simple bottom plate



☐ with complete casing



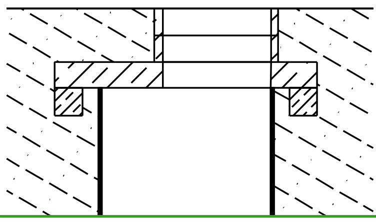
☐ with concrete casing

Thickness of concrete slab (h_b)	....	mm
Thickness of concrete bottom plate	....	mm
Height of concrete ring (h_a)	....	mm
Concrete class of bottom plate	....	
Concrete filling (h_f)	....	mm

Spigot:	Diameter	Wall thickness	Angle
Through-pipe	______ mm	______ mm	______ °
1st spigot	______ mm	______ mm	______ °
2nd spigot	______ mm	______ mm	______ °
3rd spigot	______ mm	______ mm	______ °
4th spigot	______ mm	______ mm	______ °

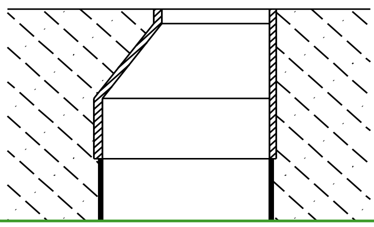
Manhole cover:

☐ separately supported over

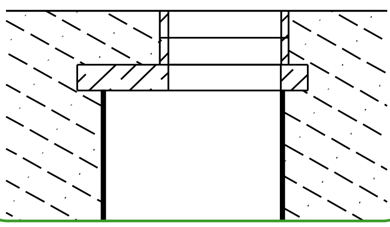


☐ no cover

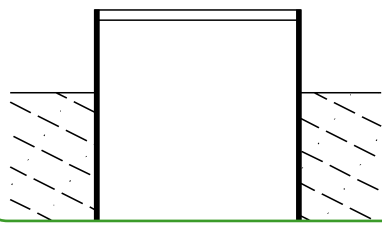
☐ standard concrete cone



☐ put-on cover



☐ with PE flat roof



7. Static load questionnaires/manhole data sheet

7.3 Explanations re. questionnaires

Safety classes

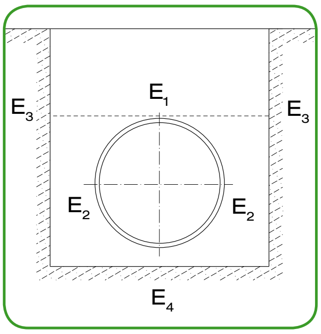
Safety class A (standard safety class)

- Potential risk of groundwater pollution
- Restricted use
- Failure would have significant economic consequences

Safety class B (special safety class)

- No risk of groundwater pollution
- Minor use restrictions
- Failure would have minor economic consequences

Soil types



E1 Trench filling above the top of the pipe

E2 Pipe zone to the side of the pipe

E3 Ground adjacent to the trench or soil installed beside the pipe zone

E4 Ground below the pipe

Group	Unit weight B kN/m³	Inner friction angle	Deformation modulus E_B in N/mm² at Proctor density D_{pr} in %					
			85	90	92	95	97	100
G1	20	35	2.4	6	9	16	23	40
G2	20	30	1.2	3	4	8	11	20
G3	20	25	0.8	2	3	5	8	13
G4	20	20	0.6	1.5	2	4	6	10

Soils are classified in the following groups (in square brackets: codes according to DIN 18 196):

Group 1: Non-cohesive soils (gravel, sand) [GE, GW, GI, SE, SW, SI]

Group 2: Slightly cohesive soils [GU, GT, SU, ST]

Group 3: Cohesive mixed soils, coarse clay (cohesive sand and gravel, cohesive stony residual soil) [GU, GT, SU, ST, UL, UM]

Group 4: Cohesive soils (clay, loam) [TL, TM, TA, OU, OT, OH, OK, UA]

Covering conditions for trench backfilling

There are 4 covering conditions A1 to A4 for the backfilling of the trench above the pipe level:

A1: Filling/covering of trench in layers against the natural soil (without verification of degree of compaction)

A2: Vertical shuttering in the pipe trench using trench sheeting or lightweight piling profiles, which is only removed after backfilling. Shuttering plates or equipment are gradually removed as the trench is being filled.
Uncompacted trench backfilling. Hydraulic installation of embedding material (only suitable for soil group G1)

A3: Vertical shuttering in the pipe trench using sheet piling, wooden planks, riveting plates or similar equipment that are only removed after backfilling.

A4: Compacted trench backfilling/covering in layers against the natural soil, with verification of Proctor density according to ZTVE-StB. Covering condition A4 is not permissible for soils of group G1.

7. Static load questionnaires/manhole data sheet

7.3 Explanations re. questionnaires

Pipeline embedding

For the embedding of the pipeline sections, we distinguish between 4 embedding conditions B1 to B4:

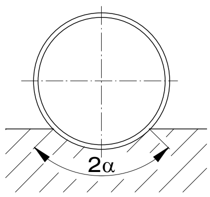
B 1: Compacted embedding in layers against the natural soil or in the embanked embedding (without verification of degree of compaction).

B 2: Vertical shuttering in the pipe trench using trench sheeting or lightweight piling profiles, which is only removed after backfilling. Trench secured with shuttering plates or equipment, provided that soil can be properly compacted after removal of the shuttering. Hydraulic installation of embedding material (only suitable for soil group G1).

B 3: Vertical shuttering in the pipeline zone, using sheet piling, wooden planks, riveting plates or similar equipment, without effective re-compaction after removal of the above equipment.

B 4: Compacted embedding in layers against the natural soil or in the embanked embedding with verification of Proctor density according to ZTVE-StB. Embedding condition B4 is not permissible for soils of group G4.

Support



Support type 1

Installation

The calculation method is valid for pipelines that are installed, supported and embedded according to DIN 4033.

Loads and wheel footprints of standard vehicles

Standard vehicle	Total load	Wheel load	Wheel footprint	
kN	kN		Width m	Length m
HGV 60	600	100	0.60	0.20
HGV 30	300	50	0.40	0.20
CV 12	20	rear 40	0.30	0.20
		front 20	0.20	0.20

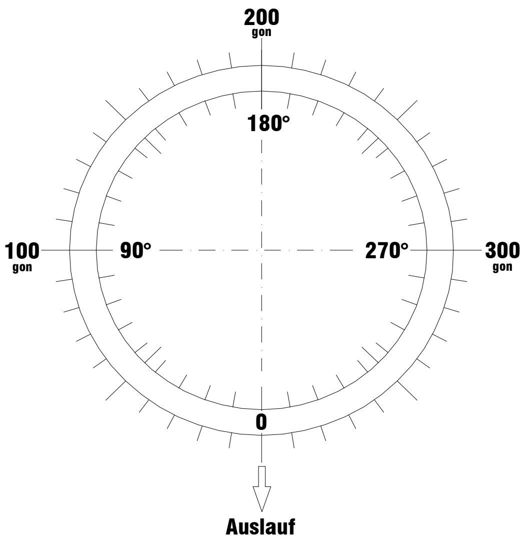
Outside of road traffic areas, CV 12 must be applied as the minimum load.

7. Static load questionnaires/manhole data sheet

7.4 Manhole data sheet

Company:	Project:	Quantity:	Component:
		Estimated delivery date:	
Description of manhole:		Date:	Person responsible:
		Ordered by:	

☐	Tangential manhole DN: ______ mm	
☐	Inspection manhole DN: ______ mm	



Top ground surface		metres above sea level
Groundwater level		metres above sea level
Cover plate / cone		mm
PE manhole		metres above sea level

☐	Medium height of manhole
☐	Shaft steps
☐	Access shaft frames within channel
☐	Ladder B: ________ Wst: ________
☐	Entry aid
☐	Lifting eyes
☐	Berm
☐	Pump sump pit DN: ________ h = ________ mm
☐	Channel up to pipe crown
☐	Channel up to pipe middle
	Note: Optionally you can send a sketch.

Remarks: ____

____

____

____

								End						
	DN	DA	° Degree	Profile / SDR	Length of adapter inside	Inside light-coloured	Floor level (metres above sea level)	Electro-fusion socket	Spigot end	Smooth end	Welding neck + loose flange	Reduction	Rewind to DA	Remarks
(1) outflow														
(2) inflow														
(3) inflow														
(4) inflow														
(5) inflow														

8. Installation

8.1 General installation guidelines

Introduction

Sewage pipe systems are civil engineering constructions that need to meet a number of standards and regulations, among them the current installation guidelines for pipe systems that apply in Germany, known as DWA-A 139.

Due to the light weight of PE and PP pipes and manholes and their stability, these elements can be handled with light equipment. Plastic pipes are therefore particularly suitable for installation along narrow roads and in hilly areas, as they offer the most economical solution.

Transport

PKS® sewage pipes, fittings, manholes and special construction elements must be transported on suitable vehicles. During transport, they must be properly secured against shifting on the load platform. Ensure that other objects on the load platform do not impact on the pipes. The load platform must be level and free of any debris that could cause damage to the pipes. Special care must be taken when loading and unloading the pipes to prevent damage to the pipes.

Handling

Plastic pipes and fittings must be loaded and unloaded with suitable lifting gear. Never allow pipes to drop to the ground. Do not drag the pipes along the ground. When handling profiled sewage pipes, pay attention to the sockets and spigot ends as they must not become dirty or damaged. Pre-assembled components (e.g. storm water tanks) must be lifted by the attached lifting eyelets in order to prevent inadmissible bending stress due to their weight.

Fig. 70 - Loading of PKS® DN 2300 sewage pipe and DN 2300 branch section

Fig. 71 - Installation of PKS® special element

Fig. 72 - Unloading and installation of PKS® DN 1800 pipe

Fig. 73 - Unloading and positioning of PKS® DN 3000 pipe

8. Installation

8.1 General installation guidelines

Storage

PE/PP pipes must be stored on level ground. Do not place the pipes on stones or sharp-edged objects. The pipes must be stored so that they cannot become deformed. Protect them against dirt and mechanical damage.

In warm weather, pipes and fittings must be protected against heat. We recommend storing the pipes and fittings in the shade or under a light-reflective tarpaulin or foil. Many geotextiles are suitable for this purpose.

As a rule, the pipes must be protected against deformation and damage and handled with the necessary care during transportation and storage. Pipes that have been damaged must not be installed.

Storage of DIN 16961 / DIN EN 13476 spiral pipes

The pipes must be stored so that they cannot become damaged. Ensure that the spigot ends and the sockets are protected against dirt and deformation, as they can otherwise not be properly joined.

For temporary storage on the construction site, it might be necessary to prepare the storage location, depending on the ground and weather conditions:

- Pipes must be secured against rolling off by placing them on squared timber sections and/or inserting wedges.
- The first layer of pipes must be placed on square timber sections.
- Do not stack the pipes higher than 3 metres.

When storing pipes of different diameters together, ensure that the electrofusion sockets and spigot ends of the PKS® pipes are not damaged. If necessary, position the pipes so that these sections protrude from the stack.

Before storing the pipes, check them carefully to ensure that the original packaging is not damaged. Should the packaging be damaged, check the respective pipe for dirt and clean it immediately. Subsequently cover the cleaned sections with foil. Do not apply adhesive foil or tape to the electrofusion wire or the spigot end of the pipe.

Storage of DIN 8074/8075 PE pipes

PE pipes are supplied in bundles according to the AGRU-FRANK GmbH factory standard for packaging. The bundles are shipped on pallets. Small batches are supplied as loose pipes.

To load and unload the pipe bundles and individual pipes, use wide textile straps and protect the pipes against mechanical impact.

Before unloading the pipes, prepare the on-site storage area. The storage area should meet the following requirements:

- Minimum width 12 m, 6 m or 5 m (depending on pipe length)
- Stone-free, level ground (sand bed, concrete slab, etc.)
- Protected against mechanical impact
- Installation of intermediate supports to prevent sagging or shifting of the pipes

Pipe pallets must be stacked in such a way that the axial timber crates are positioned one on top of the other.

The stack height must be chosen carefully to prevent permanent deformation of the pipes. Prevent point and linear bearing points of the pipes.

Protect all parts of the pipe against dirt.

Fig. 74 - Storage of PKS® sewage pipe

Fig. 75 - Storage of Sureline® pipes

8. Installation

8.2 Trench installation - PKS®/TSC pipes

According to DIN EN 1610, a load carrying capacity certificate must be submitted for all underground sewage and drain pipes prior to installation. For PKS® /TSC pipes, the calculation of the carrying capacity according to ATV-DVWK-AT 127 is deemed sufficient. The pipes must be installed with reference to the static calculations. The information required for the static calculations (e.g. ground conditions, installation conditions, etc.) must be obtained from the customer in a questionnaire (see pages 44 ff.).

Flexible pipes must be installed "loose", as this reduces the stress on the pipe. The static calculations must take into account the bedding angle. Normally, a bedding angle of 120° is used in the calculations.

According to DIN EN 1610, the base bed must have a thickness of 10 to 15 cm from the bottom of the pipe. Only use stone-free, compactable bedding material of class G1 or G2 as specified in DIN EN 1610. Bedding of the same material must then be filled to a level 15 cm above the top of the pipe. The bedding material must be compacted in layers. Ensure that the compactor does not touch the pipe. To compact the material above the pipe, do not use a compactor until the bedding thickness above the top of the pipe is minimum 30 cm. The top fill material must also be filled and compacted in layers. Top fill layers of up to 1 metre depth can be compacted with light to medium weight compactors. Heavy compactors may only be used above this level.

In the event of high temperature fluctuations, especially where the pipe is exposed to direct sunlight, it might expand or contract in axial direction. In underground PKS® pipes, the profile acts as a fixed point. It is thus sufficient to fill the pipe trench in order to prevent elongation along long stretches of the pipeline.

Recommendations

- The pipeline trench should be free of stones and the bedding material must be compactable.
- Take suitable measures to prevent soil from falling into the trench and ensure that the bedding material is not accidentally spread into the ground surrounding the trench.
- The ground material on both sides of the pipe must be refilled and compacted in layers. Where the sides around the pipe have not been properly compacted and a heavy machine is used for the compacting of the top layer, the pipe might be shifted to the side. This might for example occur if a road roller passes over a pipe without compacted side bedding.
- During pipe laying, the trenches must be kept free of water in order to prevent floating pipe sections.
- When connecting flexible pipes (PKS® /PROFIX pipes) to a concrete manhole, proceed with special care as the manhole might shift due to soil settlement.
- Leakage tests must always be performed before the pipe trenches are backfilled, as it is otherwise difficult to locate and repair leaks.

Fig. 76 - Installation of pipeline section

Fig. 77 - Compacting of side bedding

8. Installation

8.2 Trench installation - connection to concrete elements

Due to the surface structure of PE/PP, there is no direct connection between the PE pipes and the concrete used to connect them to other fixed structures. There is a capillary gap between the pipe wall and the concrete through which liquid can escape and enter the concrete wall. In order to integrate PE pipes into concrete walls, it is therefore necessary to use FRANK wall connection elements, sockets for manhole connections and manhole connection sockets that have been specifically designed for this purpose.

