

TECHNICAL CATALOGUE

PVC

PIPES AND FITTINGS



GENERAL NOTES

The technical catalog is subject to change in certain time intervals as a consequence of the adoption of new ones products and modifications thereof. For this reason, it is necessary to check if you have the latest version of the technical catalog. The technical catalog date is located on the cover page of the catalog and the latest version you can download from www.pestan.net or request it via mail office@pestan.net. Quick access to chapters is provided with the help pictograms.

Important information



Before you start installing Pestan PVC pipes and fittings for underground drainage and sewerage, be sure to read all references related to safety at work, all for your own security and safety of people around you. During the whole system installation the system keep this instruction with you. If some details from this technical catalog are not clear contact us at mail office@pestan.net

Safe recommendation



Legal note

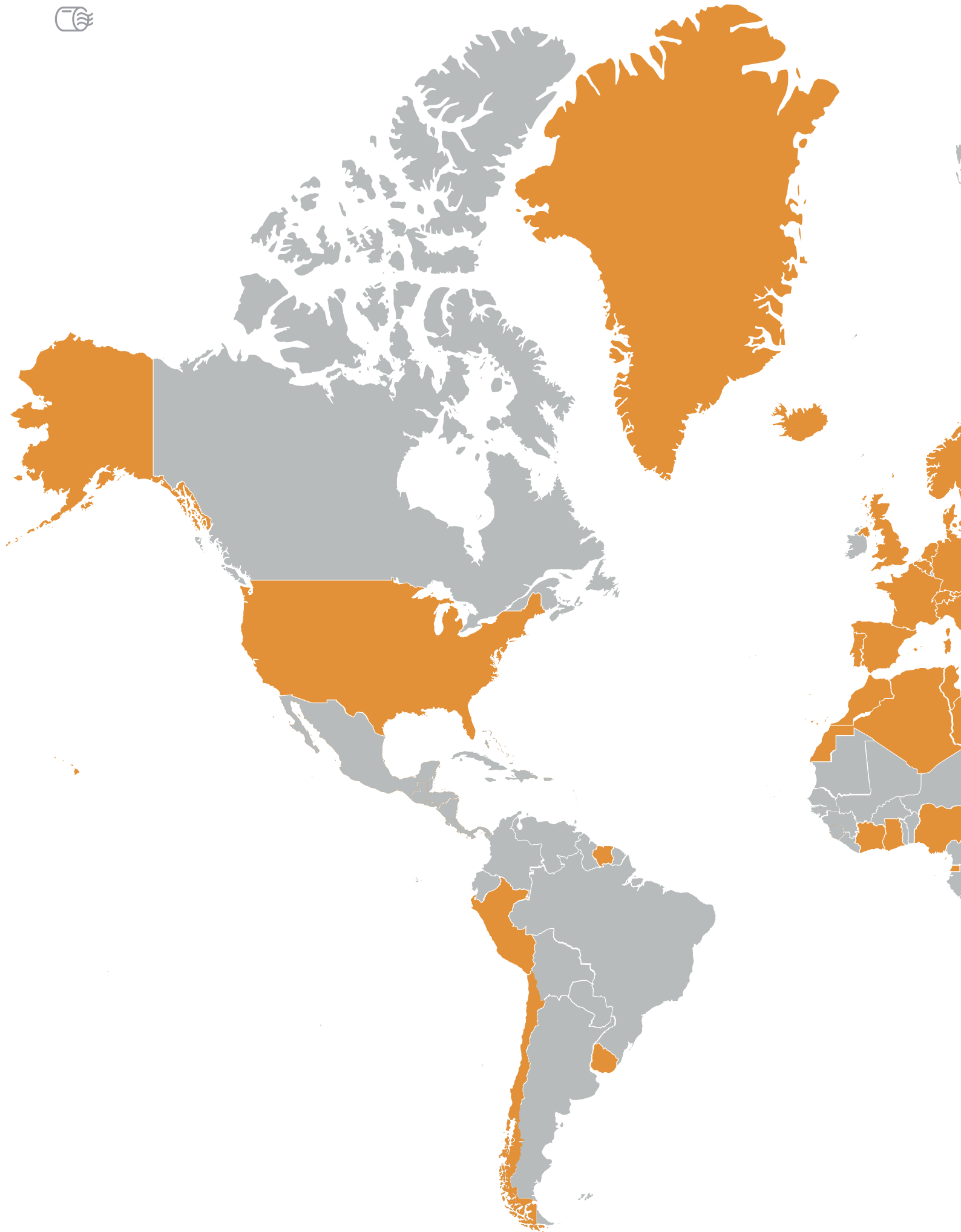


General safety recommendations:

- Consider the general safety rules for prevention of accidents when placing pipes and fittings
- Ensure sufficient light when installing pipes and fittings
- Keep your work area clean
- Keep away children, pets and unauthorized personnel from tools and places for placing pipes and fittings (this is specially important in case of renovation)

Measures during system installation:

- If you have jewelry or other items that is hanging, be sure to remove them before installing
- Cutting tools should be properly disposed of and to use with great care because they have sharp edges
- When cutting pipes, a safe distance should be maintained between the hand holding the tube and cutting tools, and never put your hands near the part where the tool cuts
- When you are servicing, maintaining, or changing the place assembly, always turn off the power on the tool.





ABOUT US

Private company Peštan is the leader in the Balkans in production of plastic pipes and fittings for water, sewage and gas. The company was founded in 1989 and produces water pipes made of polyethylene. Over time, she introduced new ones materials (polypropylene and PVC) and expanded the production program. Today more than 5000 products can be found from the pipe and fittings and PVC profiles, through luxurious and modern drains, to the tape for irrigation.

Production plants are located in Arandjelovac 70 kilometers south from Belgrade, and foreign representations in countries in the region are:

Bosnia and Herzegovina, Romania, Croatia as well as in Ukraine and UAE.

The company is present on the market of Europe, Russia, the Middle East, North Africa, Latin America and the United States Country. Export is oriented and sales are realized in over 70 countries of the world!

PEŠTAN established the organization and business of the Company and certified according to the requirements of the Integrated System management,

- quality management of ISO 9001 (since 2004)
- environmental management, ISO 14001 (since 2010)
- management of health and safety at work of OHSAS 18001 (since 2010)

PEŠTAN has certified its products according to the appropriate one normative regulations in the most eminent certification bodies: DVGW, MPA, SABS, BULGARKONTROLE, EBETAM, IGH, VUPS, VUSAPL, ICC, SKZ, EMI...

We are doing our best to satisfy the needs of our customers, the company continuously introduces innovations and improves cadres and equipment. Since 2009, SAP ERP has been introduced to the company with modules MM, SD, PP, Fi and CO, and since 2012 are functionality expanded and WMS. Introduction of WCM and WMS system increased efficiency, contributed to deployment cost and professional maintenance. Since 2015 in Sap is implemented and quality management module (QM).

Employees of the company Pestan, which has over 1000, are joint Efforts justify the slogan of the company: WE BUILD THRUST!

1 STANDARDS

STANDARDS APPLYING ON PEŠTAN PVC PIPES AND FITTINGS

EN 1401-1:2009- Plastics piping systems for non-pressure underground drainage and sewerage - Unplasticized poly(vinyl chloride) (PVC-U) - Part 1: Specifications for pipes, fittings and the system.

EN 13476-1:2007 Plastics piping systems for non-pressure underground drainage and sewerage - Structured-wall piping systems of unplasticized poly(vinyl chloride) (PVC-U), polypropylene (PP) and polyethylene (PE) - Part 1: General requirements and performance characteristics.

EN 13476-2:2007 Plastics piping systems for non-pressure underground drainage and sewerage - Structured-wall piping systems of unplasticized poly(vinyl chloride) (PVC-U), polypropylene (PP) and polyethylene (PE) - Part 2: Specifications for pipes and fittings with smooth internal and external surface and the system, Type A.

ISO 3126:2005 Plastics piping systems - Plastics components - Determination of dimensions

EN 744:1995 Plastics piping and ducting systems - Thermoplastics pipes - Test method for resistance to external blows by the round-the-clock method

EN 1411:1996 Plastics piping and ducting systems - Thermoplastics pipes - Determination of resistance to external blows by the staircase method

EN 12061:1999 Plastics piping systems - Thermoplastics fittings - Test method for impact resistance

EN 12256:1998 Plastics piping systems - Thermoplastics fittings - Test method for mechanical strength or flexibility of fabricated fittings

EN 727:1994 Plastics piping and ducting systems - Thermoplastics pipes and fittings - Determination of Vicat softening temperature (VST)

EN ISO 2505:2005 Thermoplastics pipes - Longitudinal reversion - Test method and parameters

EN 580:2003 Plastics piping systems - Unplasticized poly(vinyl chloride) (PVC-U) pipes - Test method for the resistance to dichloromethane at a specified temperature (DCMT)

ISO 580:2005 Plastics piping and ducting systems - Injection-moulded thermoplastics fittings - Methods for visually assessing the effects of heating

EN 1053:1995 Plastics piping systems - Thermoplastics piping systems for non-pressure applications - Test method for watertightness

EN 681-1:1996/A3:2005 Elastomeric seals - Material requirements for pipe joint seals used in water and drainage applications - Part 1: Vulcanized rubber

EN ISO 9969:2007 Thermoplastics pipes - Determination of ring stiffness (ISO 9969:2007)

EN ISO 13968:2008 Plastics piping and ducting systems - Thermoplastics pipes - Determination of ring flexibility (ISO 13968:2008)

EN ISO 1183-1:2012 Plastics - Methods for determining the density of non-cellular plastics - Part 1: Immersion method, liquid pycnometer method and titration method (ISO 1183-1:2012)

EN ISO 1167-1:2006 Thermoplastics pipes, fittings and assemblies for the conveyance of fluids - Determination of the resistance to internal pressure - Part 1: General method (ISO 1167-1:2006)

EN 1610:2015 Construction and testing of drains and sewers



2 INFORMATION

BASIC INFORMATION ABOUT PEŠTAN PVC PIPES AND FITTINGS

The Pestan PVC pipes and fittings program are made of PVC material (polyvinyl chloride) according to the latest extrusion and injection molding technology of pipes and fittings. Pestan PVC pipes for street sewer systems are made as three-layer (EN 13476) and compact (EN 1401) pipes. State-of-the-art pipe extrusion technology has elevated the underground drainage system outside buildings to a higher level. The possibility of recycling without loss of physical and mechanical properties make PVC material environmentally friendly.

Pipes and fittings within the PVC Pestan product range are intended for street sewer systems. The PVC pipe and fitting system is universal and can be used to remove all types of wastewater and stormwater in civil engineering systems.

Installation and manipulation of piping elements is very simple and is described in the following sections of this technical manual. Pipe fittings are connected via fittings, while the watertightness of the joint is ensured by rubber rings made of EPDM rubber. The inner layer of PVC sewage pipes has very low roughness, resulting in good hydraulic performance, high abrasion resistance as well as sediment retention and bacterial culture capture for the inner wall of the pipe.

PVC pipes are resistant to corrosion and have an estimated life of 50 years if used properly.

Pipes and fittings have excellent thermal stability and are resistant to:

- Short thermal loads up to 60 °C
- Continuous thermal load up to 40 °C

In terms of chemical resistance PVC pipes are resistant to: salt water, alcohol, acids, bases, sulfates, aggressive gases and all kinds of detergents. They are suitable for drainage of chemically aggressive waste, pH values from 2 (for very acidic wastewater) to 12 (for very basic wastewater).

The PVC program is sensitive to wastewater containing a high percentage of gasoline (petroleum), benzene or acetone. For detailed chemical resistance of the pipeline, see the chemical resistance table that is an integral part of this technical catalog.

Pipe and fitting joints are 100% leak-proof to a pressure of 0.5 bar (5m water column).

The pipes are intended for external use for a limited period of time due to their long-term UV

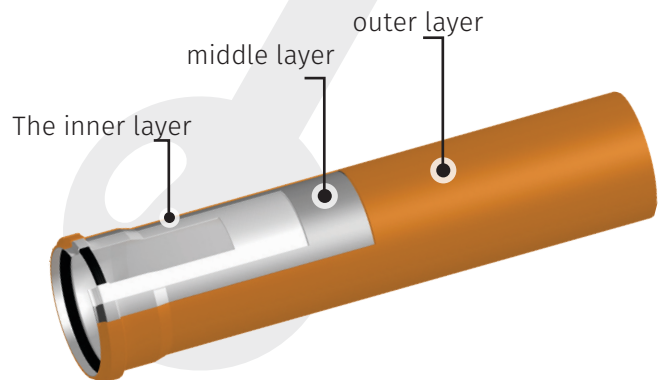
stability. Also the pipes are intended for installation underground. Does not install at temperatures below 5 °C.

The PVC pipe program belongs to the flammability class B2 of DIN 4102, or to the group of normally flammable materials.

Pestan PVC pipes can be compact or three-layer, each contributing to the desired product characteristics. Within Peštan PVC production program are:

- Three-way PVC pipes with diameters from DN 110 to DN 630
- Compact PVC pipes with diameters from DN 110 to DN 630
- Injected fittings with diameters from DN 110 to DN 400
- Welded fittings of larger diameter and not standard shape

When it comes to three-layered tubes, the center layer differs from the inside and the outside in structure and chemical composition.