FRANK manhole connection socket (SAM)

The FRANK manhole connection socket (SAM) allows for the production of welded connections between pressure pipes and concrete manholes that offer excellent tensile strength. The manhole connection sockets are available for extruded sewage pipes from DN 150 to DN 500.

The manhole connection socket is installed in the precast concrete manholes conforming to DIN 4034 so that it is flush with the formwork. The puddle flange mounted on the manhole connection socket ensures that the connection is perfectly tight. When concreting in the connection, ensure that the concrete is sufficiently compacted. After the concrete work is completed and formwork is removed, the pipe is inserted and welded to the socket.

FRANK wall connection type PKS® 2, type PKS® 2a

The FRANK type PKS® 2 and 2a wall connections are suitable for PKS® sewage pipes of DN 300 to DN 1200. The type PKS® wall connections are tight to a water column of 10 metres.

The length of the wall connection depends on the actual concrete wall thickness and must be custom-made (type PKS® 2 element). The FRANK type PKS® 2 and 2a wall connections are installed into the concrete structure so that they are flush with the formwork. The wall connections are equipped with a wire for electrofusion welding. The wall connection can withstand high radial and axial forces as they are transferred from the PKS® pipe to the concrete structure.

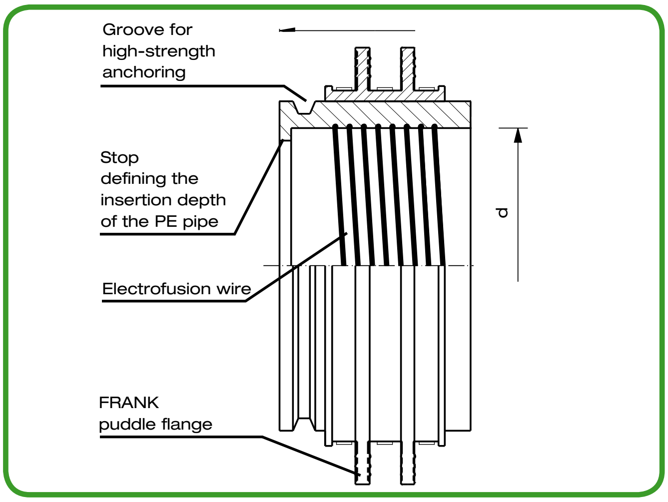


Fig. 78 - Installed FRANK manhole connection socket (SAM)

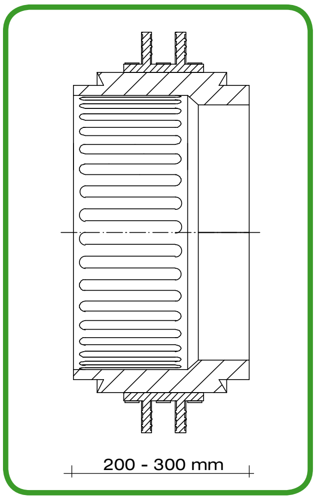


Fig. 79 - Type PKS® 2

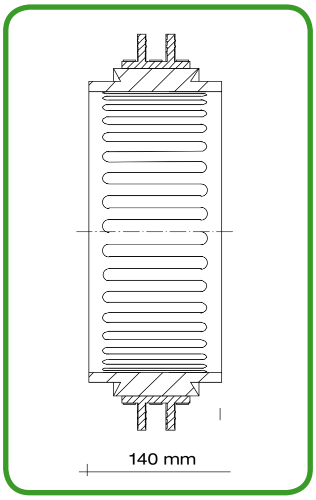


Fig. 80 - Type PKS® 2a

Fig. 81 - Installed FRANK manhole connection socket (SAM)

Fig. 82 - FRANK type PKS® 2a wall connection (L= 140 mm)

8. Installation

8.2 Trench installation - connection to concrete elements

FRANK wall connection type PKS® 1

For DN 300 to DN 3500 pipes, we have developed the FRANK type PKS® 1 wall connection with mounted FRANK puddle flange for PKS® sewage pipes. The wall connection is tight up to a water column of 10 metres The FRANK type PKS® 1 wall connection is supplied fully fitted on the PKS® pipe. The pipe with the wall connection element is placed in the formwork. We recommend backfilling the pipe trench prior to concreting the wall connection. Close the formwork and encase the connection in concrete. Ensure that the concrete is properly compacted around the wall connection, and in particular below the pipe. If the concreting work must be performed at a temperature below 0°C, take the necessary measures to ensure that the concrete meets the relevant quality standards.

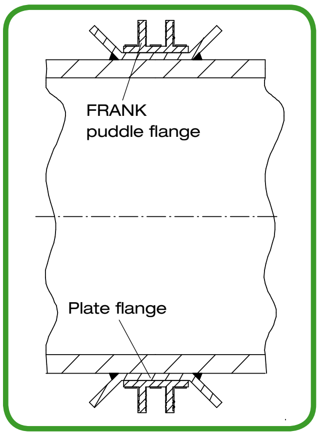


Fig. 83 - Type PKS® 1 - cross-section

Fig. 84 - Type PKS® 1 at pipe end

Tightness certificate for FRANK type PKS® 1 wall connection

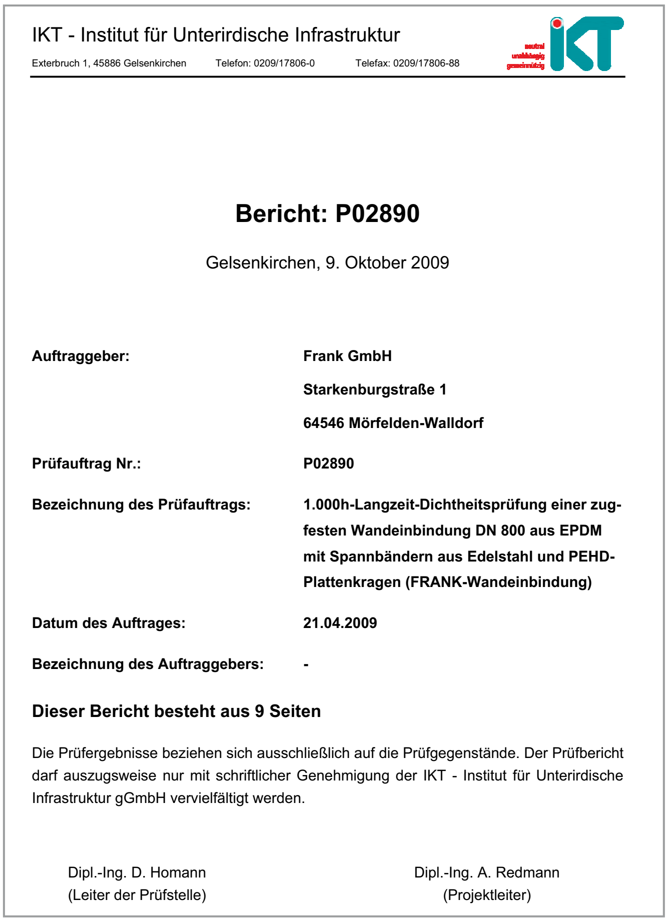
In May 2009, Institut für Unterirdische Infrastruktur GmbH (IKT), a testing institute specialising in underground infrastructure projects based in Gelsenkirchen, Germany, was commissioned to perform long-term tightness tests (1000 h) of FRANK type PKS® 1 wall connection, size DN 800.

The tests were performed with two wall connections consisting of DN 800 spiral pipes and circular DN 1250 formwork encased in waterproof concrete. Before the wall connections were made, a perforated pressure water pipe was built into the DN 800 spiral pipe. After the concrete had cured, a test pressure of 1.0 bar was applied to the integrated pressure pipe.

This pressure was maintained over the entire test period of 1000 hours. During the leakage test, no testing liquid escaped from the tested construction. The tested construction was then cut open in order to identify the testing liquid flow inside the structure. The visual inspection revealed that discoloured areas expanded from the perforated pressure pipe to the plate flange. There were no signs of any further penetration into the wall connection.

This test thus showed that the construction remained tight during the test period of 1000 hours at a test pressure of 1.0 bar. The two tested wall connections successfully passed the long-term test and provided perfectly tight connections to the concrete structure.

(Source: IKT report published in 2009)



IKT - Institut für Unterirdische Infrastruktur

Exterbruch 1, 45886 Gelsenkirchen Telefon: 0209/17806-0 Telefax: 0209/17806-88

Bericht: P02890

Gelsenkirchen, 9. Oktober 2009

Auftraggeber:	**Frank GmbH** **Starkenburgstraße 1** **64546 Mörfelden-Walldorf**
Prüfauftrag Nr.:	**P02890**
Bezeichnung des Prüfauftrags:	**1.000h-Langzeit-Dichtheitsprüfung einer zugfesten Wandeinbindung DN 800 aus EPDM mit Spannbändern aus Edelstahl und PEHD-Plattenkragen (FRANK-Wandeinbindung)**
Datum des Auftrages:	**21.04.2009**
Bezeichnung des Auftraggebers:	**-**

Dieser Bericht besteht aus 9 Seiten

Die Prüfergebnisse beziehen sich ausschließlich auf die Prüfgegenstände. Der Prüfbericht darf auszugsweise nur mit schriftlicher Genehmigung der IKT - Institut für Unterirdische Infrastruktur gGmbH vervielfältigt werden.

Dipl.-Ing. D. Homann (Leiter der Prüfstelle) — Dipl.-Ing. A. Redmann (Projektleiter)

Fig. 85 - IKT report - Leakage testing of high-strength FRANK wall connection

8. Installation

8.3 Trenchless installation

Introduction

In Germany, many existing sewage pipe systems are leaking or do not have the load-bearing capacity required today. In many cases, the pipes can be restored by means of relining, where a new pipe is inserted into the defective pipeline. Extruded solid wall pipes and PKS® pipes with integrated electrofusion sockets are particularly suitable for repairs by relining. The electrofusion sockets can withstand high tensile stress while the flexibility of the material used in solid wall and PKS® pipes allows for bending radii of up to 50 x DN. In PKS® pipes with outside profiles, the profile provides the anchoring structure for the insulating filler, preventing longitudinal expansion due to temperature differences.

Plastic pipes can be produced for use as non-load-bearing liners for insertion into existing pipelines or as load-bearing sewage pipes for new installations. When installing insulation, the fact that this material produces buckling pressure on the pipe must be taken into account and the pipes must be dimensioned accordingly. It might even be necessary to fill the pipes with water prior to installing the insulation. In addition, the possibility that the pipes might become buoyant during the insulation process must be taken into account. On request, we perform certifiable static calculations according to DWA-M 127-2. In practice, the following relining methods are used:

Pipe string relining (long pipe relining)

For this purpose a number of pipes are welded together to form a string, which is then pulled or pushed into the sewage pipe. Pipe strings of up to 500 m can be pre-assembled outside the system section to be repaired. Pipes from DN 800 can be individually placed in the pipeline to be repaired and then welded from the inside.

Short pipe relining

Here, the pipes are pushed or welded together in a manhole. After a weld is completed, the pipe string is pulled into the sewage pipe to be repaired so that the next section can be lowered into the manhole and connected. For this type of renovation, FRANK provides pipes of 1 to 6 m length as well as PKS® pipes with moulded electrofusion sockets.

Ploughing

Using a special plough, a slit is cut into the ground. Special plough attachments push the soil outwards so that a pre-assembled pipeline can be installed in the same process. The space around the pipe can then be filled with sand or fine backfill material mixed with water to allow for additional compaction. As there is no pressure on the pipe from the overlaying topsoil, the pipeline is properly stabilised in the ground.

Milling

With this method, a pipe trench is cut using special milling equipment, and the pre-assembled, flexible pipe is installed in the same process. The excavated material is then used for backfilling. Milling is only suitable for pipe installation in free terrains.

Installation with drilling rockets/burst lining

The burst lining method is used to replace existing pipelines by laying a new pipe in the same trench. This is done by using dynamic or static energy. The cone-shaped bursting body destroys the old pipe and pushes out the adjacent trench material to form a circular cavity. The new pipe is pulled into this cavity immediately following the bursting process, whereby the new pipe is of the same or a greater diameter (up to DN 600).

Hydraulic drilling (horizontal)

Drill heads for hydraulic drilling include a cutting tool and openings through which a betonite mixture is expelled at high pressure. The drill head is steered by the pressure of the betonite suspension through a programmable interface at the drill head. After the pilot drill bore is produced, an expansion head is attached together with the pipe, which is then pulled through the opening.

Fig. 86 - Short pipe relining

Fig. 87 - Horizontal hydraulic drilling

Fig. 88 - Burst lining

8. Installation

8.3 Trenchless installation

Advantages of Sureline® pipes in trenchless installation

The forces acting on a pipe during trenchless installation differ greatly from those during open trench laying. Trenchless methods demand sturdy pipes. When pulling a burst lining into the existing pipe or during horizontal hydraulic drilling, the outer surface of the pipe becomes normally scratched, and the resulting grooves might compromise the stress distribution in the pipe wall. Point loads, e.g. from stones, can result in additional local stress on the inside of the pipe. In pipes made from conventional materials, this tends to result in crack initiation. To prevent that such stress results in cracks in the pipe wall, it is important to use a pipe material, such as FRANK PE 100-RC, that offer excellent creep resistance. Due to their high elasticity, Sureline® pipes are particularly suitable for installation along curved trenches, as the material can be bent to a certain degree. However, the minimum bending radii listed in the table below must be taken into account.

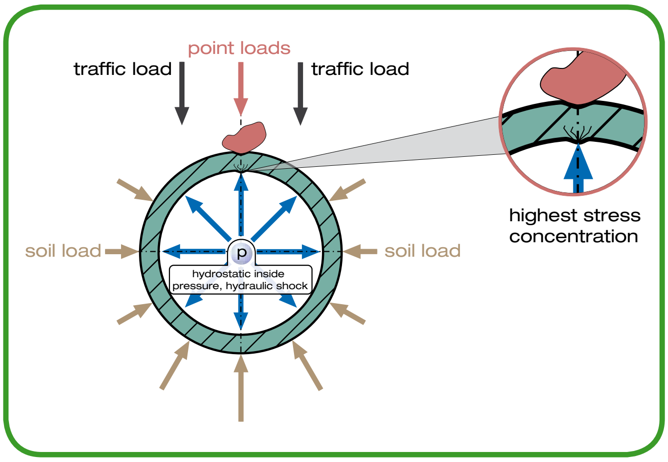


Fig. 89 - Stress on pipe in trench

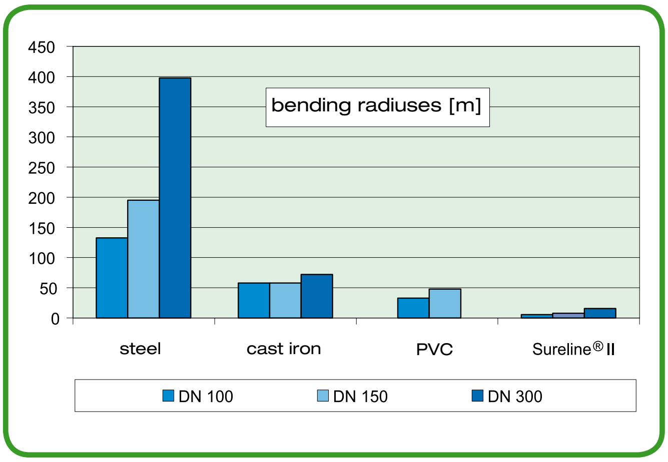


Fig. 90 - Bending radii achievable with different pipe systems

During trenchless pipe laying (e.g. by horizontal hydraulic drilling), certain tensile stress levels must not be exceeded (see DVGW GW 320 work sheet). The table below provides an overview of the maximum permissible tensile stress for the installation of Sureline® pipes at 20°C (40°C).

By making use of the flexibility of Sureline® pipes, sewage system operators can save money, as fewer fittings are required than with conventional pipes. The diagram below shows the minimum bending radii for various pipe dimensions.

da_{Pipe} [mm]	max. permissible tensile stress [kN] for Sureline® SDR 17 [kN]		SDR 11 [kN]	
110	21	(14)	31	(21)
125	27	(18)	40	(28)
140	34	(23)	50	(35)
160	44	(30)	66	(46)
180	56	(39)	84	(58)
200	70	(49)	103	(72)
225	89	(62)	131	(91)
250	109	(76)	162	(113)
280	137	(95)	203	(142)
315	174	(121)	257	(179)
355	221	(153)	326	(228)
400	280	(195)	414	(289)

For insertion times > 10h (> 20h), reduce the specified values by 10 % (25 %).

Table 7 - Max. permissible tensile stress for Sureline® pipes

da_{Pipe} d [mm]	Bending radius r [m] at +20°C	at +10°C	at 0°C
110	2.2	3.8	5.5
125	2.5	4.3	6.2
140	2.8	4.9	7.0
160	3.2	5.6	8.0
180	3.6	6.3	9.0
200	4.0	7.0	10.0
225	4.5	7.8	11.2
250	5.0	8.7	12.5
280	5.6	9.8	14.0
315	6.3	11.0	15.7
355	7.1	12.4	17.7
400	8.0	14.0	20.0

Bending radii for Sureline® pipes

Table 8 - Permissible bending radius for Sureline® pipes

8. Installation

8.4 Leakage test for gravity pipelines

According to DIN EN 1610, a leakage test of the installed plastic pipe must be performed after backfilling and removal of the installation equipment. The leakage test according to DIN EN 1610 is described in detail in DWA-A 139 and can be performed with water or with air (methods "W" and "L" respectively).

A preliminary test might be performed prior to backfilling, and such a test is recommended for the testing of pipe joints. By performing the leakage test immediately after installation of the pipe, it is possible to detect any problems at an early stage so that they can be rectified without delay. This saves money as the machinery and personnel are likely to be still on site to carry out the necessary tasks.

Leakage testing with air (method "L")

The connections can be tested for leakage, using a socket pressure tester. Before performing this test, the testing equipment must be tested to ensure that it is air-tight. This can be done by performing a leakage test of a tight pipe section, whereby all results must be carefully documented.

The leakage test with a pneumatic socket pressure tester is performed separately at each pipe weld.

Before starting the test, the welded joints must be allowed to cool down (recommended cooling time: minimum 3 hours).

The socket pressure tester is positioned at the welded connection to the tested. An initial pressure (testing pressure + approx. 10 %) is applied to the pipe, followed by a settling time of approx. 5 minutes. Subsequently, the connection can be tested (for testing times, see table 10).

If the section to be tested is within the groundwater area, the highest groundwater level must be taken into account by increasing the testing pressure by 1 kPa per 10 cm of ground water above the bottom of the pipe.

For occupational safety reasons, we recommend applying test pressures that are within the prescribed range for method "LE"

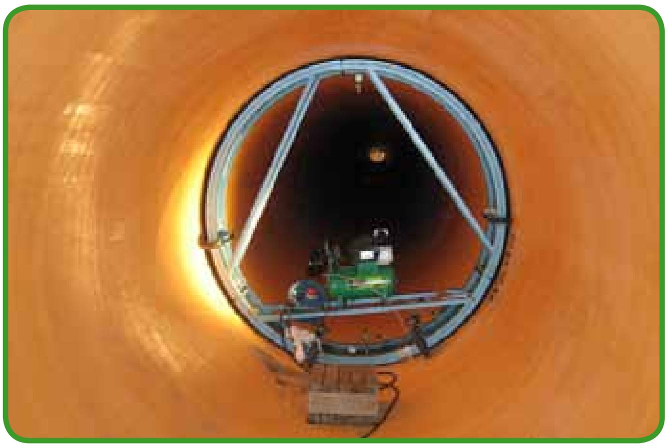


Fig. 91 - Socket pressure tester for gravity pipelines

for all pipes with DN > 1000.

If the permissible testing criteria (max Δ p) cannot be achieved, the pipe section must be tested with method "W" (leakage testing with water). In this case, the result of the leakage test with water is the only relevant test result.

	p_0 [kPa]	max Δ p [kPa]	Testing time [min]											
Pipe diameter [DN]			100	150	200	250	300	400	500	600	700	800	900	1000
Air overpressure LE	10	1.5	1.5+	2.5	3.0	4.0	4.5	6.0	7.5	9.0	10.5	12.0	13.5	15.0
LF	20	1.5	1.0	1.5	2.0	3.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
Underpressure LE_u	-10	1.1	1.5	2.5	3.0	4.0	4.5	6.0	7.5	9.0	10.5	12.0	13.5	15.0
LF_u	-20	1.1	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0

Table 9 - Testing conditions for gravity pipelines according to DWA-A 139

Testing times for pipe diameter other than those listed in the table are calculated as follows:

Method LE/LE_u: $t = 0.015 \times DN$ [min]

Method LF/LF_u: $t = 0.01 \times DN$ [min]

The testing time is rounded to the next 30 seconds.

Leakage test with water (method "W")

The requirements for this leakage testing method are not described in detail, as they are specified in the above standard. The testing process must be coordinated with the sewage system operator.

8. Installation

8.5 Leakage test for pressure pipelines

Today, pressure pipes are normally tested for leakage by means of the contraction method.

Contraction procedure according to DVGW W 400-2

This procedure consists of a preliminary test and a main test.

The preliminary test is performed to stabilise the pipeline section to be tested. It must ensure that the preconditions for a standardised and reproducible measurement of the volumetric change over time, relative to the internal pressure and temperature, are met.

Contraction testing procedure

<u>Preliminary test phase:</u>

After filling and bleeding the pipeline, the section to be tested must not be pressurised for a period of 60 minutes (settling phase).

Subsequently, the design system pressure STP is built up. This should preferably be completed within 10 minutes (for PE 100, SDR 17 the design system pressure STP = 12.0 bar).

The design system pressure STP is then maintained for 30 minutes by continuous pumping of water into the pipe.

Subsequently, pumping must stop and the pipe must be left filled for a period of 60 minutes. During this phase, the pressure pipe undergoes visco-elastic deformation. The resulting pressure drop must however not exceed 20 %. If the pressure drops by more than 20 % of the design system pressure STP, there is a leak in the pipe or the pipeline is exposed to excessive temperature differences.

<u>Main test phase:</u>

The pressure must be rapidly reduced by p_{ab} specified in table 11. The pressure drop must be achieved within maximum 2 minutes. The volume V_{ab} of the water expelled during this process is measured (pressure drop test). Compare the calculated change in volume with the actual measured change in volume ΔV_g. The pipe is sufficiently air-free, if the released volume of water V_{ab} is smaller than the calculated volume V_{zul}.

Subsequently, the pipe must be tested for another 30 minutes (testing time t_k). The pipe section is deemed tight, if the pressure measured during the above contraction time of 30 minutes is constant or shows a slight upward trend.

If the results are inconclusive, the testing time t_k might be extended to 90 minutes. During this period, the pressure must not drop by more than 0.25 bar, relative to the highest value measured during the testing time.

All pressure measurements taken over the entire test procedure must be carefully documented.

Contraction procedure - pressure drop method		
	Material	PE 100, D 355, SDR 17
Preliminary test	Testing pressure [bar]	12.0
Preliminary test	Testing time [h]	160 minutes
Preliminary test	Pressure drop [bar]	p_{ab} = 2.0 bar within 2 minutes
Pressure drop test	Extracted volume of water ΔV_{zul} [ml/m]	within 2 min; ΔV_{zul} = 192.81 ml/m
Pressure drop test	Evaluation of air tightness	measured V_{ab} (at p_{ab}) $\le V_{zul}$
Main pressure test	Testing time	30 minutes
Main pressure test	Δp_{zul} [bar]	0.25 bar after 90 minutes
	Criterion for tightness: The pressure values measured over the testing time must be constant or show a slight upward trend.	

Table 10 - Contraction procedure for pressure drop testing method example of testing conditions for PE 100, SDR 17 pressure pipe according to DVGW W 400-2

Pressure drop [bar]		
PE 100	SDR 17	2.0 [bar]
PE 100	SDR 11	3.2 [bar]

Table 11 - Pressure drop

$$V_{zul} = V_k \times L$$

$$V_{ab} \le V_{zul}$$

STP	...	System testing pressure	[bar]
p_{ab}	...	Pressure drop	[bar]
V_g	...	Calculated volume of water	[ml/m]
V_{ab}	...	Volume drop	[ml]
V_{zul}	...	Max. permissible volume of water	[ml]
Δp_{zul}	...	Permissible pressure drop	[bar]
V_g	...	Measured volume of water	[m³]
t_k	...	Testing time	[h]
L	...	Length of pipeline	[m]

9. Connecting techniques

9.1 Overview of welding methods

Electrofusion welding of DIN 16961 / DIN EN 13476 spiral pipes	Extrusion welding	Electrofusion welding of DIN 8074/8057 extruded sewage pipes	Butt welding of DIN 8074/8075 extruded sewage pipes
DVS 2207-1 Technical Code	DVS 2207-4 Technical Code	DVS 2207-1 Technical Code	DVS 2207-1 Technical Code
■ PKS® profiled sewage pipes of sizes DN 300 to DN 2400 are connected by means of electrofusion welding according to DVS 2207. ■ The resistance wires are integrated into the sockets of the PKS pipes. ■ This welding technique has been proven particularly suitable for pipes made in polyethylene used in sewage systems and has become standard practice. ■ Electrofusion welds can be easily produced on site.	■ For pipe sizes that are not suitable for electrofusion welding and for the installation of manholes, bends and other fittings, the pipes are connected by means of extrusion welding according to DVS 2207-4. ■ This method allows for customised constructions. ■ The parts are welded by continuous welding using a welding extruder. For larger connections, it is recommended to use an automatic welding machine.	■ For smooth extruded sewage pipes and Sureline® pipes, additional electrofusion fittings are used to connect pipes with nominal diameters of d 160 to d 630. In this case, the resistance wires are integrated into the electrofusion fittings (e.g. welding sockets). ■ The welding sockets made in polyethylene are produced in a modular production process. This method ensures that the electrofusion wire is fully embedded in the fitting.	■ Extruded sewage pipes and fittings made in PE 100 can also be connected by means of butt welding according to DVS 2207-1. ■ The machines and equipment used in this process must however conform to DVS 2208. ■ With the butt welding method, the prepared joint areas are prepared under pressure for proper fit on the heating element and subsequently heated at reduced fitting pressure. Subsequently, the heating element is removed and the pipes are joined together under pressure.

General welding instructions

- Protect the welding area against adverse weather conditions (e.g. precipitation, wind, direct sunlight, temperatures < 5°C). If it is possible to take suitable measures (e.g. preheating, erecting a tent) to ensure that the pipe wall temperature required for welding is maintained, welding work can be carried out at any outdoor temperature, provided that the welder is not hampered in his work by the adverse conditions. If required, produce sample seams under the expected conditions to determine whether welding is possible.
- If certain sections of the pipe surface are heated by direct sunlight while others remain cool, cover the welding area to ensure a uniform temperature across the relevant pipe section.
- All connections must be established while there is no stress on the pipes, irrespective of the chosen welding method.
- The connecting faces of the parts to be welded must be perfectly clean. Clean the connecting faces just before welding, using a special PE cleaner. Cleaning is extremely important and must be carried out with special care. Dirt and moisture can interfere with the welding process, preventing accurate and tight welding. If the welding faces have not been properly cleaned, the connection might leak at a later stage!
- All tools required for welding such as tension bands, clamping and tensioning tools, etc. must only be operated by trained and qualified personnel.
- The instructions of the German Welding Society DVS must be adhered during the entire welding process.

9. Connecting techniques

9.2 Electrofusion welding of DIN 16961 / DIN EN 13476 spiral pipes

Introduction

At the construction site, the individual pipe sections must be connected to each other. While these joints must be perfectly tight, they must be easy to produce at reasonable cost. Tight connections are obviously a prerequisite for tight sewage pipe systems. The welding methods available for the joining of PKS® profiled sewage pipes meet these requirements.

Electrofusion welding has for many years been used for the joining of sewage pipes made in polyethylene. The method is also been successfully used for the joining of polypropylene pipes.

With electrofusion welding, the pipes and fittings are heated by resistance wires and subsequently fused together. The resistance wires are integrated into the sockets of the PKS® pipes. Where smooth sewage pipes are to be joined, these wires are built into the electrofusion fitting.

The energy required for the process is produced by a welding transformer. The relevant welding parameters are normally set by scanning the barcode applied to the pipe or the fitting.

Only identical materials can be welded together with this method.

By heating the socket, a preset shrinking stress is produced, which ensures that the pressure required for welding is applied.

The method is extremely safe, as safety low voltage is applied to the socket or fitting, and most processes are automated. In addition, the welding time is relatively short. This allows not only for fast installation but also saves money.

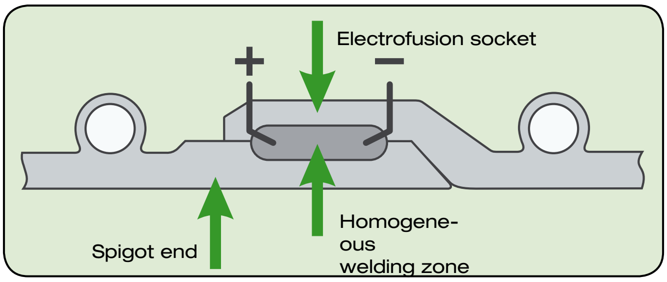


Fig. 92 - Diagram of electrofusion weld in a socket

Advantages of electrofusion welding

- Automated welding by means of automatic welding machine
- Homogeneous welded connection, no inside welding bead
- Perfectly tight welded connection of great tensile strength, preventing infiltration/exfiltration
- Quick connection, saving costs
- Easy pipe welding under site conditions
- Suitable for DN 150 to DN 2400

Who is entitled to weld pipes?

All welding work must be performed by persons who have been specially trained in this task and who are certified for the respective welding technique.