Inner layer: Made of polyvinyl chloride, the smooth orange inner surface prevents the buildup of sediment and reduces abrasion on the tubes.

Middle layer: Made of expanded polyvinyl chloride and reinforced with mineral fillers, it gives the pipes strength and flexibility.

Outer layer: Made of polyvinyl chloride, orange, gives the tubes better impact resistance and greater safety when handling and installing the product.

Three-layer pipes are manufactured to EN 13476 while compact pipes are manufactured to EN 1401.



| Material | PVC (polyvinyl chloride) | PVC (polyvinyl chloride) |
|-------------------------------|--|--|
| Tube structure | Three-layer tube (outer smooth layer, inner smooth layer and foam layer of polyvinyl chloride) | One-layer PVC pipe |
| Density | Smooth layer = 1.42-1.48 g / cm ³ ; Foam layer = 0.8-1 g / cm ³ | 1,42-1,48 g/cm ³ |
| Temperature resistance | short-term up to 60 °C, long-term up to 40 °C | short-term up to 60 °C, long-term up to 40 °C |
| Linear elongation coefficient | 5x10-5 mm/mm °C | 5x10-5 mm/mm °C |
| Chemical resistance | pH 2-pH 12 | pH 2-pH 12 |
| Modulus of elasticity | 2,7-3,3 GPa | 2,7-3,3 GPa |
| Connection mode | Socket and rubber ring - leak-proof up to 0.5bar pressure | Socket and rubber ring - leak-proof up to 0.5bar pressure |
| Field of application | UD - buried inside the structure of the building and outside the structure of the building | UD - buried inside the structure of the building and outside the structure of the building |
| Fire classification | B2 normal flammability | B2 normal flammability |

Table 1: Basic properties of PVC materials

The main characteristics of PVC pipes are:

- Made of very light material with excellent mechanical properties,
- Simple and easy way of transport and handling,
- Fast and inexpensive mounting, by connecting couplings to pipe ends
- Resistant to corrosion in alkaline, acidic or aggressive environments,
- They are a good electrical insulator,
- Resistant to mechanical stress,
- Life span of 50 years,
- Without pipeline maintenance,
- EPDM rubber sealing rings according to (EN 681)

2.1 Marking of pipes



PESTAN DN/OD 315 SDR 34 SN8 UD PVC-U EN 1401-1:2009 www.pestan.net SRB 06:41 2019/01/31

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1. Barcode

2. Pestan logo

3. Diameter and SDR

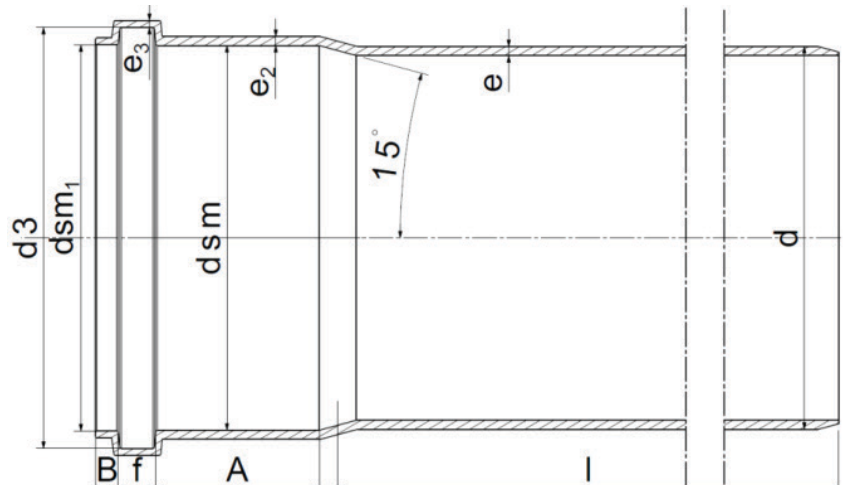
4. Ring strength

5. Material

6. Production standard

7. Peštan logo

8. Time and date of production



| EN 1401 (SDR 41) - SN4 | | | | | | | | | |
|------------------------|---|--------|--------|--------|--------|--------|--------|--------|--------|
| (mm) | DN 110 | DN 125 | DN 160 | DN 200 | DN 250 | DN 315 | DN 400 | DN 500 | DN 630 |
| Dem (mm) | 110 | 125 | 160 | 200 | 250 | 315 | 400 | 500 | 630 |
| e (mm) min | 3,2 | 3.2 | 4.0 | 4.9 | 6.2 | 7.7 | 9.8 | 12.3 | 15.4 |
| d3 (mm) min | 120.3 | 137.1 | 173.8 | 215.6 | 272.9 | 338.9 | 427.1 | 533.2 | 427.1 |
| B (mm) min | 6 | 7 | 9 | 12 | 18 | 20 | 24 | 28 | 24 |
| A (mm) min | 32 | 35 | 42 | 50 | 55 | 62 | 70 | 80 | 70 |
| L (mm) | 250, 500, 1000, 2000, 3000, 4000 i 6000 | | | | | | | | |

| EN 1401 (SDR 34) - SN8 | | | | | | | | | |
|------------------------|---|--------|--------|--------|--------|--------|--------|--------|--------|
| (mm) | DN 110 | DN 125 | DN 160 | DN 200 | DN 250 | DN 315 | DN 400 | DN 500 | DN 630 |
| Dem (mm) | 110 | 125 | 160 | 200 | 250 | 315 | 400 | 500 | 630 |
| e (mm) min | 3,2 | 3.7 | 4.7 | 5.9 | 7.3 | 9.2 | 11.7 | 14.6 | 18.4 |
| d3 (mm) min | 120.3 | 137.1 | 173.8 | 215.6 | 272.9 | 338.9 | 427.1 | 533.2 | 427.1 |
| B (mm) min | 6 | 7 | 9 | 12 | 18 | 20 | 24 | 28 | 24 |
| A (mm) min | 32 | 35 | 42 | 50 | 55 | 62 | 70 | 80 | 70 |
| L (mm) | 250, 500, 1000, 2000, 3000, 4000 i 6000 | | | | | | | | |

Table 2: Strength classes tube in relation to the SDR

2.2 Marking of fittings:



Each fitting has a barcode label.

See the detailed PVC product list for more details.

1. Logo
2. Nominal diameter and degree of obliquity
3. Fitting class
4. Material designation
5. Date

Each fitting has a barcode label. Depend on For details see a detailed list of PVC products.

- Made of very lightweight material with excellent mechanical properties
- Simple and easy way to transport and handle.

• Fast and inexpensive mounting, by connecting the couplings to the pipe end

- Resistant to corrosion in alkaline, acidic or aggressive environments,
- They are a good electrical insulator,
- Resistant to mechanical stress,

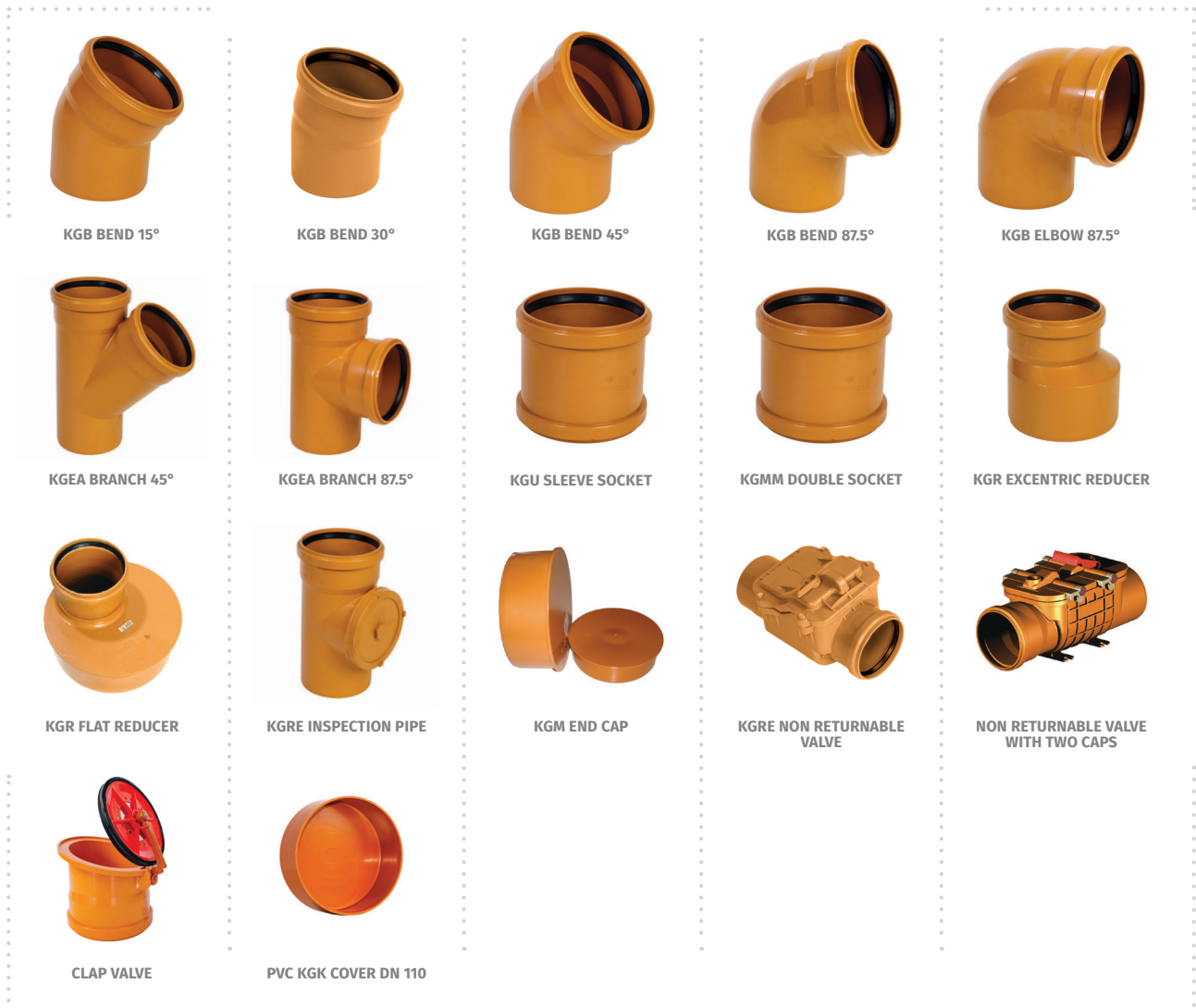
• Lifetime longer than 50 years

- Practically no costs of pipeline maintenance,
- Sealing rings are made of EPDM rubber according to (EN 681)

2.3 Production program

Within the Peštan PVC production program there is a complete program of fittings (both injection molded and welded - hand made) made in all diameters and all strengths:

- elbows at 15 °, 30 °, 45 °, 67.5 ° and 87.5 ° from diameters $\phi 110$ to $\phi 630$
- Single branch at 45 ° from diameter $\phi 110$ to $\phi 630$
- PVC FF double socket fitting $\phi 110$
- Double couplings, sliding couplings, reducers, revisions, etc.





3 PACKAGING

PACKAGING, TRANSPORT AND STORAGE

3.1 Packing of pipes and fittings

Peštan PVC pipes and fittings are packaged in transport packages (unit and pallet) in a way favorable to customers. The way packaging provides the customer with safety when storing as well as easy handling with the same.

3.1.1 Pipe packing

Standard PVC pipe packages are on pallets and in packages. Pipes of all diameters in lengths of 0.25 and 0.50 meters are packed in cardboard packaging, which in a certain number, thus packed and packed on a pallet, represent a transport packaging. A EURO pallet measuring 800 x 1200 mm is used as the basis for transport packaging.



Figure 1: Layout of the box (box)



Figure 2: Layout of the transport packaging (pallet)

Pipes in lengths of 1m inclusive with tubes of 6 meters are packed in packages which, depending on the diameters and lengths, contain a certain number of pieces in the unit package as well as in the whole packages. Each package contains a certain number of unit packs, which are packed on a certain number of wooden beams, represent the ultimate transport packaging ready for further distribution to the final customer.



Figure No.3: Layout of a packaged two-frame package



Figure No.4: Layout of a packaged three-frame package

3.1.2 Fittings packaging

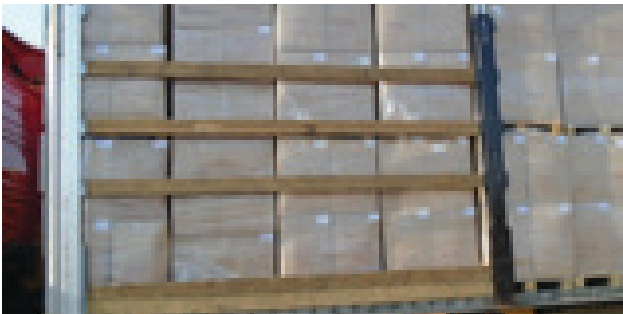
Standard packs of fittings are in cartons of certain dimensions, which represent unit packs, and which in a number form the transport packaging. Transport packages are formed on EURO pallets in dimensions 800 x 1200 mm and maximum height 1400 mm.

NOTE: For accurate information about packaging dimensions, number of pieces on unit and transport Packages contact Peštan on mail office@pestan.net

3.2 Transport and manipulation

Peštan PVC pipes and all fittings should be transported with appropriate transport vehicles. The loading area of the transport vehicle must be clean, flat, without sharp jaws and without any waste, (both on the floor of the vehicle and on all sides of the inner part of the transport vehicle).

Sizes of pallets are such that they fill int the loading space to the maximum. When it comes to the loading of the pallets, the packaging is defined so that two pallets can be placed on each other int he height of 2.9 m..



Picture No.5: Loading transport packaging

When loading transport packages of tubes, which are packed in packages, depending on the diameter of the pipes, the packages are packed in height in two or more levels. The number of levels depends on the height of the packaged package, so pipes with diameters: $\varnothing 110$, $\varnothing 125$, $\varnothing 160$ are packed in three levels, pipes with $\varnothing 200$, $\varnothing 250$, $\varnothing 315$ and $\varnothing 500$ in two levels, $\varnothing 400$ in six levels and pipes with $\varnothing 630$

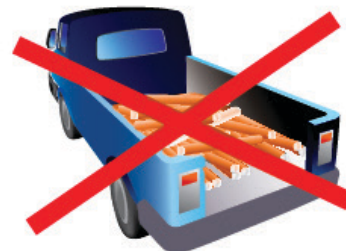
in four levels. The PVC tubes that are packed on pallets, where the unit pack is a box, are packed in two levels in height. The height of the loading area must be at least 2.9 meters.



Picture 6: Transport packaging (bulk)

When it comes to loading pipes outside the transport package (bulk), pipes must by all their length rely on a flat surface so as not to come to deformation of the same. This is what primarily needs to be taken care of because incorrect handling can lead to damaging the pipe. Take care of it, because it can handle incorrect handling get bending at their ends.

During loading and unloading, the pipes must be handled carefully. They should not be thrown, hit, dragged, push, especially for concrete and other rough ones surfaces.



Picture 7: Layout of properly and irregularly assembled pipes during transport



3.3 Storage

Peřtan PVC pipes and fittings that are packed in cardboard boxes are stored exclusively indoors (preferably shelf, one pallet-one pallet place).



Picture no. 17: The appearance of shelf storage

If there is no regal warehouse it is recommended that this packages be stored in closed space on flat surface in one level. When there is no transport packaging, and the goods arrived to final buyer as units then units should be placed on a single sturdy and dry pallet. Boxes (units) should be placed on one another aligned by the edges. Boxes must not be outside the pallet.

For storage of transport packages of pipes and joints elements, the warehouse needs to meet certain conditions.

3.3.1 Recommended storage conditions

Transport packaging stored dry, clean and closed space, with temperatures should be stored between 10 and 30 °C, and relative humidity between 50 and 60%. Packages should be protected from direct the influence of sunlight, moisture and heat, and especially They should be protected from high temperature oscillations as this can lead to the occurrence of condensation and loss of functional properties of transport packaging (cardboard boxes).

Pestán PVC pipes from 1 meter to 6 meters in length can be stored indoors and outdoors. When stored outdoors, the pipes must be protected from direct sunlight by a UV stable foil or canopy. It is recommended that these transport packages also be stored indoors or in a shaded area.

No matter where it is stored, whether indoors or outdoors, PVC pipe packages should not be stacked at more than the prescribed level:

- Pipes of all diameters 0.25 in length - one level

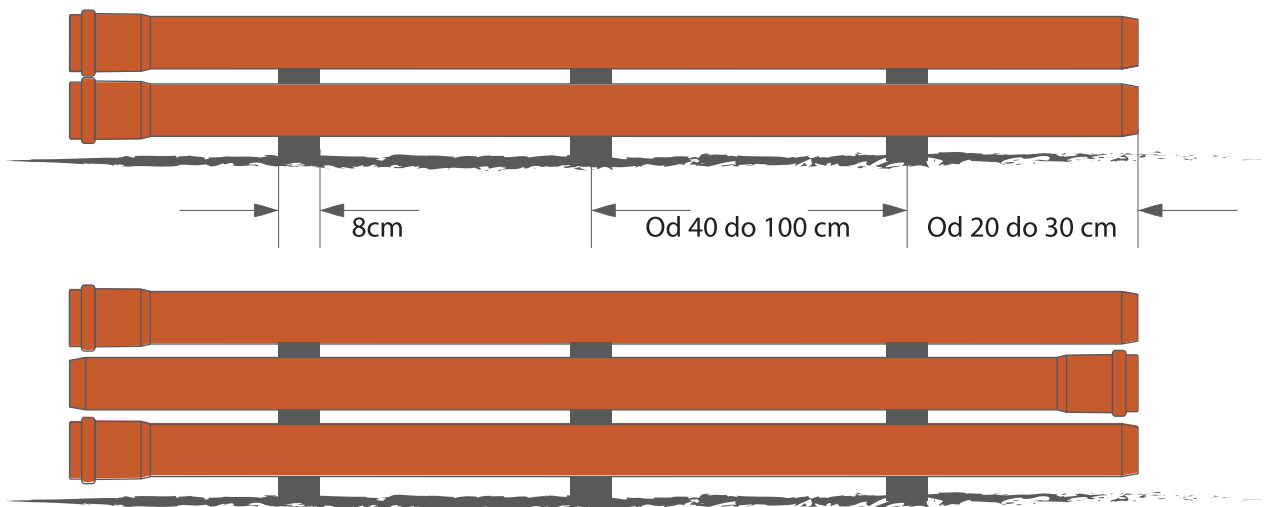
- Pipes with diameter $\phi 110$, $\phi 125$, $\phi 160$ length 0.5 meters - two levels
- Pipes with diameter $\phi 110$, $\phi 125$, $\phi 160$ length 1, 2, 3, 4, 5, 6 meters - four levels
- Pipes with a diameter of $\phi 200$ 1 meter long - four levels
- Pipes with diameter $\phi 200$ of length 2, 3, 4, 5, 6 meters - three levels
- Pipes with diameter $\phi 250$, $\phi 315$, $\phi 500$, $\phi 630$ lengths 1, 2, 3, 4, 5, 6 meters - three levels
- Pipes $\phi 400$ in diameter 1, 2, 3, 4, 5, 6 meters - six level



Picture No.9: PVC pipes

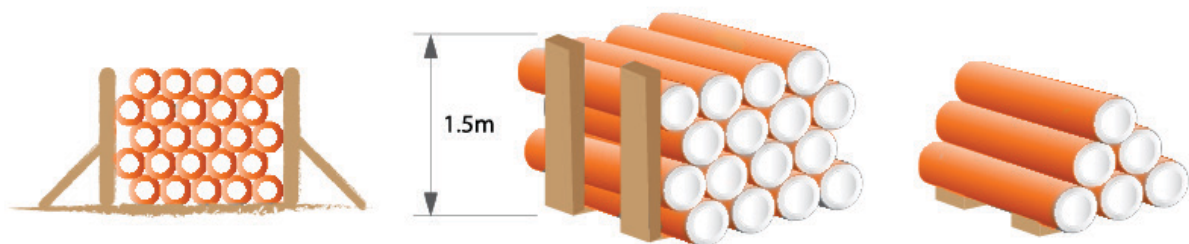
Also, when storing pipes, they must not be stored near heated surfaces and care should be taken not to come into contact with fuels, solvents, etc. In the case of loose tubes (pieces or unit packs), the following should be observed:

- Pipes should be stored on a flat surface
- Place wooden beams under the pipe so that the joints (sockets) at the ends of the pipe do not rest on the substrate and thus deform
- Do not drop, pull or push pipes on uneven surfaces when stacking
- Pay attention to the way the pipes are stacked (rotate the pipes alternately so that the joints at the ends are free and therefore do not deform)
- Ensure that a packed pile of pipes does not scatter to the sides
- The height of the crimped pipes must not exceed 1.5 meters
- Store the tubes indoors and, if no storage conditions exist, the tubes should be stored in a shaded area or covered with a UV stable protective film.



Picture No. 10: Properly placed PVC pipes on wooden beams

The wooden base for the underlay of the pipe must not be less than 8 cm thick and not less than 5 cm thick. The axial distance between the billets depending on the diameter and length of the pipe varies from 400 to 1000 mm, while the pipe clearance also depends on the diameter and length of the pipe also from 200 to 500 mm.



Picture No.11: PVC STRONG pipes properly secured to the wooden beams



4 INSTALLING

INSTALLING AND CONNECTING



Peštan PVC pipes and fittings are installed in accordance with EN 1601 Street gravity drainage system sewage system.



If there is a specific regulation within certain countries that deviates from the mentioned standard, it is obligatory to consult Pestan technical support before installing the system itself.

4.1 Pipeline types

The main task of sewage is to discharge (transport) contaminated wastewater from settlements, that is, industry to wastewater treatment plants. This requirement is the basis of the sanitary-hygiene principles and is fulfilled by the hydraulic transport of wastewater. It can be realized in a number of ways, ie sewer systems. Under the sewage system we mean ways of evacuation of different types of wastewater (faecal or sanitary, industrial and atmospheric wastewater). The appropriate sewage system for an inhabited place is selected depending on the local conditions, sanitary requirements and technical and economic indicators. Depending on the method of sewage collection and evacuation, the following sewage systems are distinguished: general (common), separation (separate) and mixed (combined) sewage systems.

4.1.1 General system

The general system is one in which all three types of used water (faecal, industrial and atmospheric) are drained by a single sewer network. Basic quantitative load of general

sewage systems cause atmospheric water, therefore, for general sewage systems, the functional dimensions of the ducts result from the required uptake of atmospheric water. A very important feature of such a sewage system is the large fluctuation of the flow (during rain, atmospheric and used water flow through the channels, while only used water flows through the channels).

4.1.2 Separation system

A sewage separation system is called such a sewage system, where atmospheric and clean industrial waters are drained by a single sewer network, and sewage and used industrial water drained by another duct system. The sewage separation system may be complete and incomplete.

A complete separation system is called the system where both networks of channels are constructed (in the form of buried closed channels).

The incomplete separation system is applied in smaller settlements, where atmospheric water is drained by rigs (open channels), while complete sewage with closed channels is built for the used water.

4.1.3 Mixed system or combined system

A mixed system or combined sewer system is called a sewerage system where in one settlement there are both general and separation sewerage systems (eg separation in newly built parts of settlements and general in existing parts of settlements).

4.2 Substrate characteristics

The first step in designing sewer systems is geotechnical exploration work along the entire pipeline route. Preliminary field and laboratory tests are required to obtain the necessary soil parameters such as soil type and its structure, granulometric composition, volume and groundwater level.

The most important condition for achieving satisfactory installation of pipe systems is the interaction of the pipe and the surrounding soil. The highest support for the installed pipe is given by the soil around the lower half of the pipe in both directions. That's why it's extraordinary important on what type of soil is laid and how the soil is compacted in the area around the pipe.

In general, there are two ways of laying pipes:

1. Laying on natural - unprepared soil;
2. Laying on a base layer (bedding) of special material that is compacted to the required level;
3. In view of the above, in any installation of pipe systems the designer is obliged to determine the conditions for laying the pipes, such as:
 4. Soil properties and suitability of local soil application for bedding;
 5. Geotechnical properties of soil for the bedding, side and overhead embankment, as well as the way of their installation;
 6. Proper pipe strength class.

4.3 Trench Excavation

Regarding the minimum required trench width (according to measurements and depth of laying), the regulations for laying waste water pipes (EN 1610) must be observed. It should take into consideration that too narrow channel adversely affects the required installation (settlement / compression area water), a too wide channel increases the cost of both result in an increase in system load.

4.3.1 The width of the trench

The width of the trench should allow for the proper laying and compaction of the fill material. The minimum width between the pipe and the slope of the trench is $b_{min} = 30$ cm. The minimum width of the trench (B) in the crown of the pipe is:

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

The width of the trench should allow for the proper laying and compaction of the fill material. The minimum width between the pipe and the slope of the trench is $b_{min} = 30$ cm. The minimum width of the trench (B) in the crown of the pipe is:

$$B = 1 \geq 4 \times DN$$

In general, these conditions apply to pipes with a diameter of $DN > 250$, since for pipes of a smaller diameter, the trench width (B) satisfies these conditions.