For electrofusion welding of PKS® pipes, FRANK GmbH offers training and instructions for welding staff on request.

Also ensure that only machinery that meets the applicable DVS requirements is used.

The welding data must be documented in welding reports or in electronic format.

Processing times for PKS sewage pipes

Dimensions [mm]	Preparation time ~[min]	Welding time (20°C) [min]	Cooling time [min]
DN 300	10	12	40
DN 400	10	13	40
DN 500	10	15	40
DN 600	10	15	40
DN 700	10	19	40
DN 800	15	15	40
DN 900	15	15	40
DN 1000	15	17	40
DN 1100	15	18	40
DN 1200	15	20	40
DN 1300	15	20	40
DN 1400	15	20	40
DN 1500	15	20	40
DN 1600	15	20	40
DN 1800	15	20	40
DN 2000	15	20	40
DN 2300*	15	25	40
DN 2400*	15	25	40

* Observe preheating time!
After welding, wait for minimum 3 hours before performing a leakage test

Table 12 - Processing times

9. Connecting techniques

9.3 Electrofusion welding following DVS 2207-1, process description for DIN 16961 / DIN EN 13476 profiled sewage pipes

1. Introduction

- PKS® pipes for electrofusion welding are supplied with spigot ends and integrated electrofusion wires in the sockets. To protect the welding ends during transport and on the building site, they are covered with a protective foil. The protective foil must only be removed immediately prior to the cleaning and joining of the electrofusion socket with the spigot end.
- From DN 800, the spigot end must be supported with a special support ring to allow for a higher joining pressure. Only use FRANK support rings, tension bands and clamping tools. For wall connections and sockets for manhole connections, always use a support ring, irrespective of the pipe diameter.
- From DN 1400, the pipes are equipped with two electrofusion wires per socket, so that two welding machines are required to produce the connection.
- After preheating (from DN 2300), wait for 10 minutes before starting the welding process.
- Ensure that the power supply on site provides minimum 15 kVA at all times.
- All instructions for the welding and joining of PKS®pipes with integrated electrofusion socket apply.
- For staff who perform this task for the first time, FRANK GmbH offers training covering the detailed welding standard as well as all special features and work practices associated with the laying of PKS® pipes.

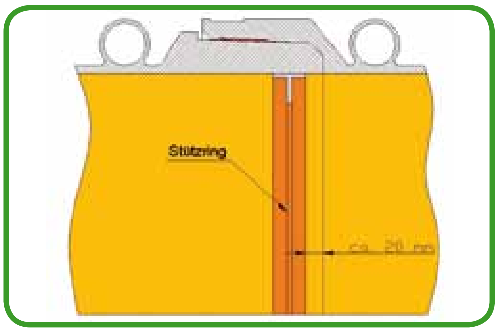


Fig. 97 - Positioning of welding ring

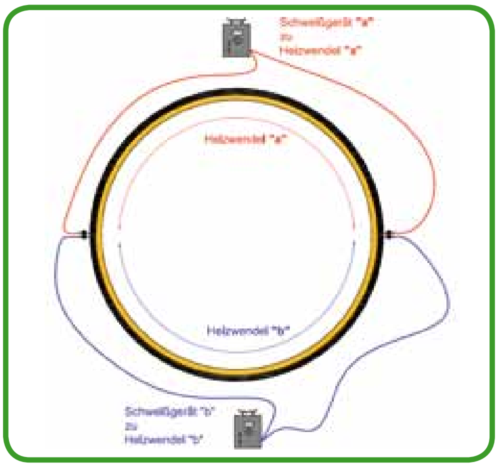


Fig. 98 - Connection of separate electrofusion wires (from DN 1400)

2. Preparation

- Clean the pipe ends with a hand brush. Check the electrofusion socket and the spigot end for damage caused during transport or storage.
- Position the pipes so that the connecting points of the wires are easily accessible.
- Remove the protective foil and clean the electrofusion socket/ spigot end with a PE cleaner, using a lint-free, white paper tissue.
- Using a permanent felt-tip pen, mark the available/measured socket depth at the spigot end. Mark the depth at minimum 3 separate points that are equally spaced along the circumference. The pipes must be pushed together to the marks or to the stop (ensure that the pipes are straight and pushed together with equal force around the circumference). For large pipes or where the site conditions make it difficult to align the pipes correctly or push them together, use a tensioning device (tension straps). Ensure that no dirt or water can enter the gap between the electrofusion socket and the spigot end.


Fig. 99 - Cleaning the electrofusion socket and the spigot end


Fig. 100 - Marking the insertion depth

9. Connecting techniques

9.3 Electrofusion welding following DVS 2207-1, work description for DIN 16961 / DIN EN 13476 profiled sewage pipes

3. Welding of pipes

- After the pipes to be welded have been pushed into each other, mount the support ring (from DN 800). Then attach the tension band in the groove of the electrofusion socket and tighten it with the clamping tool (positioned at an offset of minimum 250 mm from the connecting wires) until the gap between the electrofusion socket and the spigot end is closed along the entire circumference.
- Connect the wires of the electrofusion socket through the PKS® adapter to the PKS® welding machine. When connecting the wires to the welding machine, ensure that the welding cables are not stressed.
- After entering the welding data or scanning it with the hand-held barcode reading pen, the process can be started at the welding machine. The welding machine thereby automatically controls and monitors the welding process across the entire welding time. If there are any deviations from the set welding parameters, the welding machine automatically aborts the welding process, and an error message is displayed on the device.
- **After 2/3 of the welding time has elapsed, and at the end of the welding process, the tension band must be re-tightened.**
- During the cooling time of minimum 40 minutes, the pipe must not be moved under any circumstances.
- After the cooling time has elapsed, remove the tension band and the support ring. The welding connection is now completed and is ready for operation under full load.
- To document the installation, mark the welding point with the wire number, the name of the welder, and the date and time of welding.
- After the welding process is completed, the connection must be tested for leakage according to DIN EN 1610. From DN 700, this might be done with a pneumatic socket pressure tester or similar device. Before side filling the trench, or before pulling the pipe into a cladding pipe, you must perform a preliminary leakage test (see DIN EN 1610, section 10).

Fig. 101 - Pulling the pipes together

Fig. 102 - Tightening of tension bands

Fig. 103 - PKS® welding adapter
Fig. 104 - Connection for welding cable

Fig. 106 - Socket pressure tester

Fig. 105 - Scanning welding code

9. Connecting techniques

9.4 Extrusion welding according to DVS 2207-4, process description for DIN 16961 / DIN EN 13476 profiled sewage pipes

1. Introduction

- Extrusion welds in PKS® pipe systems of any size are produced according to DVS 2207-4 by means of continuous welding. The pipes are supplied with prepared sockets and spigot ends.
- From DN 800, the pipes must be welded at both the inside and outside. Up to size DN 800, welding from the outside is generally sufficient for normal operating conditions.
- When welding from the inside, the spigot end must be equipped with a welding groove according to DVS 2207-4. The socket end is bevelled. For extrusion welding from the outside, it is not necessary to prepare the joint as described above.

FRANK welding robot

- Apart from conventional welding techniques with welding extruders, it is also possible to join the pipes using a welding robot. The FRANK welding robot allows for fast and cost-efficient installation of the pipes.

Fig. 107 - Welding extruder

Fig. 108 - FRANK welding robot

2. Welding of pipes

- After the pipe ends have been cleaned and the pipes have been pushed together, machine the pipe faces in the welding area.
- To produce a continuous extrusion weld according to DVS 2207-4, use a welding extruder with a welding shoe that matches the weld geometry.
- If necessary, first tack the spigot end and the socket together by hot gas welding.
- After the welding process is completed, mark the weld with a permanent felt-tip pen (wire number, date and name of welder).
- At low ambient temperatures, cover the weld area to prevent it from cooling too quickly.
- Remove the flashing that might appear under the welding shoe surfaces without causing any notches.
- After the weld has cooled, perform a leakage test, for example with a socket pressure tester.

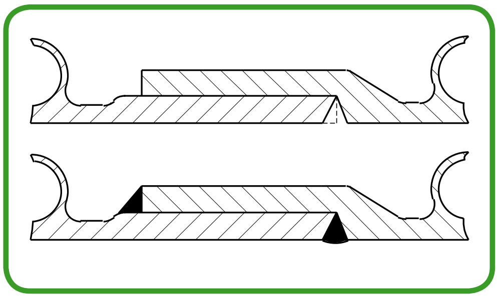


Fig. 109 - Weld seams

Fig. 110 - Extrusion seam/welding seam

9. Connecting techniques

9.5 Electrofusion welding according to DVS 2207-1, process description for extruded DIN 8074/8075 pipes

1. Introduction

- To join extruded pipes by means of electrofusion welding, the fittings and pipes are heated and welded by means of resistance wires, similar to the process for PKS sewage pipe systems.
- Only identical materials can be welded together by this method. The instructions of the German Welding Society DVS must be adhered during the entire welding process.
- All welds must be produced with welding machines (e.g. FRANK polycontrol plus) that have been designed for this task.
- Protect the work area against direct sunlight and moisture. If necessary, erect a welding tent (umbrella).

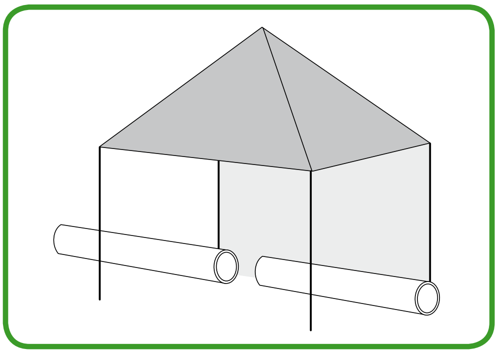


Fig. 111 - Welding time

2. Preparation

- Install the welding machine and check the welding equipment. Cut the pipe ends at right angles, using a suitable cutting tool, and deburr the outside edge. If the pipes ends are sagging, cut them off.
- Mark the insertion depth (insertion depth = 1/2 socket length). Clean the insertion section with a clean cloth. Peel off the oxide layer along the entire circumference to expose the insertion depth, using a hand scraper or preferably rotational scrapers. Chip thickness: approx. 0.2 mm. Remove the chips without scraping the prepared pipe surface. Prepare the electrofusion fittings in the same manner.

<u>Note:</u>
When sliding the pipes into the socket, ensure that they are not jammed. Do not attempt to drive in the pipe ends by force, for example with a hammer or mallet. If the pipes ends are no longer perfectly round so that they cannot be easily pushed together, use rounding clamps. Do not attempt to cut the pipe to fit with a hand scraper or similar tool.

- Just before producing the welded connection, remove the electrofusion socket from the packaging. Do not touch the inside of the socket or the prepared pipe surfaces with your fingers and prevent any contamination by dirt.
- If this is not possible, clean the welding faces with an approved PE/PP cleaner[1)] and a clean, lint-free, white paper tissue.
- Slide the electrofusion socket onto the pipe end to the centre stop or the marked insertion depth. Insert the other pipe end to the centre stop or the marked insertion depth.
- Check the insertion depth.

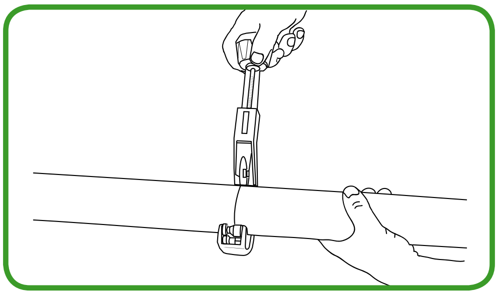


Fig. 112 - Cutting pipe to size

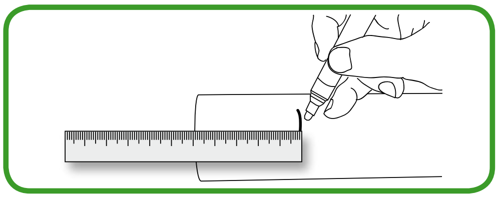


Fig. 113 - Marking pipe

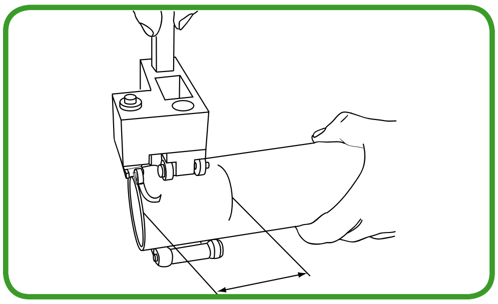


Fig. 114 - Machining pipe surface

<u>Note:</u>
It is not possible to weld the pipes correctly without first machining the welding area!

9. Connecting techniques

9.5 Electrofusion welding according to DVS 2207-1, process description for extruded DIN 8074/8075 pipes

3. Welding of pipes

- Secure the joint to be welded with clamps. Ensure that the wire connections face upwards and that the pipes are positioned so that they are not stressed during welding.
- Connect the welding cables, using suitable connectors. Ensure that the welding cables are not stressed. Observe the operating instructions for the welding machine!
- The welding machine indicates that contact is established. Scan in the welding parameters, using the reading pen or scanner. Check the information on the display (manufacturer, diameter, etc.). If the details are correct, press the start button.

Note:
When using a FRANK electrofusion welding machine, you are now prompted to confirm whether the pipes have been prepared and aligned. If this is the case, press the green button!

- Start the welding process at the device. Check the information on the display (e.g. set welding time, actual welding time).
- The clamp/tension straps must remain mounted during the entire welding and cooling time.
- An audible signal from the machine indicates that the welding time has elapsed.
- Do not remove the clamp/tension strap at this point but wait until the cooling time has elapsed. Allow the pipe to cool down properly!
- If welding is aborted during the welding time (e.g. due to a power failure), it is not permissible to use the same socket again for the joining of smooth extruded pipes!
- All welding parameters of the joint are stored in the automatic welding machine (e.g. FRANK polycontrol plus). This information can be printed out later in the form of a welding report. If your machine does not produce such reports, you must document the weld on site, using a paper form.
- Indicators inform you of the progress and successful completion of the welding process.

Option:
Our electrofusion sockets are equipped with a traceability code (yellow). Depending on the features of your welding machine, this code can be read in order to document the component details.

- The pressure test must only be performed after all welded connections are fully cooled (normally approx. 1 hour after completion of the last weld). The pressure test must be performed according to the relevant standards (e.g. DVS 2210-1, EN 805, page T-59).
- For recommended welding equipment and tools, please refer to our latest price list.

Check:
Should a mark be at a distance from the socket end, the pipe end is not correctly centred or pushed to the stop in the socket. Realign the pipes and secure them again in the correct position. The marks must be visible right at the edge of the socket.