You can see the minimum recommended trench widths in the table below.

| DN | $d \leq 1.00m$ | $1.00m \leq d \leq 4.00m$ | $d \geq 4.00m$ |
|-----|----------------|---------------------------|----------------|
| 160 | 0.60 | 0.80 | 1.00 |
| 200 | 0.70 | 0.80 | 1.00 |
| 250 | 0.75 | 0.85 | 1.00 |
| 315 | 0.80 | 0.90 | 1.00 |
| 400 | 0.90 | 1.00 | 1.10 |
| 500 | 1.00 | 1.10 | 1.20 |
| 630 | 1.15 | 1.25 | 1.35 |

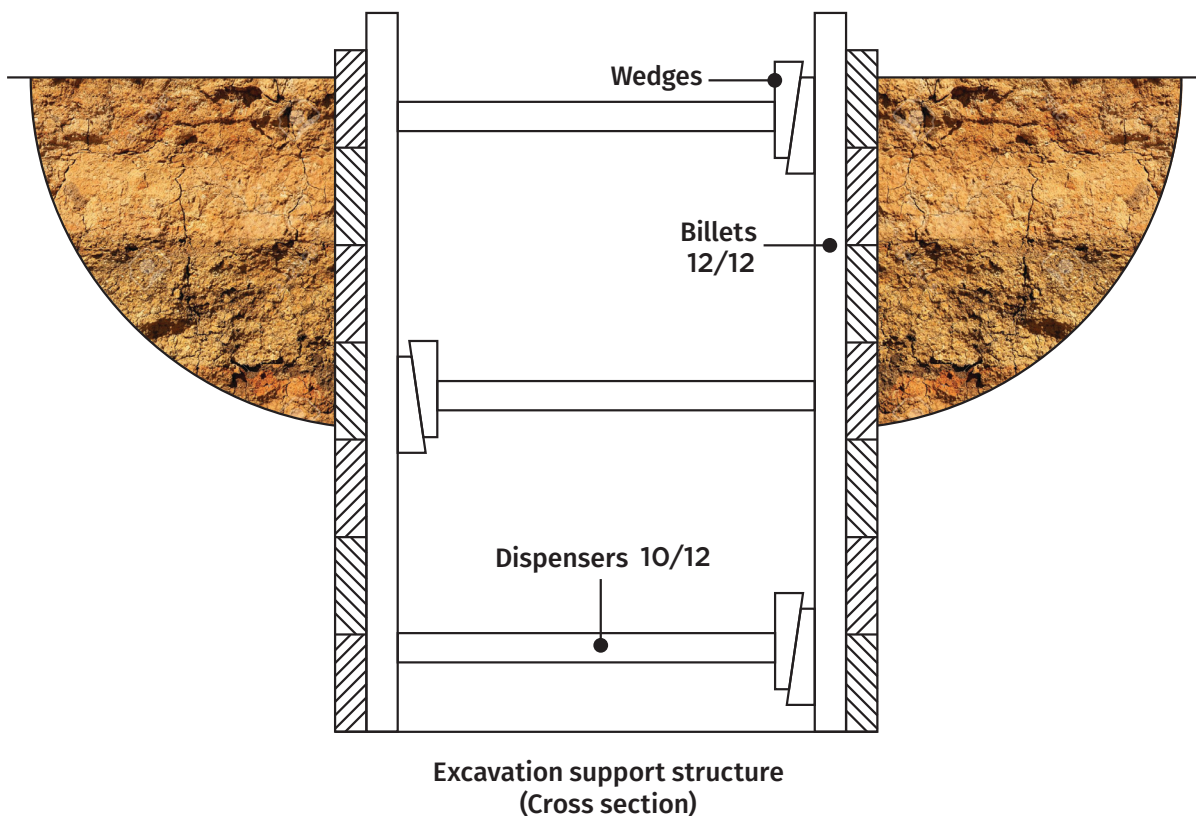
Table 3: Recommended trench widths



4.3.2 Excavation Protection and Support

Excavation of the earth up to 100 cm deep can be carried out without excavation of the trench, if the strength of the earth itself allows. Excavation of soil in depths greater than 100 cm may only be carried out with gradual securing of the sides of the excavation. Shoring of the excavation sides is not necessary if the sides are done by angle (natural slope of the terrain), or when digging up to a depth of more than 200 cm.

The trenches and ducts must be constructed to a width that permits the undisturbed work of breaking the sides and the work of the workers in them. The minimum width of trenches and the depth of the channel is determined to 100 cm freely. At a depth of more than 100 cm, the width of the trench or channel must be such that the clear width of the trench, after completion, is at least 60 cm. Example pictures below:



Picture 12: Example of excavation subgrade

If more pipes are placed in the trench or channel then the distance between the pipes should be 15 cm. Wood and other materials used to break up the sides of trenches and ducts must, by their strength and dimensions, fit the purpose for which they are intended, in accordance with the applicable technical regulations. that is, standards. The excavation of trenches and canals must be appropriate to the geophysical characteristics, distraction and pressure of the soil in which the excavation is carried out, as well as to the appropriate static calculation. The excavated material from the trenches and canals must be discarded at such a distance from the edge of the excavation that there is no possibility of plunging that material into the excavation. The spacing between the individual formwork elements (excavation side) must be determined in such a

way as to prevent the soil from falling apart, in accordance with soil characteristics.

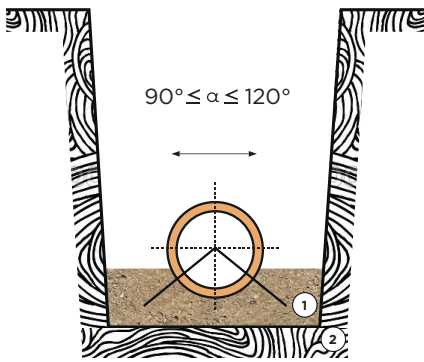
The formwork for supporting the sides of the excavation (trench, canal, pit) must extend at least 20 cm above the edge of the excavation to prevent material from falling off the ground into the excavation.

When ejecting the earth from the excavation, gutters laid on special supports must be used from a depth of more than 200 cm. The entrances shall not be burdened with an amount of excavated material larger than the specified one, which the worker must be familiar with before starting work, and must have an edge protection of at least 20 cm high.

4.4 Placing (laying) pipes in the trench

4.4.1 Laying on natural soil

In some cases it is possible to lay pipes on the bottom of the trench, but only in incoherent dry soils that do not contain larger rocks (> 20 mm), such as gravel, coarse sand, fine sand and sandy clay. In such soil, the pipe is laid directly on a thin (10-15 cm) unbound leveling layer. The purpose of the leveling layer is to raise the bottom of the trench to the required angle and to provide the required fall, and to ensure a stable, uniform bearing of the pipe at an angle of 90° (Picture 1).



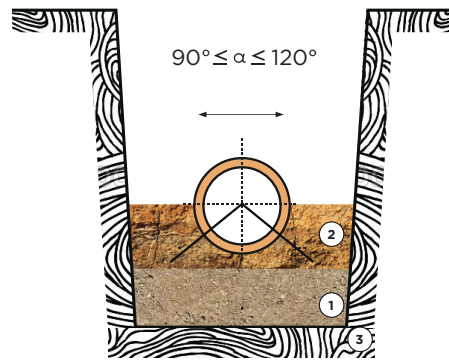
Picture 13: Laying pipes on natural soil

1. The bottom of the trench
2. Unbroken leveling layer

4.4.2 Installation with sand bedding

Installation with sand bedding need to be use in case of:

1. When in favorable natural conditions the trench is mistakenly deeper than the depth of the designed for the installation of tubes;
2. For rocky, cohesive (clay) and muddy soils
3. Poorly bearing soils, such as organic mud and peat; and in all other cases where provided for by the project. Examples of cases from points 1 and 2 are shown in Picture 2.



Picture 14: Example of installation in a well-supporting soil

1. The base layer
2. Flattening layer
3. The bottom of the trench

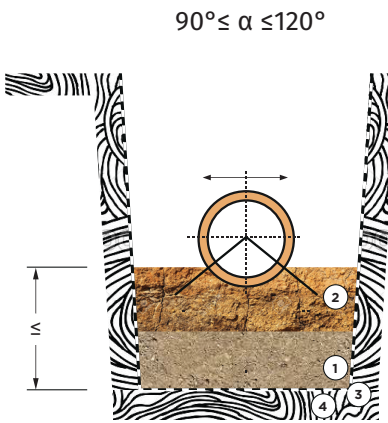


When laying the pipeline on two layers of sand and gravel material with a maximum grain size of 20 mm, it should:

- The base layer is made of well compacted material 25 cm thick (minimum 15 cm).
- and a leveling layer 10 to 15 cm thick, unbroken.

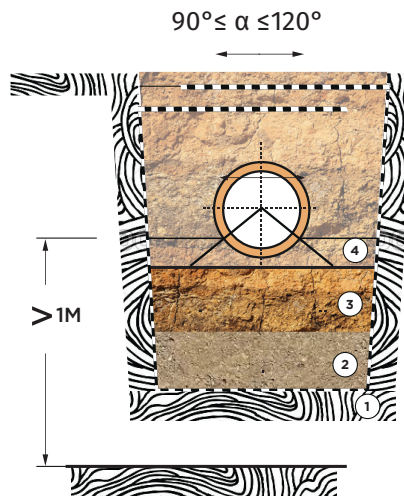
In poorly bearing soils, depending on the thickness of the poorly bearing layer, below the projected pipeline level, two solutions are possible:

1. Where the thickness of the weakly bearing layer is $< 10\text{m}$ (Figure 3). In this case, the poor bearing soil is excavated and the trench is filled with a well-compacted mixture of broken rock and sand (10: 3 ratio), and the base layer is laid on geotextile.
2. Where the thickness of the weakly bearing layer is $> 10\text{m}$ (Figure 4). In this case, a base layer of 25 cm well compacted mixture of crushed stone and sand is made (1: 3 ratio). Geotextile placement is preferred.



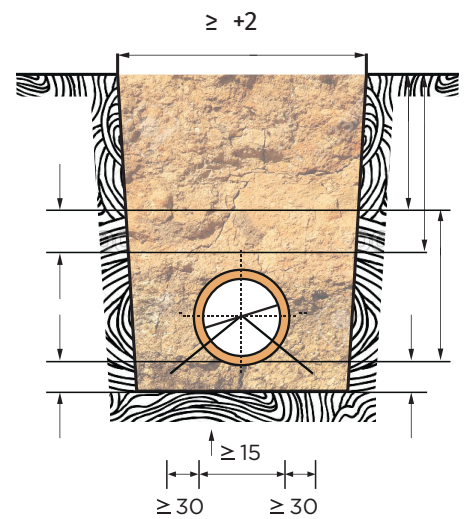
Picture 15: Example of laying on bad bearing soil thickness $\leq 10\text{ m}$

1. Leveling layer
2. Geotextiles
3. A well-compacted base layer
4. The bottom of the trench



Picture 16: Example of laying on poorly bearing soil with thickness $> 10\text{m}$

1. The bottom of the trench
2. Broken stone
3. Gravel
4. Sand



Picture 17: Cross section of the trench

With proper foundation and leveling, the class and installation density of the material for lateral and over-backfill are equally important for achieving proper pipe fitting. The criterion according to which the selected material suitable for lateral and over-ground backfill is based on achieving the required soil strength after compaction. Suitable materials

include broad-graded, naturally-grained materials, with a maximum grain size not exceeding 10% of the nominal pipe diameter or 60 mm, where the smaller value is applicable (table). Backfill material must not contain snow, ice or icy clumps of soil.

| Material | Particle diameter [mm] | Note |
|------------------------|---------------------------------|---|
| Gravel, breaking stone | 8 - 22, 4 - 16 8 - 12, 4 - 8 | the most suitable material, maximum 5 to 20% of 2 mm particles |
| Gravel | 2 - 20 | suitable material, not more than 5 to 20% of particles of 0.2 mm |
| Sand, tiny gravel | 0.2 - 20 | partially suitable material, not more than 5% of particles of 0.02 mm |

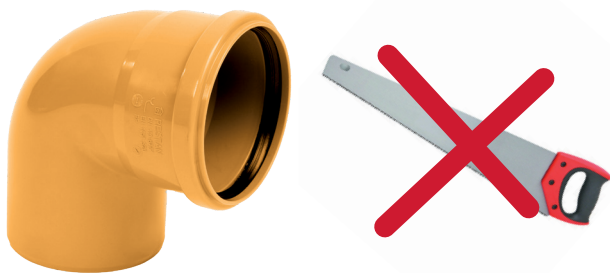
Tabela br 4: Svojstva materijala zatrpavanja

4.5 Connection of PVC

Connection of PVC sewage elements is interconnected via couplings with rubber gaskets, which provide waterproof element connection. All pipes and fittings have a socket on at least one end. Pipes that do not have sockets can be connected via double sockets or sliding couplings. Pipes can be cut either with a special pipe cutter or with a hand saw with fine teeth and using a guide as shown in the picture below.



Bonding of pipes with conventional adhesives it is not possible and should not be applied.



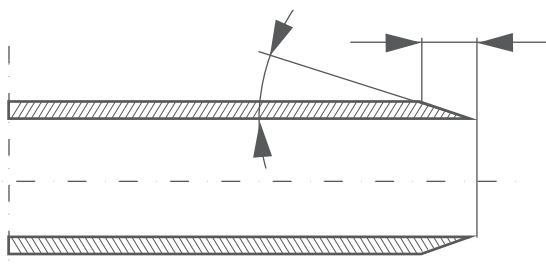
The fitting must not be shortened.

Use all protective measures when cutting

Pipe cutting must be done directly on the pipe axis and the cut end of the pipe must be cleaned and trimmed. Make the bevel of the cut end of the pipe fine sandpaper or fine file. There are special cutting tools, which during the cutting form the end of the pipe and make an inclination at the very end of the pipe. The table below shows the required bevel dimensions of the pipe ends.