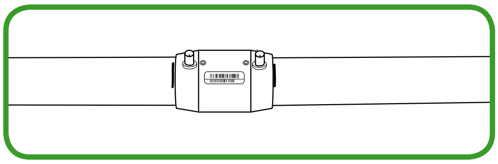


Fig. 115 - Checking insertion depth

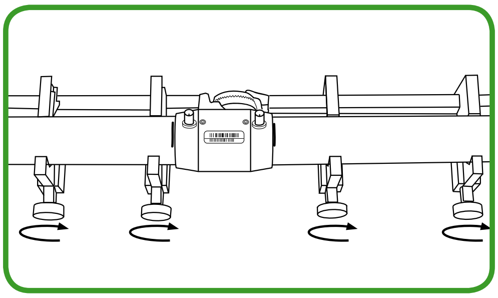


Fig. 116 - Aligning the pipes

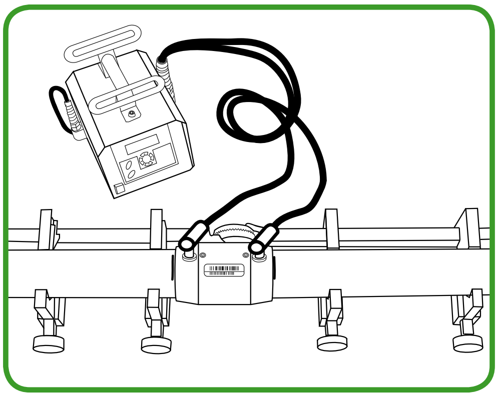


Fig. 117 - Connecting the welding machine

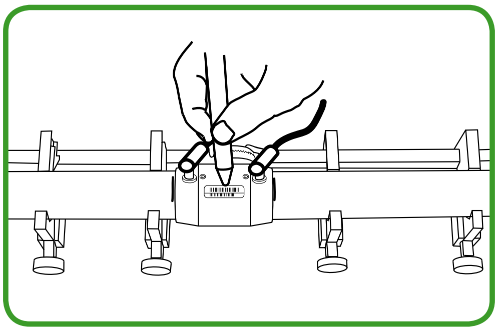


Fig. 118 - Scanning welding code

9. Connecting techniques

9.6 Butt welding according to DVS 2207-1, process description for extruded DIN 8074/8075 pipes

1. Introduction

- Butt welds must be produced by means of a suitable welding machine. The connecting faces of the parts to be welded (pipes or fittings) are prepared under pressure at the heating element. The parts to be joined and subsequently heated at reduced pressure are pushed together with force after the heating element has been removed.
- The machines and equipment used in this process must conform to DVS 2208-1. Always follow applicable DVS welding instructions (e.g. DVS 2207-1).
- The mating faces of the parts to be welded must be free of dirt or grease and must not be damaged in any way.

Fig. 119 - Butt welding machine

2. Preparation

- Position the welding machine, prepare and attach the accessories and check the welding equipment.
- If the welding site needs to be protected against the elements, erect a welding tent (umbrella).
- To prevent the pipe from cooling too quickly, for example due to a draught inside the pipe, seal the open pipe ends.
- Before commencing the welding process, check the temperature of the heating element and/or adjust it at the device (do not start welding earlier than 10 minutes before the welding temperature is reached).
- To protect the heating element against dirt and damage, it must be stored in a protective bag. Only remove it from the bag just before starting welding and place it in the bag again immediately after welding is completed.
- Prior to each welding process, clean the heating element with a clean, lint-free paper tissue.
- Clean the weld faces of the pipes with PE cleaner and a lint-free, white paper tissue. Ensure that the welding faces are free of any dirt particles!
- Before clamping the parts in the welding machine, align the pipes and fittings in axial direction so that the surfaces are parallel to each other.
- Ensure that the parts to be welded can be moved easily in axial direction. To do this, you might need to install roller stands.

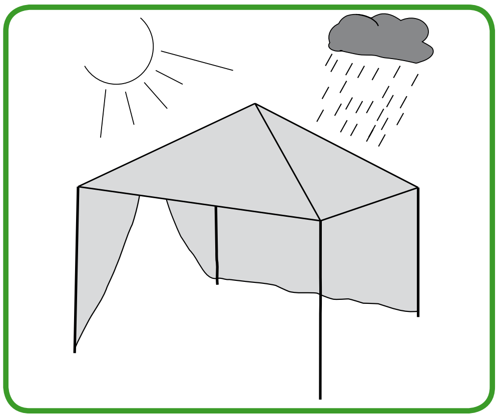


Fig. 120 - Protection against the elements - welding tent

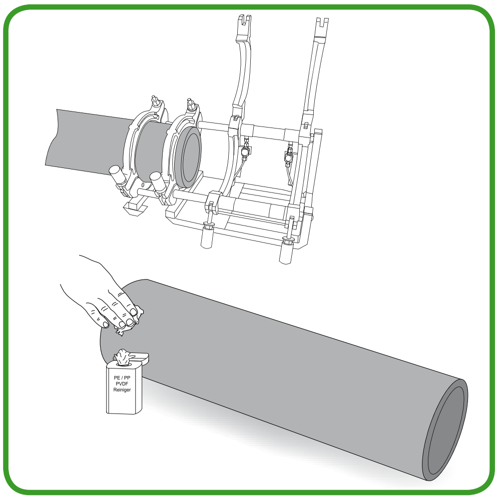


Fig. 121 - Cleaning welding faces

9. Connecting techniques

9.6 Butt welding according to DVS 2207-1, process description for extruded DIN 8074/8075 pipes

3. Welding of pipes

- Plane the pipe ends at both sides and remove the chips from the welding zone (with a paint brush, paper, tissue, etc.). Check the welding faces to ensure that the planes are parallel by pushing the parts to be joined together.
- In this process, also check the pipe offset. The rated wall thickness of the parts in the joining area must be the same.
- Determine and set the required welding parameters at the welding machine. Measure the movement pressure at the welding point and add it to the alignment/joining pressure. The tool movement pressure is measured while the welded parts are slowly moved against each other. This pressure might be greater than the joining pressure.
- The welding process is performed by applying the necessary alignment pressure. The alignment pressure must be maintained constant until the mating faces are fully flush with the heating element. This step is completed when there is a visible bead along the entire circumference of the welded parts.
- Reduce the set pressure to $p \leq 0{,}01$ N/mm² and heat the pipe for the time specified in the table of standard values. Mount the slide to remove the heating element and join the welding faces (work speedily to keep the changeover time to a minimum!).
- Gradually increase the joining pressure to the required value. The joining pressure must be maintained until the weld has cooled (forced cooling with coolant is not permitted!). After the required cooling time has elapsed, remove the clamping tools.

Inspection and reworking of welded joint

After joining the pipes, a continuous bead must be visible along the entire pipe circumference. This bead should meet the following requirements:

- *Uniform bead width and height*
- *Smooth bead surface*

If beads are not of uniform appearance, this might be due to differences in the melting properties of the joined materials. If a bead needs to be removed, it must be cut or peeled off without leaving notches behind.

- Perform a pressure test of the weld (normally about 1 hour after the last weld has been produced). The pressure test must be performed according to the relevant standards (e.g. DVS 2210-1, Supplement 2, DIN EN 805, page T-59).

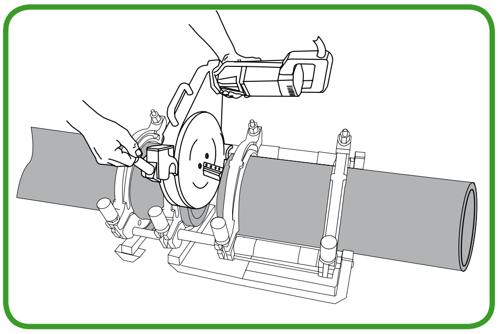


Fig. 125 - Planing pipe ends

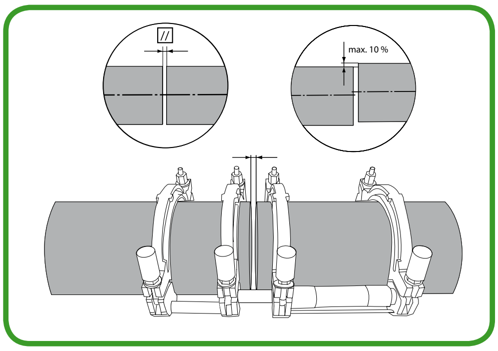


Fig. 122 - Checking pipe end offset

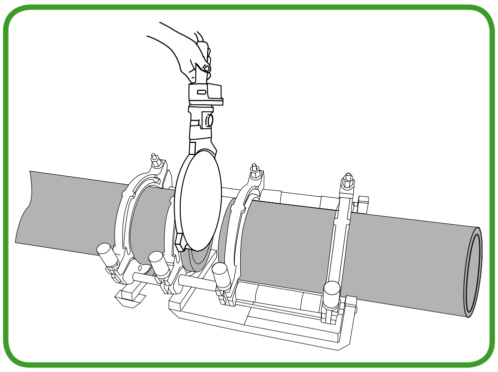


Fig. 123 - Mounting heating element

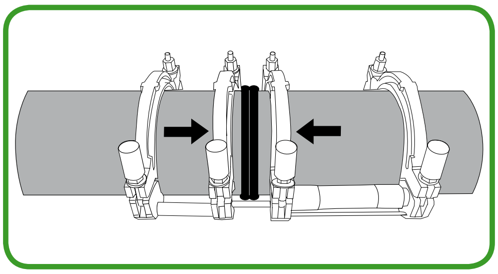


Fig. 124 - Joining pipe ends

9. Connecting techniques

9.7 House connections

1. Introduction

- If a house needs to be connected to an existing sewage pipe system, a T-fitting must installed at the PKS® pipe.
- In DN 300 to DN 3500 pipes, the house connection saddle can be welded. The smooth 90° PE T-piece (DN 150, d 160 x 9.1 mm) allows you to produce connections of any type, for example by using FRANK electrofusion fittings for PE pipes or conventional plastic fittings to fit PVC/standard sewage pipes.
- The PE T-piece can be mounted from the outside. The house connection is simply pushed with a special clamping tool into the outlet opening cut with a hole saw so that it is at right angles to the profiled sewage pipe axis. It is then permanently clamped to the pipe. The PE T-piece is then welded to the inside surface of the profiled sewage pipe by means of electrofusion with a FRANK welding machine through the plugs attached to the clamping tool. Apart from homogeneous welds produced with spiral electrofusion wires with integrated PE core, the connection is mechanically interlocked for greater tensile strength.
- The house connection saddle designed for new installation and renovation in open trenches is of a compact design and ready for installation by welding on site.
- Always observe the installation instructions of the manufacturer!

Fig. 126 - PKS® DN 150 house connection saddle

Advantages of PE T-pieces

- Compact design, ready for installation and connection to conventional PVC/ standard sewage pipe
- Easy installation from the outside by means of clamping tool
- Welding current applied through easily accessible plugs
- Improved safety thanks to mechanical interlocking
- Suitable for DN 300 to DN 3500

2. Welding of pipes

- Determine the pipe connecting point and cut an opening that is at right angles to the pipe axis, using a hole saw.
- Deburr the opening and remove the oxide layer around the welding zone with a hand scraper.
- Clean the prepared welding faces with PE cleaner and a lint-free, white paper tissue. The welding faces must be perfectly clean and dry.
- Slide the house connection saddle from the top onto the clamping tool and lock it in position and clamp it. Slide the clamping tool to the opening in the pipe and hook the threaded rod in the clamping tool. Pull the saddle with the clamping tool outwards so that the collar of the saddle touches the inside wall of the PKS pipe.
- Align the saddle and secure it with the wing bolt.
- Slide the welding adapter by 4.0 mm onto the contacts of the saddle and connect the welding machine. Scan in the welding code and start the welding process. Observe the cooling instructions of the manufacturer.

Fig. 127 - Clamping/welding

9. Connecting techniques

9.8 Plug-in connections - TSC-Pipe

1. Introduction

- TSC-Pipe is a pipe system with plug-in connections. The profiled spiral pipes and matching fittings are equipped with spigots and sockets, similar to the PKS sewage pipes.
- In TSC-Pipe, the socket is however not equipped with an electrofusion wire. The PROFIX spigot end features 2 grooves for the installation of 2 EPDM sealing rings. This integrated, locking double lip seal prevents infiltration and exfiltration of the rain water.
- To prevent damage to the sealing rings, these are supplied separate from the pipes.
- The pipes must be installed according to the applicable standards and regulations (see chapter 8.2). Always follow the instructions in the general installation guidelines (chapter 8.1).
- On site, pipes and fittings must be stored in such a way that the sockets and spigot ends are protected against impact and dirt.

Fig. 128 - Cleaning the spigot end

Fig. 129 - Marking the insertion depth

2. Connecting pipes

- Position the pipes so that the pipe ends are easily accessible. Check the socket and spigot end for damage caused during transport and storage and clean them.
- Mark the insertion depth (min. 125 mm) on the spigot end, using a permanent felt-tip pen. Mark the depth at a number of separate points that are equally spaced along the circumference.
- Slide the sealing rings onto the cleaned spigot end and position them in the grooves.
- After mounting the sealing rings, treat the socket with the supplied lubricant. Do not apply lubricant to the spigot end.
- Push the pipes together to the marked insertion depth. Make sure that the pipes are correctly aligned to each other to prevent jamming.
- The connection must be tested for leakage according to DIN EN 1610 (e.g. with a pneumatic pressure tester). Before side filling the trench, or before pulling the pipe into a cladding pipe, you must perform a preliminary leakage test.

Fig. 130 - Cleaning the socket

Fig. 131 - Applying lubricant

9. Connecting techniques

9.9 Detachable connections - flange connections

1. Introduction

- Flanges are used where tight yet detachable connections are required in a pipe system. The dimensions must conform to DIN EN 1092-1 PN 10.
- To ensure that the threads do not seize, we recommend applying an anti-seize agent, e.g. molybdenum sulphide.
- When choosing the sealing material, observe the chemical and thermal requirements.

Fig. 132 - PE welding stub

Fig. 133 - PE backing ring

Fig. 134 - Flange connections in sewage treatment plant

2. Connecting pipes

Aligning parts

- Before inserting the bolts, the sealing faces must be aligned so that they are flush and tightly packed against the seal. Do not attempt to align the flange connection by tightening the bolts, as this would result in excessive tensile stress on the bolts.

Tightening bolts

- Use bolts that are long enough to be countered with lock nuts. Place washers under the bolt head and the nuts.
- Tighten the bolts crosswise with same torque, using a torque wrench. Flange connections in treatment plants are often exposed to changing loads. It is therefore important that these connections are regularly checked and re-tightened according to the maintenance schedule.

Fig. 135 - Flange connection to PKS® pipe

10. Manholes and special constructions

10.1 PKS® manholes

Sewage pipe systems include a number of shafts and special constructions for inspection, flow control, etc. We therefore offer a range of manholes and special constructions in polyethylene and polypropylene for profiled sewage pipes systems. Components made from these materials ensure that all connections throughout the entire sewage system can be welded. Differences in material properties such as response to settling must thus only be determined once.

Normally, PKS® manholes feature a base made in polyethylene or polypropylene and a top part consisting of concrete manhole pipes according to DIN 4034. These vertical pipes transfer the traffic load directly to the manhole wall. The manhole section that is in direct contact with the wastewater and groundwater is thus made in corrosion-resistant PE or PP. Depending on the expected load, it is also possible to use manholes that are made entirely of PE 100 or PP-R.