Picture 18: Cutting pipes



Processing the end of the tube at an angle of 15°

Picture 19: Depiction of required slanting

| DN | 110 | 125 | 160 | 200 | 250 | 315 | 400 | 500 | 630 |
|--------|-----|-----|-----|------|-----|-----|------|------|------|
| S (mm) | 3,2 | 3,2 | 4 | 4,9 | 6,2 | 7,7 | 9,8 | 12,3 | 15,4 |
| b (mm) | 12 | 12 | 15 | 18,5 | 23 | 29 | 36,5 | 46 | 57,5 |

Table No 5: Table of required slanting

After preparing the cut pipe or joining the factory pieces without cutting, the following should be done:

1. Clean the socket and the straight end of the pipe. Clean with a dry cloth or cloth dampened with water



2. After cleaning the pipe, check the condition of the sealing elements.



3. After cleaning and checking the condition of the sealing element, it is necessary to lubricate the flat end of the tube. It is recommended to use Peřtan lubricants for this purpose. Petroleum based lubricants should not be used. The sleeve and the sealing rubber band must be dry and clean. They should also be lubricated



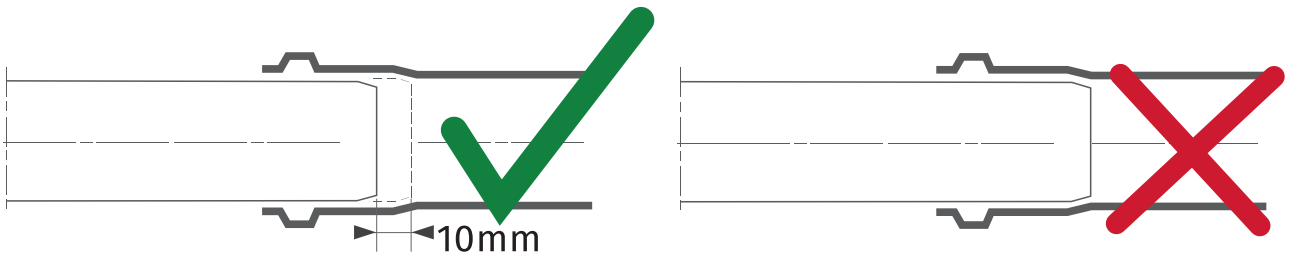


4. After the lubricant has been applied to the straight end of the pipe, insert it completely into the socket. It is recommended that the insertion depth of the pipe into the sleeve be marked so

that the straight end of the pipe (10-15 mm) can be drawn more accurately. In this way, the pipes are left to elongate or to collect during thermal expansion



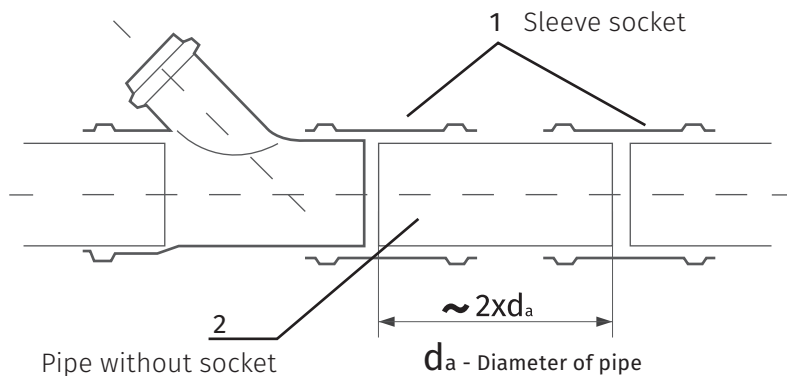
display of properly inserted pipe in the socket:



4.6 Connection of pipes and fittings

When installing the pipeline, pipe cutting occurs, resulting in the appearance of debris from the pipes that do not have a socket on them (pipe smooth on both sides). The picture below shows the method of joining the pipeline with sliding couplings and pipes without sockets. In this case,

the pipe without sockets installed between the two couplings must have a length of at least twice the nominal diameter. For example, if the diameter is 160 mm, the minimum length of pipe without sleeve must be 320 mm.



Picture 20: Coupling of pipes without sleeve with sliding coupling

When connecting pipes and fittings, follow all the steps as well as for connecting pipes:

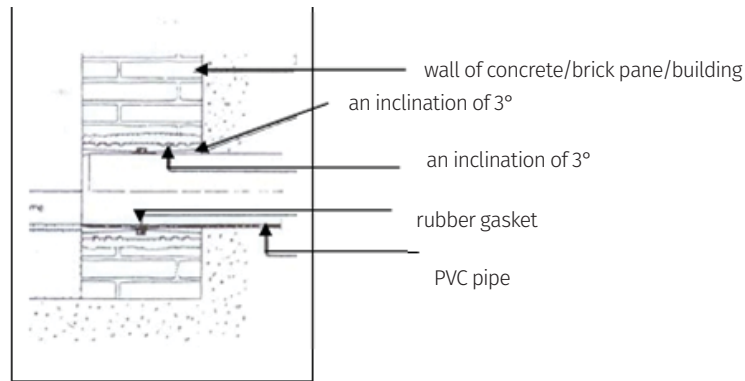
1. Clean fitting sleeve and straight end of pipe. Clean with a dry cloth or cloth dampened with water.
2. After cleaning the pipes and fittings, check the condition of the sealing elements
3. After cleaning and checking the condition of the sealing elements, it is necessary to lubricate

the straight end of the pipe and the fittings themselves. It is recommended to use Peřtan lubricants for this purpose. Petroleum based lubricants should not be used. The sleeve and the sealing rubber band must be dry and clean. They must also be lubricated.

4.6.1 Connecting with shafts and buildings

A special KGF conductor made of PVC, of various dimensions, is used to connect pipes to shafts windows or buildings. The sealing between KGF and

the pipe is done with a rubber gasket, which comes with a conductor.



Picture 21: Connecting pipes to the building shaft

NOTE: In certain cases, ie larger diameters than DN 125, a lever is necessary for connection. When using a lever, the wooden insert should be placed horizontally in the middle of the sleeve or the pipe itself so that it does not become damaged. When

using a hammer to connect the pipe, take care not to damage the pipe and sleeve when winding the chain around the pipe and attaching the hammer to the pipe sleeve itself.

4.6.2 Installing KGF Coupler

1. When concreting an element on the site through which the KGF piece is to be placed, a sufficiently large opening in the formwork must be left at the penetration through the element when sliding through which the KGF piece can be placed and could be co-concreted element concretes.
2. In the case of a prefabricated element, leave a sufficiently large opening through which the KGF piece can be fitted.
3. When installing the KGF piece, make sure that the KGF piece is positioned in the correct direction

4. After that, concreting KGF pieces in the shaft, taking care that the eraser and the inside of KGF pieces do not become soiled with concrete.
5. After the concreting process, remove the formwork of the concrete element and seamlessly connect the pipes to the concrete element through the mounted KGF piece.



Picture 22: KGF coupling

4.6.3 Steep bottom sections

When laying pipes and fittings on steep sections, due to the action of longitudinal force, precautions should be taken bedding, pipe shear, and joint spacing, which is usually achieved in practice by making concrete support blocks. In doing so, the socket must be turned upstream (ie in the counter) in order for the pipes to naturally fill. The number

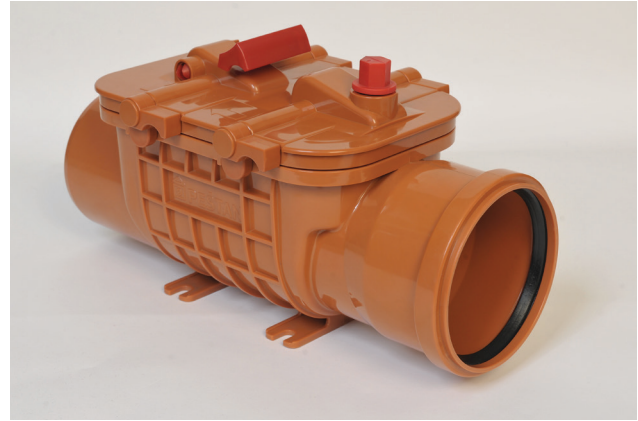
and construction of the supporting blocks depends on the longitudinal fall of the pipeline as well as in the nominal diameter of the pipe. In case of more pronounced falls, support blocks should be placed behind each socket (about every 5m). Any water retained on the slope behind the abutment block should be drained to eliminate flushing.



4.7 Installation of a flood prevention device - non-returnable valve

Non-returnable valves are installed in pipelines where there is a possibility of return of water from the street sewer to the facilities due to elevation of water in the sewer system as well as preventing the entry of rodents and other animals through the

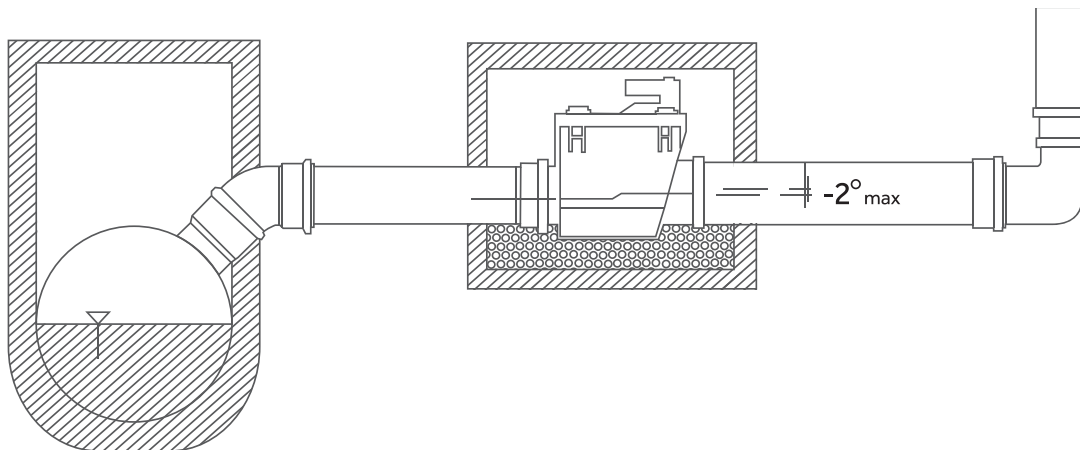
sewer pipes. Non-return valves are equipped with automatic valves to close the water flow and are in the opposite direction to the intended water flow, and are manufactured in dimensions from $\varnothing 110$ to $\varnothing 315$.



Picture 23: Non-return valves with one and two valves

Basic principle of installation:

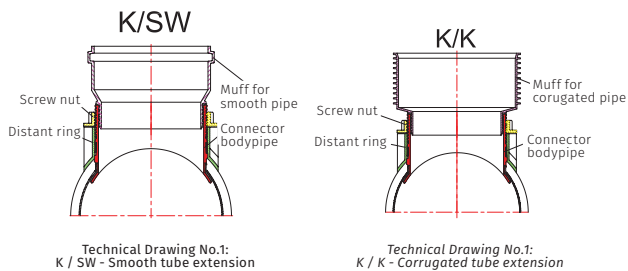
- Non-return valves are easily integrated into smaller manholes available to clean the device itself.
- Do not use sharp objects when cleaning edges.
- The maximum allowable drop when installing a non-return valve is 2%. The following diagram shows the installation diagram of a non-return valve.



Picture 24: Non-return valve installation diagram

4.8 SAG – Saddle after grip

SAG saddle after grip is intended for subsequent connection to the existing pipeline, and in combination with PP STRONG pipes gives quick and easy solution. The joint is safe and watertight, enabled by a specially tapered EPDM eraser on the inside of the SAG.



4.9 Pipeline testing

Testing of piping connections for leakage using measuring tubes or similar test fixtures. Testing is carried out on sections of the pipeline that is not yet covered. To prevent position reversal, the piping may be partially buried, pipe joints should remain uncovered. All piping sections of the pipe under test, including all divisions, are sealed tight and relieved of any pressure. Pipes and fittings are tightened so that the position of the piping does not change during the test, which will ensure the tightness of the joints.

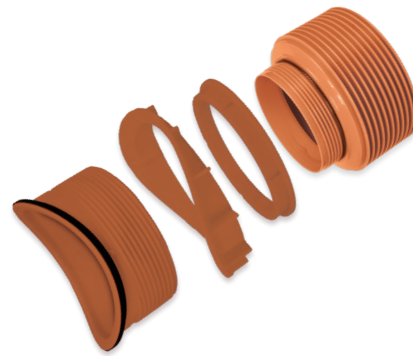
External sewerage testing can be divided into three sections:

- technical inspection,
- Watertight test
- Gas tightness test

The pipeline is tested after assembly and connection of the feed elements and is tested in segments. The segments are isolated through the inspection openings. It should be borne in mind that the highest pressure occurs at the lowest point of the pipeline segment being tested and that there is a maximum permissible pressure of 0.5 bar. It is the obligation of each contractor to make a record of the pipeline test and under these conditions the guarantee given by the Pestan company applies.

Pipeline testing can be tested in two ways:

- Water and
- By air



Picture 25: SAG - Saddle after grip

1. WATER TESTING

Filling with water is carried out in such a way that no air is retained inside the pipe. The pipe is usually filled slowly from the lowest point of the section, so that the air from the pipe exits at the end of the section, through a sufficiently large opening left for this purpose. The test is performed only one hour after filling, so that the remaining air has time to gradually exit the pipeline.

Pressure reading is performed at the lowest point of the measuring section. Gravity tubes are tested by a pressure of 0.5 bar overpressure, measured above the lowest wet point of the section of tube being tested.

The test duration is 30 minutes, in accordance with SRPS EN 1610. If necessary, more water can be added continuously, and then again measured.

2. AIR TESTING

Pipeline testing by the method of pumping air inside the pipeline is significantly faster and more efficient than water testing. The pipeline is filled so that both ends of the pipeline are closed by test balloons, one of which is a passing balloon with a manometer through which air is pumped inside the pipeline.