The manholes are equipped with an entry, steps or a ladder. PKS® manholes feature a welding socket and a spigot for connection to the PKS® pipes. We also supply manholes with extruded flumes and sockets with smooth ends. Also available are special constructions (e.g. with customised spigots for connection to existing pipes).

PKS® manholes offer similar advantages as PKS® pipes, such as a light-coloured inside surface for easy inspection, low weight and smooth surfaces preventing deposits.

Advantages of PKS® manholes

- Light-coloured inside layer for easy inspection
- Low weight
- Manholes up to DN 3500
- Smooth inside and outside finish
- Designed for fast installation
- Fully pre-assembled at the factory
- Excellent resistance to chemicals
- Low pressure loss due to minimised friction

Static load

Manholes that are exposed to high traffic loads can be equipped with a load distribution plate made in reinforced concrete. The load distribution plate transfers the traffic load to the surrounding ground so that the axial forces acting on the manhole are significantly reduced.

PKS® manholes and special constructions are individually designed by our technical department, taking into account the static strength requirements. Each shaft is thus tailor-made to meet the actual load requirements on site. A questionnaire for the dimensioning of manholes and a manhole data sheet can be found on pages 46, 47 and 50.

Fig. 136 - PKS® inspection hole, with straight flume

Fig. 137 - PKS® inspection manhole, with angled flume

10. Manholes and special constructions

10.2 PKS® standard manhole - inspection manhole

PKS® standard manholes are available in two versions, namely as inspection manholes and as tangential manholes.

PKS® inspection manhole

Sewage pipe systems from DN 300 to DN 700 are normally equipped with inspection manholes where the cross-section of the sewage pipe extends across the width of the manhole sleeve. Inspection manhole sizes:

DN 1000 for PKS® pipes from DN 300 to DN 500
DN 1200 for PKS® pipes DN 600
DN 1500 for PKS® pipes DN 700

The flume of the inspection manhole includes a raised berm that gradually slopes to the bottom of the pipe and is available as a straight section or as an angled component.

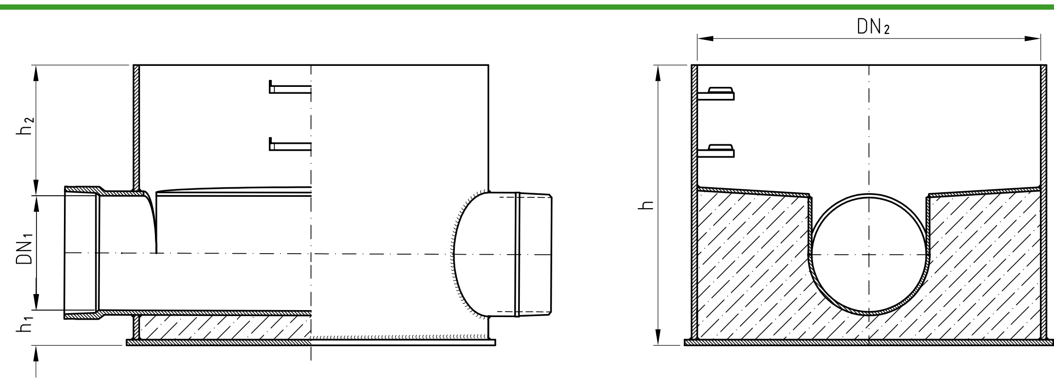
The upper part of the manhole consists of concrete pipe sections that allow for levelling with the final ground level.

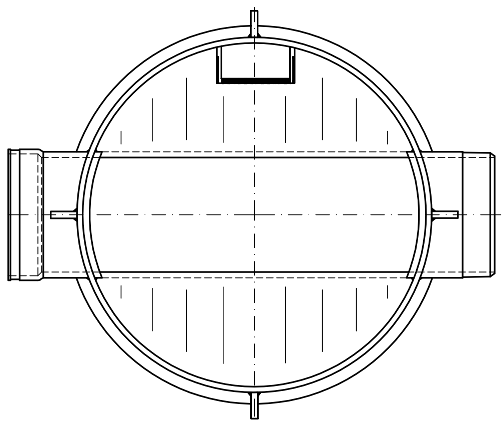
The height of the bottom part of the manhole made in PE 100 or PP can be adjusted to suit the pipe system layout. As a rule, the PKS® manhole bottom section should extend above the highest known aquifer level!

For special constructions and manholes with non-standard dimensions, contact our technical department.

Fig. 139 - PKS® inspection manhole, with straight flume

Note:
FRANK GmbH does not produce or supply concrete cones, levelling rings and reinforced concrete covers.





DN_1 [mm]	DN_2 [mm]	h [mm]	l [mm]	h_1 [mm]	h_2 [mm]
300	**1000**	1000	1600	170	530
400	**1000**	1000	1600	170	430
500	**1000**	1000	1600	170	330
600	**1200**	1200	1800	170	430
700	**1500**	1300	2000	170	430

Table 13 - Standard inspection manhole

Fig. 138 - System drawing of inspection manhole

10. Manholes and special constructions

10.3 PKS® standard manhole - tangential manhole

PKS® tangential manhole

In large-diameter PKS® pipe systems from DN 600 to DN 3500, tangential manholes are the preferred option. Tangential manholes are mounted at an offset from the centre axis of the pipeline. This allows for the construction of the actual manhole with DN 1000.

The tangential manhole features a flat, underwelded and slip-proof floor that slopes towards the main pipe. It is equipped with an entrance, steps or safety ladder and a sealing ring at the top on which the concrete pipe sections, etc. can be placed.

DN_1 [mm]	l_1 [mm]	l_2 [mm]	h_1 [mm]	h_2 [mm]
600	2000-6000	500	900	600
700	2000-6000	550	1000	650
800	2000-6000	600	1100	700
900	2000-6000	650	1200	750
1000	2000-6000	700	1300	800
1100	2000-6000	750	1400	850
1200	2000-6000	800	1500	900
1300	2000-6000	850	1600	950
1400	2000-6000	900	1700	1000
1500	2000-6000	950	1800	1050
1600	2000-6000	1000	1900	1100
1800	2000-6000	1100	2100	1200
up to 3500	on request			

Table 14 - Standard tangential manhole

Fig. 141 - PKS® tangential manhole

The joint to the reinforced concrete plate/concrete cone should be located above the highest known aquifer level.

The tangential manhole is connected to the pipe by means of an electrofusion socket and a spigot end attached to the main pipe.

As PKS® tangential manholes are relatively simple structures, they offer a cost-effective solution for large-diameter sewage pipe systems. They offer adequate access to the pipeline without the need of large-scale structures.

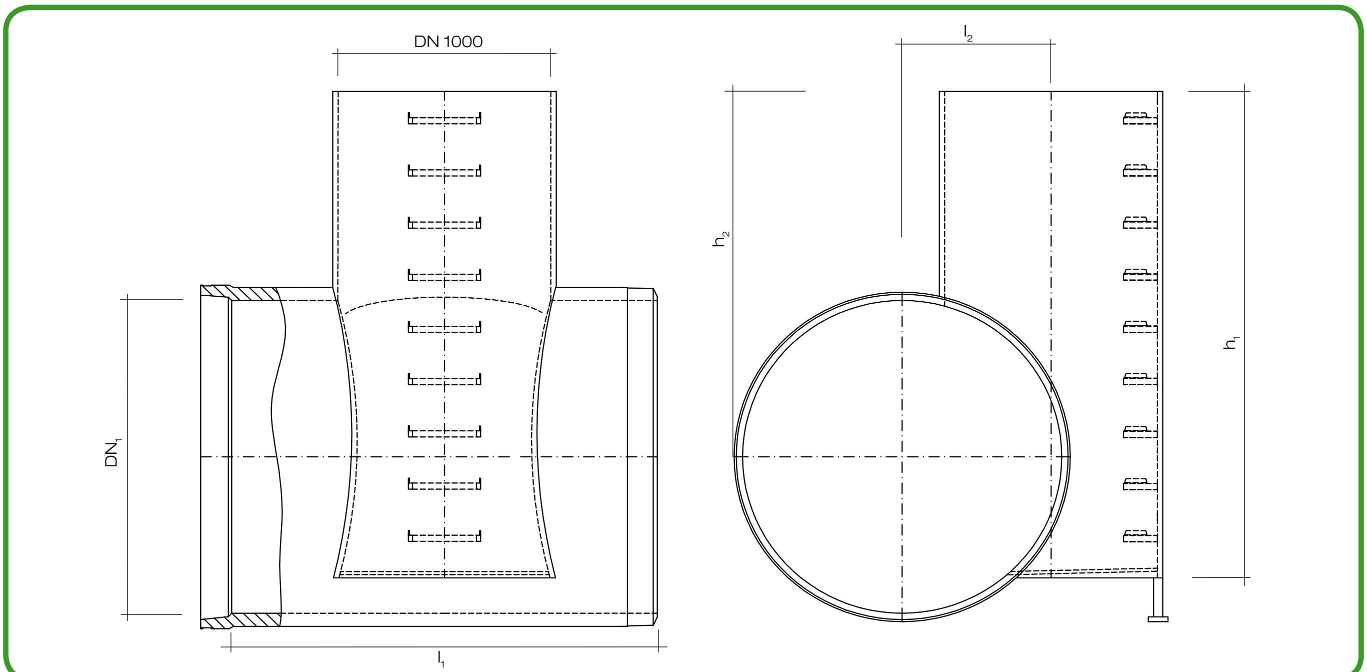


Fig. 140 - System drawing of tangential manhole

FRANK

10. Manholes and special constructions

10.4 PKS® storm water system

As wastewater treatment plants must be supplied with a constant flow rate, mixed water systems must be equipped with storage facilities in the pipeline system so that water can be held back during rainy periods.

Certain systems require basin overflows. PKS® profiled sewage pipe systems made in PE can be equipped with storm water facilities of any desired design and capacity. It is thus possible to install upstream and downstream retention tanks and devise overflow geometries that suit the actual site requirements.

Constructions such as inlet, throttle and retention manholes as required according to DWA A 117 and A 128 made in plastic can be custom-engineered and pre-assembled at the factory. Manholes with pre-formed sockets with a diameter of up to 3500 mm can for example by factory-assembled. Constructions and pipes up to DN 2400 are then connected on site by electrofusion welding. Components with larger diameters are normally extrusion welded.

Advantages:

- PKS® pipes require less excavation
- Smooth inside surface
- Pipe roughness k $\geq$ 0.01
- No need for dry weather channel
- Material approved by DIBt
- Fully pre-assembled
- Short installation time
- Technology suitable for complex geometries
- Low maintenance costs due to good self-cleaning properties
- Designed for high loads and installation in poor ground
- Strong welded pipe connections
- Light weight for easy handling

Fig. 142 - PKS® storm water overflow DN 3000 with strainer

Fig. 143 - PKS® DN 1500 storm water system

10. Manholes and special constructions

10.4 PKS® storm water system

Inlet section

In the inlet structure, the wastewater flow is normally accelerated along a steep pipe section in order to prevent deposits in the storm water tank during dry weather periods.

Storm water tank

The storm water tank acts as a temporary storage tank for wastewater. It consists of a PKS® pipe of the required capacity.

Regulation constructions /storm water constructions

The regulation construction controls the outflow from the storm water tank to the pipeline system by means of a throttle (throttle manhole) or with a pump (pump shaft).

Storm water constructions are equipped with an overflow reservoir inside the manhole, which also acts as strainer for solids and sediments. When the maximum retention capacity of the system is reached, the reservoir overflows.

Fig. 144 - Storm water overflow DN 3500 with overflow reservoir

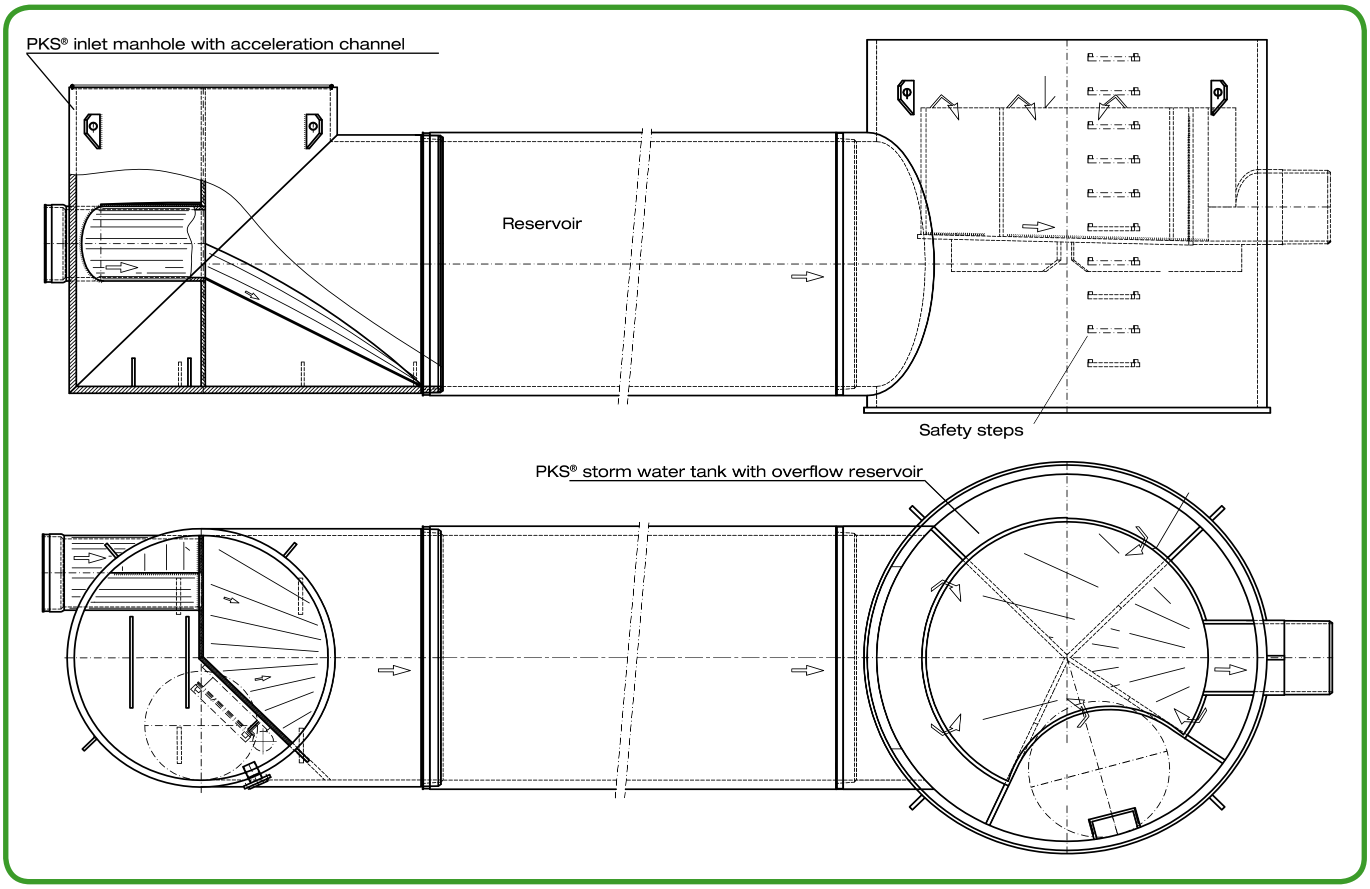


Fig. 145 - System drawing of PKS® storm water system

10. Manholes and special constructions

10.5 PKS® special constructions - examples

Fig. 146 - PKS® tangential manhole, angled, with stepped section and reduction to Y-piece

Fig. 147 - PKS® Y-piece, flange-mounted

Fig. 148 - PKS® infiltration manholes

Fig. 149 - PKS® DN 2300 overbridge

10. Manholes and special constructions

10.5 PKS® special constructions - examples

Fig. 150 - PKS® DN 3000 flushing and overflow manhole

Fig. 151 - PKS® Secutec DN 2000 (DN 2000 storm water system with leakage monitoring, DIBt-approved)

Fig. 152 - PKS® round-to-square adapter

Fig. 153 - PKS® silo DN 3000

11. Project reports

11.1 Neckar culvert: Large-diameter spiral pipes made in polyethylene

Two parallel spiral pipes are installed along a 190 metre stretch under the Neckar river. Laid at a depth of up to eleven metres, the new system is designed for long-term tightness.