Pumping is performed up to a pressure of 0.2 bar, followed by a change in pressure. The test takes 5 minutes, in accordance with SRPS EN 1610. If necessary, the air inside the pipeline can be pumped up and then stabilized and re-measured again. When testing pipelines with this method, special attention must be paid to the pipeline getting heavier difficult (securing) before testing begins.



4.10 Backfilling and Compaction

Filling (30 cm above the top of the tube) follows in layers. Up to 1 m of cover can be used lighter and

medium compaction devices. Heavy machinery can be used only afterwards.

4.10.1 Compaction level

4.10.1 Compaction level

The required degree of compaction depends on load conditions.

- For traffic areas min. compactness of the the soil in the pipe zone is 90% as modified according to Proctor's density experiment.
- Outside traffic areas, required level of compaction fullness is:
 - 85% according to Proctor's test if thickness of the top layer is > 4.0 m;
 - 90% according to Proctor's test if it's thickness of top layer is <4.0 m.

If compaction is required by modified Proctor of 85%, then:

- Compaction in layers of 0.2 m thickness using vibrating machines (weighing 50-100 kg) with compaction with both tube sides;

- Further made in layers of 0.15 m thickness using vibrating machines (weighing 50-100 kg), it is recommended that the minimum height in this way of the compacted layer be 0.30 m Wheelbase;
- Then it is further made in layers 0.20m thickness using a vibrating machine (weighing 100-200 kg), it is recommended that the minimum height of this tight layer 0.40 m;
- The final layer of 0.10 m thick should be pressed by feet.

The fill of material must be compacted in layers thickness from 10 to 30 cm. Required thickness of overtop backfill is:

- Minimum 15 cm for pipes with diameter $D_n > 400$;
- Minimum 30 cm for pipes with diameter $D_n < 400$.

4.10.2 Material compacting

Compacting degree materials depending on conditions loads and exploits need to be presented in the project documentation. Compaction is possible execute in different ways. It is possible to achieve varying degrees of compaction depending

on the equipment, thickness of the layers and compressibility of the material. In Table 2. Compaction values for gravel and sand materials are given.

COMPACTING METHODS

| Equipment | Weight (kg) | Max thickness (m) | | Minimum thickness overhead backfill (m) | Number of passes for getting tightness | |
|-------------------|-------------|-------------------|--------------|---|--|-------------------------|
| | | Gravel, Sand | Clay, sludge | | 85% Proctors experiment | 90% Proctors experiment |
| Tread | - | 0.1 | - | - | 1 | 3 |
| Manually ramming | min. 15 | 0.15 | 0.10 | 0.30 | 1 | 3 |
| Vibrating rammer | 50 - 100 | 0.30 | 0.20 - 0.25 | 0.50 | 1 | 3 |
| Vibrating board** | 50 - 100 | 0.20 | - | 0.50 | 1 | 4 |
| Vibrating board | 50 - 100 | | - | 0.50 | 1 | 4 |
| | 100 - 200 | | - | 0.40 | 1 | 4 |
| | 400 - 600 | | 0.20 | 0.80 | 1 | 4 |

* before compaction

** in case of bilateral compression relative to the tube

Table No.6: Compaction Methods

4.10.3 Main backfill

Material can be used for the main backfill from the excavation if it is fit to achieve the required compaction and if its maximum grain is less than 300 mm. For pipes with diameters DN <400 and with overburden 15 cm thick, material the main backfill

must not contain size grains larger than 60 mm. For traffic areas required is a minimum backbone compaction of 90% according to a modified Proctor density test.

4.11 Pipe Installation in Concrete

Pestans PVC pipes are made of unmixed PVC and can be laid directly in concrete if longitudinal dilation is considered. While watering in concrete tubes should be well secured so to avoid pipeline displacement during installation as not to pipeline

displacement occurred during installation concrete. Pipe connections should also be provided protective tape to prevent cement from penetrating to the sealing elements.

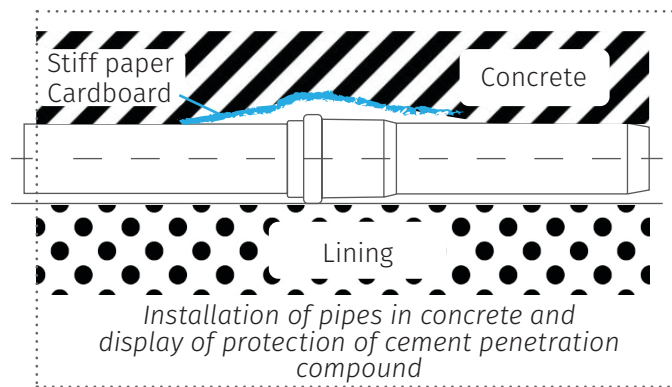


Figure 26: Installation of pipes in concrete

If the height of the groundwater relative to the pipe is such that with low filling of the pipe with waste water buoyancy may impair its stability, or it is a considerable amount of external loads, mostly then pipe cladding need to be carried out with concrete. In the first case because of weight gain, and in the other for weight increase resistance to external

load. Thickness above the crown of the concrete arose from the static calculation for active load (rarely below 30 cm). When crossing from pipes with concrete lining the pipe laid in the ground should be installed short tube 0.5 m to form a joint connection.



5 USING THE PIPELINE

5.1. Hydraulic calculation of PVC (polyvinyl chloride) pipes for street sewage system

Pestans PVC program is designed for street systems sewers, and is primarily intended for removal all types of wastewater in civil engineering systems. Because of the scope of these systems, as part of this chapters will explain ways of sizing for drainage of used water.

The drainage channel calculation consists of two parts:

- Empirical
- Hydraulic

The empirical part is about pipe sizing horizontal pipeline branches and collection of used water from sewage sites, ie connecting lines.

This part of the calculation is done empirically because of frequency of a large number of factors that on capacity the connection line is affected by: flow variability wastewater, flow rate variability, naturalness, diversity (filling points), variability in the number of persons, various lengths of time system usage and the presence of air and gases in the network. The hydraulic part is related to the calculation gravity sewer system and selection gravity flow parameters in pipelines, at their partial fulfillment. The goal of hydraulic calculation of a sewer system is a choice the most economical pipe diameter for the appropriate flow. There are several reasons for this: plugging in households street sewer connections, speed changes streams in channels...

5.1.1. Introduction

For evacuation of excess water from the territory of the settlement sewer or sewer systems are being built. Every modern and tidy settlement owns its own sewer network which the water used is carried to the plant for purification before discharge into the recipients (water receivers). Surplus waters in the territory settlements are considered used water from households, institutions and industry, then water which fall in the form of an atmospheric precipitate settlements, and in some cases so-called "other people's" water which reach the sewers via poor quality pipe joints or through inspection shafts. Wastewater means a mixture different waters, where each component has its own composition, that is, changed the original chemical composition and physical properties. Depending on the origin and characteristics, waste waters are divided into four categories:

- Household water used (fecal or sanitary wastewater)
- Industrial water used
- Atmospheric waters
- Municipal wastewater

The objects and appliances they collect used water from the place where they are created and taken to the place for purification or discharge into a recipient called sewage system or sewage system. The sewage system consists of the following group of objects:

- Sewer or sewer network, respectively secondary (secondary) and main (primary) a collector network used to water collected and discharged to the treatment plant
- Sewage network buildings (pumping stations, audit shafts, home connections, etc.) to which enables proper functioning, management and network maintenance
- Wastewater treatment plant, by which the water used is purified to degree that is in accordance with the prescribed standards
- Discharges that are purified (or unpurified) used water is discharged into the water receiver (recipient)

5.1.2. Variant solutions for wastewater drainage from settlements

Modern construction practice in construction takes several basic variants of sewage solutions and methods of wastewater drainage settlements. There are basically three variants of the code sewage disposal from a particular populated place, as follows:

1. Free-flow wastewater treatment in sewage collectors, as well as pumping applications gravity station sewer system
2. Sewage disposal with periodic by flowing under pressure (the pressure in the pipeline is higher of atmospheric), with a large number of pumping stations and long thrust conduits-sewage under by pressing
3. Sewage disposal with periodic flow, creating a vacuum (pressure in the pipeline is smaller than atmospheric), using vacuum pumping cell-vacuum sewer Gravity sewer system with flow with Free water mirror is the most common a way to evacuate used water from inhabited environment in contemporary construction practice and has widespread use in our midst, due to a number of advantages in in relation to the vacuum system and the pressure system.

The main feature of this method of evacuation of waste water is that the flow is the free flow in the pipelines with water mirror, allowing it to flow freely in the pipeline and odor removal. In the pipeline is required provide such flow that it is not enabled precipitation of suspended solids in the water used, and this is achieved by selection of such slope (fall) of the pipeline it provides the occurrence of self-cleaning speed in sewers pipelines. With gravity sewers easy and simple control is provided and collector maintenance and are set up for this purpose inspection shafts or shafts, approximately every 50 m (in dependencies on pipeline diameter). In the event of a crash on the gravity sewer, fast is enabled detection and response to the elimination of the observed accident, and gravity sewer also allows direct connection of each home connection after building a basic sewer network in the street.

5.1.3. Hydraulic calculation of free flow sewage network - gravity the system

When hydraulic calculation is being done “PEŠTAN” sewage pipes were adopted to be used water flows through the sewer network with a free water mirror and at the same time channels only partially filled with used water. There are several reasons for this: it is the simplest resolved connection of home connections to the street sewage; changes in flow velocity in channels caused by flow changes are much smaller than would be the case with pressure flow; by flowing fresh air over the waste water a variety of gases are provided which can be extracted from the wastewater while at the same time water aeration is done. On the benefits of the gravity system sewage system and its use and functioning there were words in Chapter 3. Hydraulic calculation gravity sewer system implies selection of gravity flow parameters in pipelines, at their partial fulfillment. Aim for hydraulic calculation of a sewer of the system is to choose the most economical pipe diameter for proper flow, to which it is dimensioned pipeline (sewer system is dimensioned to the maximum hourly flow of water used which was discussed in Chapter 4). It is in nature wastewater flow with free water the mirror takes place in the sewer network in conditions

turbulent-transient and non-stationary modes. The unsteady or unstable regime is a consequence character of the functioning of the sewer network in the observed cross-section of a channel or collector, where over time the water depth and velocity varies, respectively flow. However, the practical calculation of hydraulic parameters (flow and flow rates used water) partially filled sewage networks in Free-flow flow conditions are enforced assuming turbulent-transient, stationary and uniform flow regime by individual sections of the network. These assumptions on the basis for the sewer network budget in free flow conditions are as follows:

1. Depth of water used (h), flow surface cross sections (F) and flow velocity (v) are constant in all cross sections observed sewage sections over a period of time moment
2. Drop in energy line (IE), drop in waterline mirrors (IOs) and tube bottom drop (ID) are equal — Figure 2.



These simplifications that are introduced don't create great errors as consequences by the opportunity sewage network hydraulic calculation. You can say that designing a sewer system is not just a result of a theoretical knowledge, already far more experience. The calculation applies a whole series of guidelines, which were created as

a result of practical long-standing experiences as well as simplifications of theoretical knowledge. The guidelines are just a good starting point for designing, or making project decisions and solutions, which should always be tailored to local ones characteristics and experiences.

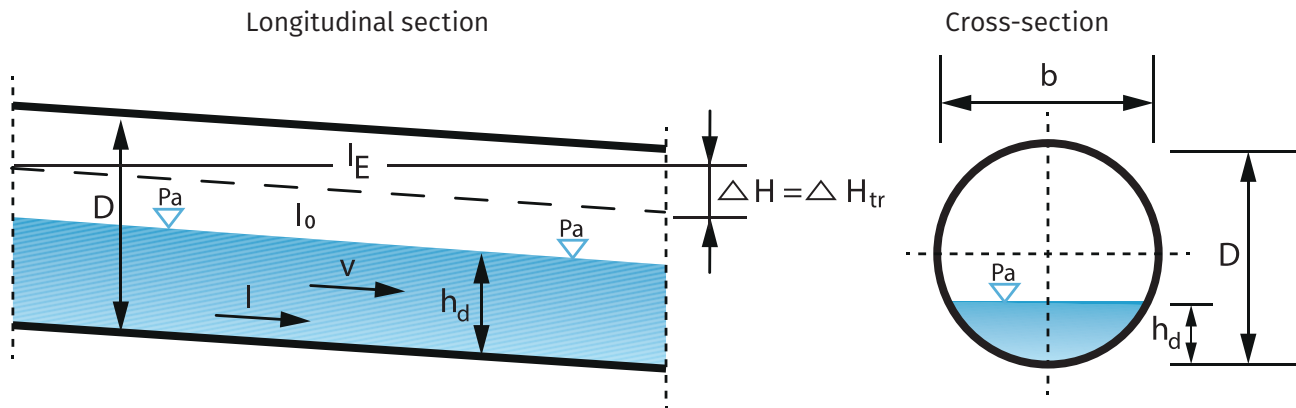


Figure 26: Uniform flow pattern in a partially filled round sewer

For hydraulic calculation of PVC sewage systems pipes of the PEŠTAN Arandelovac factory with free water mirror flow (gravity flow) and for a water with temperature of 10 °C, tables are presented in which they are shown results of hydraulic calculation (waste flows full profile water and flow rates waste water for full profile). Also, a table with water flow rates and velocities flow in PVC sewage pipes at partial profile completions, because this table serves to the designer executed the actual fulfillment budget waste water profiles (in cm or mm) as well as calculation of actual effluent flow rate in pipelines. Values of wastewater flow rates in PVC sewer pipes (for a fully filled profile and uniform flow) are obtained on the basis of Prandtl-Colebrook's formulas, because they turned out to be the results obtained by applying this equation are closer of reality, since it flows in a sewer network enters turbulent-transition mode:

$$v = -2 \log \left(\frac{2.51 \gamma}{d \sqrt{2g \cdot I \cdot d}} + \frac{k}{3.71d} \right) \cdot \sqrt{2g \cdot I \cdot d} \quad (1)$$

wherein:

- v - mean velocity of wastewater flow in the pipeline (m/s)
- Pipeline Bottom I-Drop (Power Line Drop) (‰)
- γ - kinematic viscosity coefficient (m²/s)
- k - absolute (drive) pipe wall roughness (mm)
- g - acceleration of Earth's gravity; g = 9.81 m/s²
- d - pipe inner diameter (m)

The preceding term for the rate of effluent flow at full profile (Form No. 1) was obtained at based on the Darcy-Weisbach equation for calculation falling energy lines due to friction along the length of the

pipe (ie to calculate friction energy losses along the pipe):

$$(2) \quad I = I_0 = I_E = \frac{\Delta H}{L} = \frac{[\Delta H]_{tr}}{L} = \lambda / D \cdot v^2 / 2g \quad (2)$$

$$\Delta H_{tr} = \lambda \cdot \frac{L}{d} \cdot \frac{v^2}{2g}$$

where are they:

- v - mean velocity of wastewater flow in the pipeline (m/s)
- L - length of pipe (m)
- ΔH_{tr} - hydraulic friction losses (m)
- d - pipe inner diameter (m)
- g - acceleration of Earth's gravity; g = 9.81 m/s²
- λ - coefficient of friction resistance

The coefficient of friction resistance λ , over which from the form No.2 we get a drop in the energy line due to friction in the pipe, it is calculated via Prandtl-Colebrook's formula, which encompasses a turbulent transition regime and asymptotically satisfies the turbulent rough and turbulent smooth mode:

$$\frac{1}{\sqrt{\lambda}} = -2 \cdot \log \cdot \left(\frac{k}{3.71 \cdot d} + \frac{2.51}{\text{Re} \cdot \sqrt{\lambda}} \right) \quad (3)$$

As noted above, the flow is waste water in the sewer network is getting turbulent transient flow regime, so the friction coefficient is λ function of both the Reynolds number and the inside diameter pipe and the absolute (drive) roughness of the pipe wall, which can also be observed from Form No.3.

In form number 3 we can notice that the coefficient friction resistance, among other things, depends on value Reynolds number:

- $Re = \frac{v \cdot d}{\gamma}$ (4)

where they are:

v - mean velocity of wastewater flow in the pipeline (m/s)
d - pipe inner diameter (m)
γ - kinematic viscosity coefficient for water (m²/s).

So by combining Form No.3 for computation coefficient of friction resistance, Form No.4 for computation values of Reynolds number and form no.2 for calculating the fall of the energy line (by uniform flow that occurs in sewage collectors the drop in the energy line equals the drop in the water level mirrors and fall of the bottom of the pipeline) a form is obtained No.1 for calculating the flow rate of wastewater at fully filled sewer pipe. Flow rate of wastewater in PVC sewage pipes (at full profile) are obtained using the continuity equation:

$$Q = v F \quad (5)$$

$$F = d^2 \pi / 4 \quad (6)$$

wherein:

v - mean velocity of water flow in pipes (m / s)
F - pipe cross-sectional area or flow-through area (m²)
Q - flow rate of water (l/s)
d - pipe inner diameter (m)

The final expression form for the flow rate is waste water in sewage pipes at full profile, is obtained when in Form No.5, the flow velocity waste water replaced by Form No.1 and surface the cross-section of the pipe F is replaced by the form No.6:

- $Q = -\log \left(\frac{2.51 \cdot \gamma}{d \cdot \sqrt{2 \cdot g \cdot I \cdot d}} + \frac{k}{3.71 \cdot d} \right) \frac{d^2 \cdot \pi}{2} \sqrt{2 \cdot g \cdot I \cdot d}$ (7)

In the above forms we see that the value of the coefficient of friction resistance, and therefore team and value of wastewater flow rate i value of wastewater flow at full profile depend on the

driving roughness of the pipe wall. Namely, in practice, the initial roughness was shown to be pipe wall, made by a sewer pipe manufacturer analyzes and determines laboratory on new ones tubes completely inadequate for hydraulic budget, because it ignores the assembly character sewage networks and all its power plants properties. The assembly character of the sewer network covers all local energy losses that are occur on a single pipeline (forks, knees, arches) etc.) and it also covers the existence of auditing shafts (manholes) on the sewer network and pipe joints. Under drive characteristics one sewer system goes without saying altered wastewater quality relative to potable, containing suspended in its composition matter, coarse particles, sand, various others inorganic and organic matter, which are deposited in tubes and alter its factory roughness. Of course, to this deposition of suspended matter in sewage collectors come after a certain exploitation period and use of sewage system networks, but this exploitation period must to consider, because to the designer the essential behavior is and proper functioning of the network in working conditions. To meet the designers, to be covered a specific exploitation period of use sewer networks and to get it right functioning of the sewage network in the workrooms in the circumstances, the term propulsion (real roughness). Because of all this, real (drive, absolute) roughness of sewer pipes is much higher than the factory declared value, established by laboratory tests. However, how the required profile dimensions and functioning designed sewage networks are directly dependent from the magnitude of the assumed roughness of the pipe wall (less roughness causes higher throughput channels), there is an aspiration for designers to chooses as little roughness as possible. Therefore, it is recommended to the designers, since the actual roughness is very difficult to determine, for the size of the driving roughness select the middle values obtained on the basis of tests, measurements and tests carried out experiences so far. For the size of the drive wall roughness of PVC sewer pipes (k) 'PESTAN' recommends selection in accordance with ATV-A-110E, 10 Standards for the Hydraulic Dimensioning and the Performance Verification of Sewers and Drains (Table 2):



| Scope | Drive roughness k (mm) |
|---|---------------------------|
| Channels with connectors and special panes; complex profile channels and channels complex profile built on site (masonry, concrete); channels from non-standard pipes | 1,50 |
| Channels with shafts, turns and connections (up to DN 1000); channels special panes (for all DN's). | 0.75 |
| Straight sections of canals with windows | 0.50 |
| Flat sections of canals without shafts; pressure sections; siphons | 0.25 |

Table 6: Roughness values according to ATV-A-110E, 10.

Except for these values of the coefficients absolute of the roughness of the pipe wall given in the table above, hydraulic calculation of the factory PVC pipelines 'PEŠTAN' was executed for three other selected values absolute roughness coefficient: $k = 0,125$ mm; $k = 1.0$ mm and $k = 1.25$ mm, which are often represented in domestic and foreign literature and which are often used for hydraulic sewer calculation PVC piping. So for each of these seven values of the coefficient of absolute wall roughness pipes individually, 'PEŠTAN' was created by a spreadsheet hydraulic calculation of PVC sewer pipes (wastewater flows for full profile are calculated and effluent flow rates for full profile). So, designers were given the opportunity to select the most favorable absolute value pipe wall roughness, using standard ATV-A-110E, 10, and also using personal experience and data from literature, and were also given the opportunity to perform a

hydraulic calculation for multiple values absolute roughness of the pipe wall and yes afterwards make a comparison of the results obtained and those adopted diameter and choose a more affordable and cost-effective variant. The value of the kinematic viscosity coefficient is $\gamma = 1.31 \cdot 10^{-6}$ m²/s, for a water temperature of 10 °C. As for the selected values of the bottom drop pipelines, they range from 0.1 ‰ to 50 ‰ and for these selected values the bottom of the pipeline falls wastewater flow rate in full sewer profiles as well as flow rate in full profiles were calculated. It is also important to emphasize that local losses in sewage collectors do not enter in calculation because they are included in the drive roughness. This recommendation does not apply to individual supporting facilities on the sewer network (siphons, drains, etc.) and suppresses pipelines at pumping stations when all local losses must be taken individually.

5.1.4. Minimum falls of the pipeline bottom

When laying "PEŠTAN" sewer pipes special attention should be paid to longitudinal decline pipes especially to the minimum. Since it is flowing in sewage collectors gravitationally and that in the used (waste) water is certain amount of sediment drawn (suspended particles), the minimum longitudinal fall represents that slope of the pipe which, in the gravitational flow of the water used, provides the energy needed to pull the coating that is, preventing the precipitation of suspended ones particles in pipelines. Minimum longitudinal fall represents the technical-economic category. By applying larger longitudinal falls it is secured greater traction or greater certainty that it will not settle to suspended matter but at the same time, in lowland settlements in particular, significantly increase the cost of sewer construction. There are very extensive theoretical considerations from

which resulted in various sizes recommended minimum longitudinal falls. Since it is done on the techno-economic category, each of these recommendation can be attacked or defended. Minimal longitudinal falls can be obtained by using certain empirical patterns, and the pattern that most commonly used in domestic and foreign engineering practice is:

$$\bullet I_{\min} = 1/d$$

In this pattern, size d represents the intrinsic diameter of sewer pipe in (mm), and I_{\min} represents the minimum longitudinal slope of the pipe. If apply this form to 'PEŠTAN' sewer PVC pipes will be given the following values of minimum longitudinal pipeline falls (which are date tabulated):

| DN | Class of pipes | d (mm) | Imin (‰) |
|-----|----------------|--------|----------|
| 110 | SN4,SN8 | 103,6 | 9.65 |
| 125 | SN4 | 118,6 | 8.43 |
| 125 | SN8 | 117,6 | 8.50 |
| 160 | SN2 | 153,6 | 6.51 |
| 160 | SN4 | 152 | 6.58 |
| 160 | SN8 | 150,6 | 6.64 |
| 200 | SN2 | 192,2 | 5.20 |
| 200 | SN4 | 190,2 | 5.26 |
| 200 | SN8 | 188,2 | 5.31 |
| 250 | SN2 | 240,2 | 4.16 |
| 250 | SN4 | 237,6 | 4.21 |
| 250 | SN8 | 235,4 | 4.25 |
| 315 | SN2 | 302,6 | 3.30 |
| 315 | SN4 | 299,6 | 3.34 |
| 315 | SN8 | 296,6 | 3.37 |
| 400 | SN2 | 384,2 | 2.60 |
| 400 | SN4 | 380,4 | 2.63 |
| 400 | SN8 | 376,6 | 2.66 |
| 500 | SN2 | 480,4 | 2.08 |
| 500 | SN4 | 475,4 | 2.10 |
| 500 | SN8 | 470,8 | 2.12 |

Table No.7: Table of required min falls depending on the diameter and class of pipe



It should be emphasized that the values of the nominal and inside diameter of PVC sewer pipes as well as a class of pipes are taken from Tables No.1-7, and on the basis thereof the inner diameter of the PVC pipes it produces 'PESTAN' calculated minimum longitudinal falls pipeline according to the above form. Long falls and velocities of wastewater flow in the pipeline are linearly dependent magnitudes. Therefore, when talking about minimum and maximum speeds, we are talking about both minimum and maximum drops. The velocity in the pipeline is due to the longitudinal slope of pipes, so design is simplified with knowledge of the limitations of longitudinal falls. The drops are in

function of the shape and size of the profile, as in function of the roughness of the pipe material. Apply the budget form above of minimum longitudinal falls represents very a sharp criterion for the calculation of minimum longitudinal pipeline crashes and thus makes it difficult to achieve values of minimum longitudinal falls they need to satisfy sewer collectors. Thus, for determining minimum pipe crashes of PVC, the following diagram may be applied, on which it is depicted dependence of minimum longitudinal fall pipes as a function of transverse profile-internal diameter PVC pipes (in the case of round profiles):