Over the last few years, sewage system operators have become increasingly aware of the environmental issues associated with sewage and wastewater. Local governments are addressing the problem of leaks in drains, manholes and pipeline systems.

Fig. 154 - PKS® pipes ready for installation

As a result, operators demand pipes made from materials that are less prone to leakage.

Recent studies show that leaks occur not only in old pipes but also in recently installed sewer lines. One of the reasons for this are flaws in the system design, such as the use of unsuitable pipe and socket material, resulting in leaking socket connections. Pipelines made in rigid materials are particularly prone to leaking, as they can burst suddenly under a short-time load. The resulting cracks and fractures do not only lead to the escape of sewage into the environment but reduce the static load strength of the pipeline. In such cases, organic and inorganic substances contained in the sewage can pollute the groundwater, while fresh water might infiltrate the sewage system. As the number of combined sewer systems that collect rainwater runoff, domestic sewage, and industrial wastewater decreases, sewers carrying highly loaded wastewater need to be tighter than ever, as any leaks here can cause even more serious pollution. Operators are thus on the lookout for pipe materials and connecting techniques that guarantee lasting tightness of the pipeline system. Based on its many years of practical experience with pipeline systems made in polyethylene (PE 80 /PE 100), FRANK GmbH has developed a range of fittings and system components that meet the ever more stringent requirements for the various applications, including sewage discharge. The solutions developed by FRANK also meet the latest plant engineering standards. One product that clearly stands out here is the spiral pipe made in polyethylene (PE 100), as it offers a number of distinct advantages over conventional materials. As the properties of modern polyethylene materials can be fine-tuned, pipe systems made from this material can be equally optimised for any specific task. Key parameters are the internal pressure strength across the pipe's service life, resistance against slow and fast crack propagation and the pipe's mechanical strength.

Large-diameter spiral pipes made in polyethylene

Focussing on the improvement of the internal pressure strength, the resistance to slow and fast crack propagation and the long-term mechanical strength, FRANK has developed the profiled sewage pipe (PKS®) and associated fittings made in polyethylene.

Over many years, FRANK has been able to devise a production process for lightweight yet dimensionally stable products that are resistant to chemicals and mechanical forces and have an exceptionally long service life.

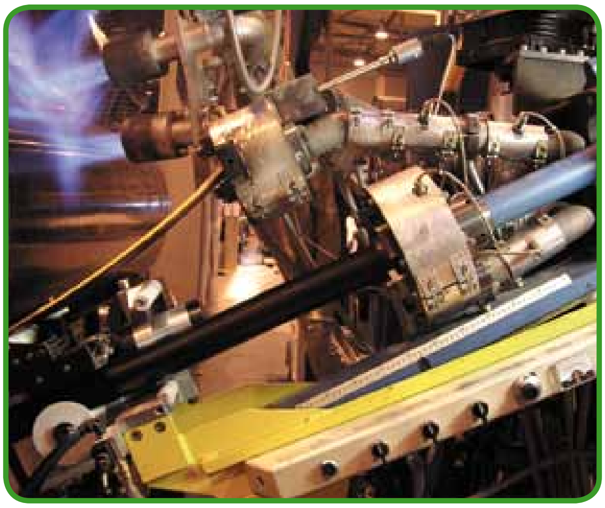


Fig. 155 - Modern machinery guarantees consistent high product quality

A distinct feature of modern pipes from FRANK GmbH is the integrated electrofusion socket. The co-extruded yellow inside layer made in PE allows for efficient revision procedures and inspections by camera.

The projects described here demonstrate the above advantages of FRANK pipes and fittings and their practical usage. Large-diameter spiral profiled sewage pipe systems from FRANK are currently being installed on many industrial sites, in sewage treatment systems, on landfill sites and in road construction. They are also particularly suitable for pipe relining.

11. Project reports

11.1 Neckar sewage pipeline under-river crossing: Large-diameter spiralpipes made in polyethylene

Fig. 156 - Available in lengths of up to 12 m

Sewer lines crossing the Neckar at Mannheim

The "Grabenstrasse" culvert was first laid in 1903 as a riveted iron pipe with an inside diameter of 1400 mm. It was connected to a combined sewage and rain water pipe system that extended under the city centre of Mannheim. In October 2002, the pipe was to be cleaned, which required the culvert to be pumped empty. Over the nearly 100 years since its installation, the load on the pipe increased as the river bed was lowered several times to provide a deeper shipping channel. When being emptied, the culvert became buoyant in the river and eventually broke. Its repair became an urgent matter.

The engineering firm of de la Motte & Partner Ingenieurgesellschaft mbH based in Reinbeck near Hamburg was commissioned to perform a feasibility study. It subsequently drew up the construction plans and supervised the construction based on a cost guarantee. The actual construction work was performed by the Neckardüker Consortium set up by Diringer & Scheidel, Mannheim, which was responsible for the pipeline and manhole construction, and Bohlen & Doyen, Wiesmoor, which carried out the hydraulic engineering work. Together with the sewage system operator and the water management department of the city of Mannheim, the partners developed a solution that met the actual site requirements. One main concern was the fluctuating water levels in the pipe (depending on the weather). The pipe section also had to allow for a high flow rate to prevent deposits. In addition, the culvert had to last for a long period of time and had to be installed in such a way that it would not become buoyant under any circumstances.

One key advantage of the chosen PE pipe over other materials is its light weight, which allows for easy handling. In addition, the smooth pipe inside prevents deposits. The chosen material also had to withstand exceptionally high loads when the pipe is empty, as it is exposed to a high water pressure. In addition, the pipe had to be anchored in the river bed to prevent floating.

Requirements, objectives and certification

During the planning phase, the system operator requested detailed static load calculations according to ATV-DVWK-A 127 as amended, based on specific water levels and trench base heights. These revealed that the FRANK pipes meet the requirements as regards ring stiffness when the pipes are fully filled as well as when they are completely empty, for example during a repair or inspection. In addition, the spiral PE 100 pipes met the following key requirements:

- Long-term tightness of welded connections between the various components
- Constant production conditions
- Seamless quality control
- Easy installation on site
- Excellent cost-efficiency
- Certified long-term durability

The river was crossed by two PKS® pipes from FRANK GmbH with DN 800 and DN 1400 that were installed parallel to each other. They were welded together on the river bank and then laid in a boxed steel structure where all fittings were mounted until the complete pipe system was lowered to the bottom of the Neckar river on the 12 August 2003.

To allow for easy access for maintenance or cleaning, the two pipe strings were equipped with a revision manhole each located in the foreland area.

After the boxed steel structure was filled with waterproof concrete to prevent it from floating, the under-river pipe section was connected to the existing pipeline system. The completed project was inspected and accepted by the client on the 6 November 2003.

Fig. 157 - Neckar sewage pipeline prior to installation in river bed

11. Project reports

11.1 Neckar culvert: Large-diameter spiral pipes made in polyethylene

Fig. 158 - Neckar under-river pipeline section is being lowered to the bottom of the river bed

PE - the ideal material for this project

The companies involved in this project were already familiar with the advantages of plastic pipes in sewer systems. The decision to use PE 100 pipes in this projects was based on both technical and commercial considerations.

PE 100 - a cost-effective solution

Spiral pipes, pressure pipes and fittings made in PE 100 have a relatively low specific weight of 0.959 g/cm^3, which is of significant advantage for the handling and installation of the components. This helps of course lower the installation costs. Spiral pipes with a diameter of more than DN 300 can be manufactured in a flexible, low-cost production process. During the planning phase, the relevant positive experiences from other projects were highlighted to convince the client as well as the construction consortium of the advantages of the proposed solution.

Technical advantages of PE 100

Compared with conventional pipe materials (manufactured according to the Darmstadt method), PE 100 offers better chemical resistance, higher operational safety and significantly improved abrasion resistance. In addition, they are also easier to weld and guarantee more durable tightness of the system. From an environmental point of view, PE 100 can be produced with relatively little energy and the material is fully recyclable.

Certified long-term durability

Pipe systems made in PE 100 have been used for many decades for the transport of gas, water, wastewater and substances that are water pollutant and have thus an excellent track record. The tested service life of such installations is currently at around 50 years, whereby experts expect this figure to increase to 80 to 100 years as tests continue. ISO 9080 (previously ISO/TR 9080) describes a scientifically verified extrapolation method that allows for predictions regarding the long-term durability of thermoplastic materials. This method is based on the Arrhenius law. Based on long-term data of pressurised pipe specimens exposed to high temperatures, it is possible to determine the service life of pipes at lower temperatures. The relevant extrapolation factors are laid down in ISO 9080. The minimum service life curve in DIN 8075 for PE 100 has been devised on the basis of the same principle. By opting for Hostalen CRP 100 Black (PE 100), manufacturers and users of pipe systems can now choose a material with a calculated service life of more than 100 years. This multimodal, third-generation PE compound is produced by Basell Polyfone GmbH at its plant in Frankfurt/Main in a multi-stage polymerisation plant. Hostalen CRP 100 Black (PE 100) has been approved by the German Institute for Civil Engineering (DIBt) in Berlin.

Weldable materials for permanently tight pipe systems

The guide values for welding parameters for this multi-modal material as regards pre-heating, joining pressure build-up and cooling time under joining pressure, etc. are laid down in the latest edition of DVS 2207 for pipes and plates made in PE (PE 100).

Summary

Wound large-diameter pipes from FRANK GmbH made in multi-modal PE (PE 100) materials allow for the fast and cost-efficient production of heavy-duty pipe systems, manholes and constructions with guaranteed long-term tightness. As the pipes are equipped with integrated electrofusion sockets, they are easy to connect by means of welding. The light-coloured, smooth and abrasion-resistant inside surface of the pipe allows for easy inspection as well as trouble-free operation.

11. Project reports

11.2 Steinhäule wastewater treatment plant

Introduction

New statutory regulations for the treatment of wastewater and sewage have forced plant operators to improve the effectiveness of their treatment systems. Further improvements of the quality of the discharged water are likely to focus on the retention of ecologically critical substances that are virtually non-biodegradable, such as residues from drugs and nitrates from agricultural land use.

Future regulations will be based on the standards set by the European Union, which is in the process of devising communal directives for the protection of waterways and groundwater, and the licensing of treatment plants.

In order to tackle these challenges, the cooperative behind the Steinhäule sewage treatment plant realised that it needed to increase the capacity of its plant and invest in modern technology. The plant is to be extended by additional clarifying basins and a filtration unit so that its can be upgraded in line with the latest statutory requirements.

The installation of overground pressure pipes with an inside diameter of DN 1000 to DN 1400 for the underground denitrification and distribution basins with many custom-engineered components required a detailed technical planning procedure, including extensive static strength calculations for the envisaged pipe dimensions and site layout.

For this project, spiral large-diameter pipes made in PE 100 were chosen, which were then installed in cooperation with an installation company and under the supervision of an engineering firm.

treated in the Steinhäule plant. This corresponds to a wastewater volume of about 80,000 to 100,000 m³ a day. Around 40 % of the wastewater is produced by industry and other businesses. In the treatment process, approx. 20 to 40 tons of sludge (dry matter) is removed, which is incinerated. It takes about ten hours for the water to pass through the treatment plant. In comparison, given the self-purifying power of the Danube, it would take about ten days to treat the same amount of wastewater, if it were directly discharged into the river.

Fig. 159 - Steinhäule wastewater treatment plant

Catchment area of Steinhäule plant

The Steinhäule treatment plant is located near the river Danube, downstream of the power plant of "Böfinger Halde". It is owned by a consortium that includes the city councils of Ulm, Neu-Ulm, Senden and Blaubeuren as well as the towns of Berghülen, Blaustein, Dornstadt, Illerkirchberg, Illerrieden, Schnürpflingen and Staig. The wastewater from the above areas is treated according to the statutory regulations and then discharged into the Danube.

The plant extends over an area of 11 hectares. Every day, the effluent of around 200,000 people in the catchment area is

Plant requirements

The new construction of the denitrification and distribution basins includes eight cascades with inlet and outlet pipelines. Each cascade level has a capacity of 2400 m³.

The overground and underground pipe systems had to meet the following requirements:

- Pressure pipes with an inside diameter of DN 1000 to DN 1400 for flexible water transport and distribution.
- The underground pipelines include various special components such as T-pieces, valves, wall connections and reducers.
- Flow capacity: 55 to 70 m³/min
- Operating temperatures: 5 and 20 °C respectively
- Max. permissible operating / system pressure: 1.5 bar
- Plant service life: > 50 years

11.2 Steinhäule wastewater treatment plant

Pipe and fitting production

FRANK GmbH based in Mörfelden has more than 45 years of experience in the production of PE pipe materials and is one of the leading manufacturers of spiral pipes in Europe. FRANK GmbH also operates plants in Poland and New Zealand.

The pressure pipes, bends and T-pieces for this project were manufactured by two subsidiaries of FRANK GmbH in Wölfersheim. Thanks to its flexible, state-of-the art production machinery, the Wölfersheim plant is well equipped for the production of customised pipe dimensions of up to DN 3500 in PE and PP.

In order to minimise the on-site installation costs, most pipeline segments (pipe with fittings) were pre-assembled at the factory in Wölfersheim. These segments with lengths between 4 and 8 metres were then transported on a low-loader to the construction sites.

The static strength calculations of the pressure pipes, bends and fixed flange fittings were performed by FRANK Deponietechnik GmbH in cooperation with the engineering firm Ingenieurbüro Pöltl. These calculations were then verified by LGA in Nuremberg and Dr. Ing. Dietmar H. Maier, Karlsruhe. The bearing points were subsequently calculated by Ingenieurbüro Brandolini & Seitz in Ulm.

Engineering aspects

Due to the specific requirements to be met by the upgraded plant and the overground installation of the pipes, it was necessary to carry out detailed static strength calculations, which was done during the extended technical planning phase.

The calculations focused on the effects of increased inside pressure and thermal expansion, taking into account the design of the fixed points and the required support spans.

The relevant static strength values for PE 100 were made available by the material producer.

Static strength calculations

The static strength calculations for this project were extremely demanding. The standard method according to DVS 2210-1 was used to determine the dimensions of the pipes without fittings, as this method allows for the accurate calculation of the internal pressure stress, the support spans and the forces acting on fixed points due to longitudinal expansion. The results were then used for the construction of the straight pipe sections between the various fittings. The figures showed that the PE 100 pipeline could be installed with the same support span as a stainless steel system.

Finite element analysis of fittings

The fittings such as T-pieces, bends, reducers and fixed flanges needed to be evaluated separately. These fittings were all made from solid spiral pipe material to ensure that they had the correct wall thickness. The relevant calculations were performed using the finite element method (FEM). The main advantage of this method lies in the fact that it can be used for calculations in a wide range of disciplines, as each component is divided into a large number of very small elements. Subsequently, the forces acting on these elements are evaluated in order to determine the forces that affect the actual component. With this approach, it is thus possible to determine the wall thickness required for any possible geometric shape.

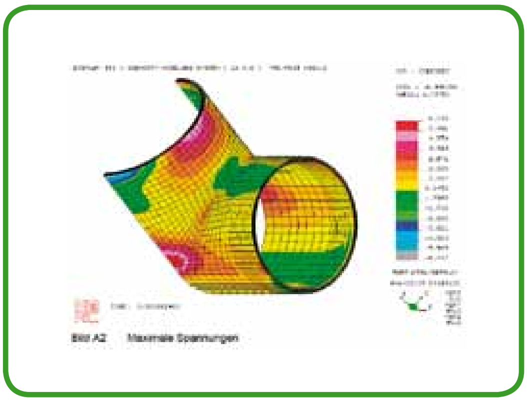


Fig. 160 - Finite element model of DN 1400 T-piece (source: LGA Nuremberg)

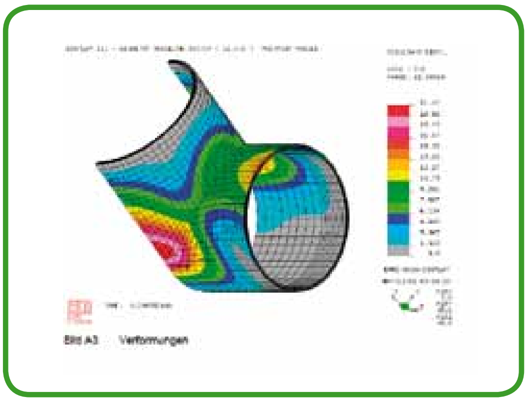


Fig. 161 - Finite element model of DN 1400 T-piece (source: LGA Nuremberg)

11. Project reports

11.2 Steinhäule wastewater treatment plant

Result

Considering the requirements, calculations and analyses, the consortium decided on the 23 July 2006 to use pipes and fittings made in PE 100 for the connection between the denitrification basins. The entire installation was completed within only two months. The total weight of the installed pipes and fittings was around 100 tons.

The experiences from the Steinhäule project will be evaluated for future projects as they show that PE 100 is a viable alternative to stainless steel pipelines in plant construction.

Fig. 162 - Inside the treatment plant

Fig. 164 - PKS® T-piece with elbow

Fig. 163 - Supports/clamps for r PKS® pipes

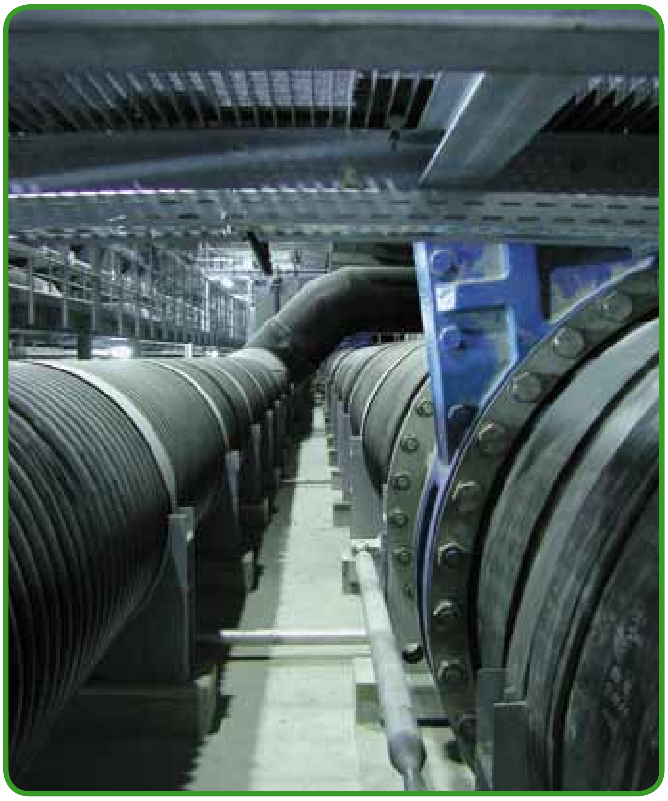


Fig. 165 - PKS® pipe flange connections

11. Project reports

11.3 Sureline® pipes for Hamburg pressure drainage system

Introduction

The Hamburg city drainage authority HSE needed to construct a pressure pipeline to connect three pump stations in the districts of Bergedorf to the wastewater mains. The locality features a major thoroughfare (Kurt-A.-Körber-Chaussee) with a number of industrial estates on both sides. There is thus a lot of traffic at all times of the day. In addition, the pipeline is crossed by numerous house connections. Considering these conditions and the good results from previous projects where pipes were laid under a riverbed by means of horizontal hydraulic drilling, HSE decided to use this advanced installation technology also for this project.

Planning

The total pipeline length for this project was around 2000 m to be completed with pipes of various diameters (da 280 - da 400, SDR 11). HSE decided to use sewage pipes with a light-coloured inside layer from the FRANK Sureline® range.

Fig. 166 - Sureline® pipe 315 x 18.6 mm

Another aspect that spoke for this method was the excellent properties of the proposed pipe material. Apart from the well-known advantages of PE 100 pipes over conventional pipe material, the Sureline® pipes from FRANK offered unrivalled resistance against slow crack propagation, which makes them the ideal solution for alternative installation technologies. Other requirements laid down by HSE such as long-term E modulus, resistance to fast crack propagation, and compliance with the ZP 14.6.36 standard were easily met by the PE 100 pipes, which have been tried and tested in similar projects.

Apart from the high quality of the pipe material, HSE was also keen to find a pipeline installation contractor that had the necessary expertise and experience. The successful bidder needed to meet the requirements laid down in DVGW GW 301 or GW 302 (group GN 2) respectively.

After careful examination of all submitted documents, HSE chose Vorwerk GmbH based in Tostedt and its partner company Nacap B.V. from Eelde (Netherlands) as the pipe installation contractors.

Construction

HSE completed the planning of this highly complex project within around four to five months. The actual construction phase took only three months.

The pipes were welded on site (butt welding with heating element) and subsequently pulled into the drilled channel. One section of the system (section A, length 1145 m) required the use of a stainless steel sleeve (508 x 9.5) as the pulling forces during installation (friction, pipe weight) were deemed too high for plastic pipes. The remaining section B was drilled in three parts (220 m, 270 m and 420 m) for installation without a protective sleeve. The connection of the individual Sureline® pipes was extremely easy, as they could be welded according to the DVS 2207 parameters without any further preparation or reworking. The actual pulling forces during installation measured on the pipe were between 120 and 200 kN, which is about half of the permissible limit forces. The construction progress was constantly monitored by HSE and the contractors worked closely together. This complex project could be brought to a successful conclusion with a final pressure test.

Summary

Despite the difficult site conditions, HSE was able to complete this project in a most cost-effective manner without compromising the quality of the construction. Compared with the estimated open-trench installation costs of around EUR 3m, the project was actually completed at a total cost of approximately EUR 1.8m, which corresponds to cost savings of around 60%.

This was mainly due to the fact that the Sureline® pipes were installed at a depth of around 6 to 9 m (in section A) and around 3.0 m (in section B). As most underground supply and discharge pipes and other infrastructure lines (gas, telephone, power) are installed at a much higher level, work at this depth could progress unhampered. The only slightly costly item that was required with this solution was a shaft with a depth of 10 metres. Overall, the chosen installation was the most economical one. What is more, this project showed that pipe systems that are readily available in the market and modern installation methods can be effectively combined to lay pipelines in urban areas with minimum disruption to other supplies.

11. Project reports

11.4 Storm water channel Sportlaan, Netherlands

Project description

Municipality of Dedemsvaart, Province of Overijssel, Netherlands

The storm water tank made from PKS® pipes was to replace an old concrete storm water system. By renewing the storm water tank, the leaking concrete construction was to be put out of operation, while the capacity of the tank was to be increased to 450 m^3.

The municipal council and its contractor Sallandse Wegebouw opted for a storm water tank made in PE 100, as these plastic pipes can be tightly sealed by means of electrofusion sockets and have a perfectly smooth inside surface so that no additional flushing system for cleaning would be required.

In addition, PKS® pipes can be installed quicker than other pipes, doing away with the need for costly, large water retention tanks.

Fig. 167 - Installation of PKS® pipes

Fig. 169 - Laying of PKS® pipe DN 1800, in pre-welded sections of 18 m

Fig. 168 - Two DN 1800 pipe strings of 78 m in length, installed between the road and a pond

The delivery included 156 m PKS® DN 1800 pipes, a number of PKS® DN 1800 30° bends, a PKS® DN 1800 inlet section and a PKS® DN 3000 overflow/pump shaft.

All pipes, bends and manholes were welded and installed within two weeks by Sallandse Wegebouw.

Fig. 170 - Installation of DN 3000 overflow/pump shaft

12. Standards and regulations

FRANK pipes and fittings are made from standardised moulding materials and produced according to recognised German and international standards. The list below is an excerpt of the standards, technical codes and regulations referred to in our catalogue:

DIN/DIN EN/DIN EN ISO

DIN 1910-3
Welding - Welding of plastics - Processes

DIN 1989
Rainwater harvesting systems

DIN 4102-1
Fire behaviour of building materials and building components - Part 1: Building materials; concepts, requirements and tests

DIN 4262-1
Pipes and fittings for subsoil drainage of trafficked areas and underground engineering - Part 1: Pipes, fittings and their joints made from PVC-U, PP and PE

DIN 4266-1
Drainage pipes for landfills - Part 1: Drainage pipes made from PE and PP

DIN 8074
Polyethylene (PE) - Pipes PE 80, PE 100 - Dimensions

DIN 8075
Polyethylene (PE) pipes - PE 80, PE 100 - General quality requirements, testing

DIN 8077
Polypropylene (PP) pipes - PP-H, PP-B, PP-R, PP-RCT - Dimensions

DIN 8078
Polypropylene (PP) pipes - PP-H, PP-B, PP-R, PP-RCT - General quality requirements and testing

DIN 16928
Pipes of thermoplastic materials; pipe joints, Elements for pipes, laying; general directions

DIN 16961-1
Thermoplastics pipes and fittings with profiled wall and smooth pipe inside - Part 1: Dimensions

DIN 16961-2
Thermoplastics pipes and fittings with profiled wall and smooth pipe inside - Part 2: Technical delivery specifications

DIN 16962-4
Pipe joint assemblies and fittings for types 1 and 2 polypropylene (PP) pressure pipes; adaptors for fusion jointing, flanges and sealing elements; dimensions

DIN 16962-5
Pipe fittings and joint assemblies for polypropylene (PP) pressure pipes - Part 5: General quality requirements and testing

DIN 16962-6
Pipe joints and elements for polypropylene (PP) pressure pipelines types 1 and 2; injection moulded elbows for socket-welding; dimensions

DIN 16962-7
Pipe joints and elements for polypropylene (PP) pressure pipelines types 1 and 2; injection moulded tee pieces for socket-welding; dimensions

DIN 16962-8
Pipe joints and elements for polypropylene (PP) pressure pipelines types 1 and 2; injection moulded sockets and caps for socket-welding; dimensions

DIN 16962-9
Pipe joint assemblies and fittings for types 1 and 2 polypropylene (PP) pressure pipes; injection moulded reducers and nipples for socket welding; dimensions

DIN 16962-10
Pipe joint assemblies and fittings for types 1 to 3 polypropylene (PP) pressure pipes; injection-moulded fittings for butt welding; dimensions

DIN 16962-12
Pipe fittings and joint assemblies for polypropylene (PP) pressure pipes - Part 12: Flange adapters, flanges, sealing rings for socket welding; dimensions

DIN 16963-4
Pipe joint assemblies and fittings for high-density polyethylene (PE-HD) pressure pipes; adaptors for fusion jointing flanges and sealing elements; dimensions

DIN 16963-5
Pipe fittings and joints and assemblies for PE 80 and PE 100 polyethylene pressure pipes - Part 5: General quality requirements and testing

DIN 16963-6
Pipe joint assemblies and fittings for high-density polyethylene (PE-HD) pressure pipes; injection-moulded fittings for butt welding; dimensions

DIN 16963-7
Pipe joint assemblies and fittings for high-density polyethylene (PE-HD) pressure pipes; fittings for resistance welding; dimensions

DIN 16963-8
Pipe joints and elements for high density polyethylene (HDPE) pressure pipelines types 1 and 2; injection moulded elbows for socket-welding; dimensions

DIN 16963-9
Pipe joints and elements for high density polyethylene (HDPE) pressure pipelines types 1 and 2; injection moulded tee pieces for socket-welding; dimensions

DIN 16963-10
Pipe joints and elements for high density polyethylene (HDPE) pressure pipelines types 1 and 2; injection moulded sockets and caps for socket-welding; dimensions

DIN 16963-11
Pipe fittings and joint assemblies for pressure pipes made from types PE 80 and PE 100 polyethylene - Part 11: Dimensions of bushings, flanges and sealing elements, for socket welding

DIN 16963-14
Pipe joint assemblies and fittings for types 1 and 2 high-density polyethylene (HDPE) pressure pipes; injection moulded reducers and nipples for socket welding; dimensions

DIN EN 476
General requirements for components used in drains and sewers

DIN EN 752
Drain and sewer systems outside buildings

DIN EN 805
Water supply - Requirements for systems and components outside buildings

DIN EN 1091
Vacuum sewerage systems outside buildings

DIN EN 1295-1
Structural design of buried pipelines under various conditions of loading - Part 1: General requirements

DIN EN 1555
Plastics piping systems for the supply of gaseous fuels - polyethylene (PE)

DIN EN 1610
Construction and testing of drains and sewers

DIN EN 1671
Pressure sewerage systems outside buildings

DIN EN 1778
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