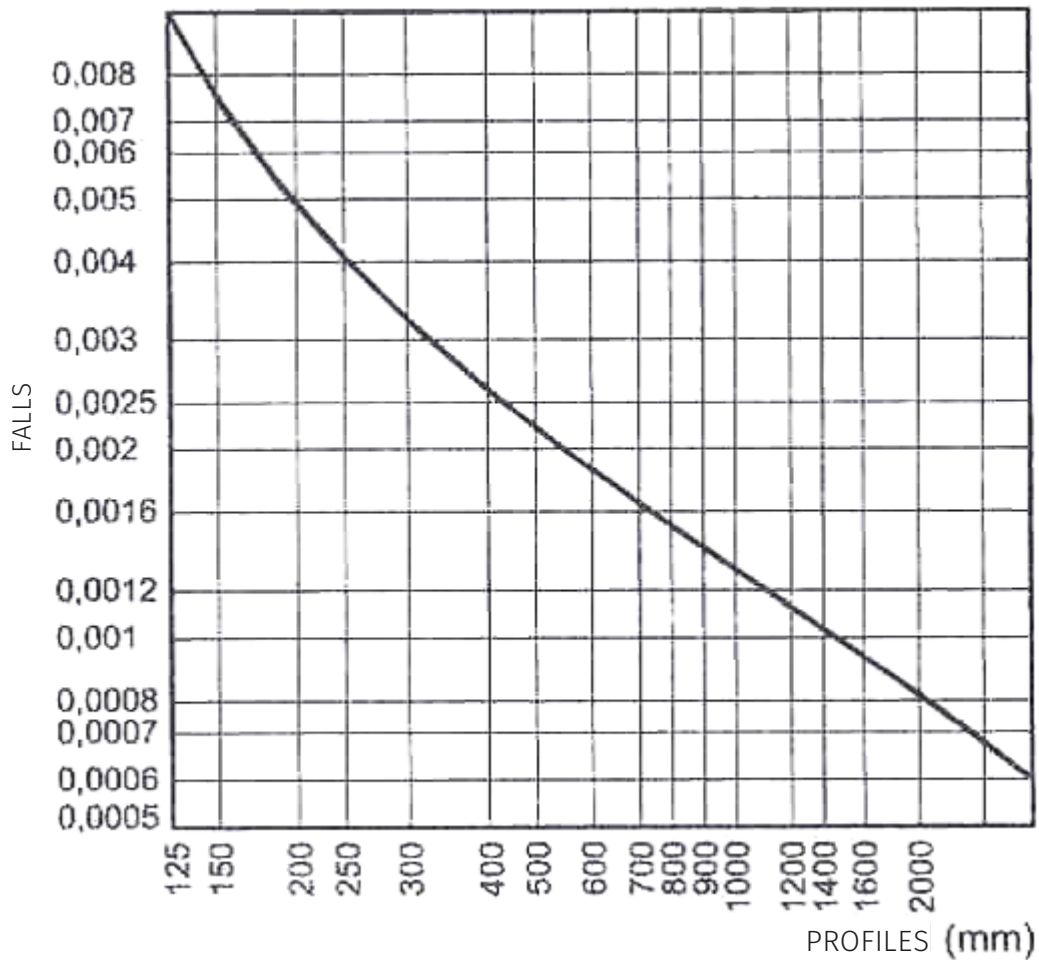


Diagram no. 1: Minimum falls when installing PVC pipes

5.1.5. Minimum pipe diameters

In the initial branches (sections) of the sewer networks, the calculation flow is very small, so it would according to hydraulic calculus got extremely small channel dimensions. For the reason that wastewater is frequent they also carry large waste materials that they can cause clogging of the duct, which sometimes gets on keep the precipitate at the bottom of the channel and substantially reduce free channel profile, which at the beginning of the channel sections considerable hydraulic loading can occur and to facilitate duct cleaning it is restricted use of the smallest channel or collector profiles. Thus, e.g. years of research in Russia and indicated to Germany that the average annual number the clogging of the profile depends directly on the dimensions profiles. These studies have shown that he is average annual number of channel clogs at profile 200 mm is twice smaller than profile 150 mm, that is, at 300 mm profiles

5.1.6. Degree of channel filling

The degree of filling of a sewer pipe represents reserve element in production picks of used water and the necessary space for maintaining the used water in an aerobic state. As noted above, the flow of water in sewage pipes the most common flow is with with a free mirror (if done correctly home connection, duct venting, drifting away of floating atter etc.). In case of wastewater level in sewage collectors is exceeded a certain value of pressure flow in pipes occurs pressure flow. To avoid this, it enforces the collector charge height limitation, depending from the size (inner diameter) of the collector. The following fill heights for round are recommended PVC profiles:

Hydraulic tables for Peštan PVC tubes are available on the company's website

Peštan in the download section of PVC KG pipes and fittings.

Download the tables at the link:

www.pestan.net/en/pvc-kg-cevi-i-fitting

or by scanning a QR code:

over three times smaller than 200 mm profile. On the other hand, practice has shown that there is no need for special saving in the dimensions of the smallest profiles, future that when building sewer networks (especially for smaller profiles up to ≈ 300 mm) larger part of the investment cost (70 to 80%) is waste to supporting works (excavation, trench excavation, loosening, groundwater evacuation, drafting placenta, backfill, removal of excess material etc.), while the pipe material itself is smaller (15 to 30%), depending on profile size, depth excavation, soil categories, etc. Minimum diameter pipe also represents a technical-economic category. In practice, for a minimum pipe diameter, adopts \varnothing 200-300 mm diameter for sewage. For mixed sewage sewage and atmospheric waters, for a minimum pipe diameter \varnothing 300-400 mm diameters are adopted.

For $d = 200-300$ mm; $hp = 0.60xd$

For $d = 350-450$ mm; $hp = 0.70xd$

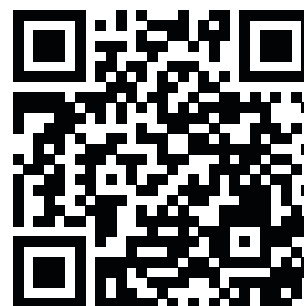
For $d = 500-900$ mm; $hp = 0.75xd$

wherein:

hp - collector charge height

d - Inner diameter of PVC sewer pipe

Accordingly, the calculated charge height (for relevant flow) must be equal to or less than the maximum allowable channel fill sizes.

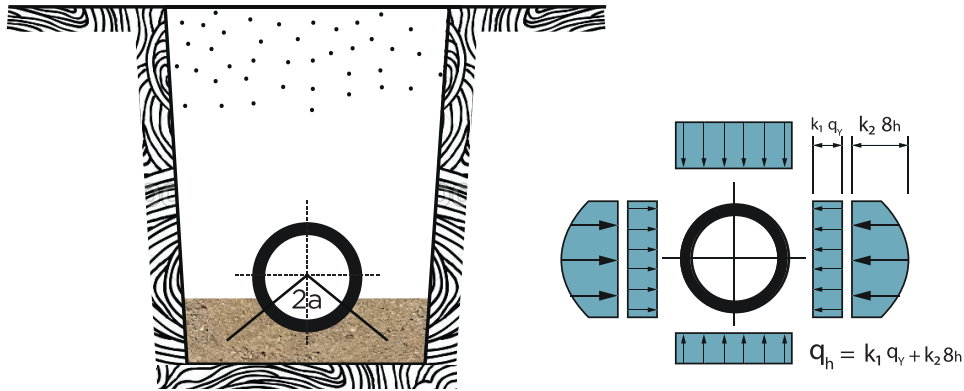


5.2. Static calculation

5.2.1. Deformation calculation

Static calculation refers to the budget deformation of flexible and ribbed (corrugated) plastic sewer pipes laid in the ground, that is, on the placenta (sand, gravel), with certain

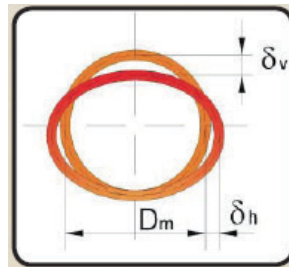
pipe angle, 2α [°], without influence of underground water, conducted in accordance with German guidance ATV - A guidelines 127.



Picture 27: Scheme of load sharing on a sewer pipe laid in the ground

Plastic pipes are a deformable structure, that is, they take over loads (stresses) without fracture phenomena. Vertical load on the tube

causes its deformation (δ_v), hence its height decrease so that the round tube is elliptical, Picture 2.



Picture 28: Elliptical shape of deformation of a round sewer pipe

It is necessary to determine the size of the vertical deformation of the pipe which at the relevant load must not exceed the permissible value. In this case, except for the special cases caused by installation conditions and loads,

it is required that the (relative) vertical deformation (δ_v), at the relevant load, no be greater than the permissible deformation $\delta_{v.dop} = 6.0$ [%], i.e.

- $\delta_v \leq \delta_{v.dop} = 6\%$

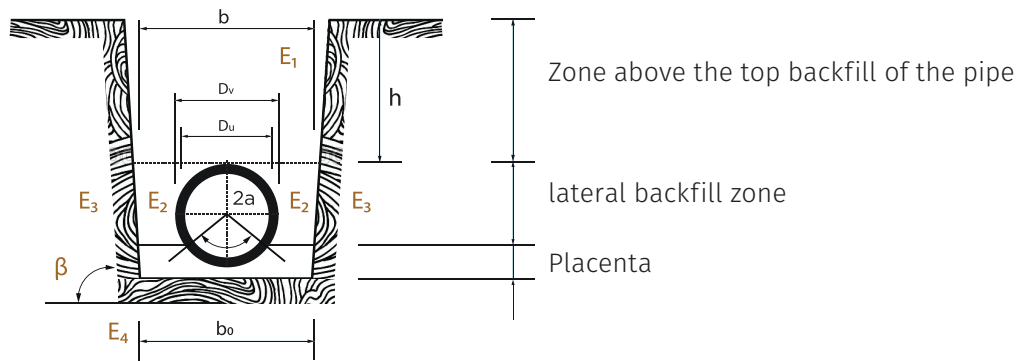
The magnitude of the relative vertical deformation of the pipe is given by the expression:

- $$\delta_v = -\frac{100 \cdot c_v^* (q_v - q_n)}{8 \cdot SN}$$

Where are:

SN (kN / m²) - ring (nominal, circumferential) pipe strength
 c_v^* (1) - coefficient of total vertical deformation of pipe diameter
 q_v (kN / m²) - vertical pipe load
 q_n (kN / m²) - horizontal pipe load

5.2.2. Coefficient of vertical pipe deformation (cv*)



Picture 29: Deformation zone

Total vertical deformation coefficient of pipe (cv*) with the associated parameters is defined with following expressions:

$$\begin{aligned}
 & \bullet E_2 = \frac{2}{3} \cdot \alpha_B \cdot E_{20} \\
 & \bullet \zeta = \frac{1,44}{\Delta f + (1,44 - \Delta f) \frac{E_2}{E_3}} \\
 & \bullet \Delta f = \frac{\frac{b}{D_v} - 1}{1,154 + 0,444 \left(\frac{b}{D_v} - 1 \right)} \leq 1,44 \\
 & \bullet S_{Bh} = 0,6 \cdot \zeta \cdot E_2 \\
 & \bullet V_{RB} = \frac{8 \cdot SN}{S_{Bh}} \\
 & \bullet K^* = \frac{c_{h1}}{V_{RB} - c_{h2}} \\
 & \bullet c_v^* = c_{v1} + c_{v2} \cdot K^*
 \end{aligned}$$

Where are:

cv1, cv2 (1) - vertical deformation coefficients of the pipes (Table 1)

ch1, ch2 (1) - horizontal deformation coefficient of the pipes (Table 1)

K* (1) - pressure coefficient of substrate reaction

VRB (1) - coefficient of strength (strength ratio tubes and substrate strengths)

SBh (kN/m²) - horizontal strength of the substrate

z (1) - horizontal strength correction factor of the substrate

E1 (kN/m²) - modulus of elasticity of the material in the zone above the top-end filling of the pipe (Table 2)

E2 (kN/m²) - modulus of elasticity of the material in the lateral backfill zone

E3 (kN/m²) - modulus of soil elasticity along the trench. Usually taken E3 = E1 (Table 2)

E4 (kN/m²) - modulus of soil elasticity under the pipe. Usually E4 = 10E1 is taken

E20 (kN/m²) - module computational value elasticity, depending on soil type, conditions non-contact pipes on the placenta and its backfill (Table 2)

aB (1) - correction factor (impairment factor) modulus of elasticity E2

Df (1) - parameter

Dv (m) - outer diameter of the pipe

Du (m) - inner diameter of the pipe

b (m) - the width of the trench at the depth of pipe placement

h (m) - height of embankment above the top of the pipe

b (°) - the slope angle of the side walls

aBi (1) - parameter dependent on the resting conditions tubes on the placenta, and usually, in accordance with manufacturer and the required method of nesting pipe recommends aBi = 2/3 or 1/3

| 2α[°] | cv1[1] | cv2[1] | ch1[1] | ch2[1] |
|-------|---------|--------|--------|---------|
| 60 | -0,1053 | 0,064 | 0,1026 | -0,0658 |
| 90 | -0,0966 | | 0,0956 | |
| 120 | -0,0893 | | 0,0891 | |

Table No.8: Value of the coefficient of vertical and horizontal deformation of the pipe as a function of the angle of installation (angle of installation) of the pipe (2α)

The value of the coefficient of vertical and horizontal deformation of the pipe as a function of the angle of inclination (angle pipe fittings (2α))



| Soil Groups | Drive roughness k (mm) |
|--|--------------------------------|
| (in brackets are labels according to DIN) | E1, E20x10[kN/m ²] |
| S1: Unbound soil (GE, GW, GI, SE, SW, SI) | 6 - 23 |
| S2: Weak soil (GU, GT, SU, ST) | 3 - 11 |
| S3: Bonded mixed floors (GU, GT, SU, ST, UL, UM) | 2 - 5 |
| S4: Hard soils (TL, TM, TA, OU, OT, OH, OK) | 1,5 - 2 |

Table No.9: Value of modulus of elasticity E1 and E20 for characteristic soil groupings

5.2.3. Vertical pipe load qv

Under normal pipe installation conditions, vertical load (qv) is greater than the horizontal loads (qh). Load difference (qv - qh) causes the vertical to decrease and increase horizontal pipe diameter. In the vertical load includes:

- the influence of the soil above the pipe tips
- additional load on the soil surface, such as
- building load, traffic load, etc.

Vertical pipe load (qv) due to load ground layer (pe) and vehicles (pv) with the associated parameters are defined by the following expressions:

$$\begin{aligned}
 & q_v = \lambda_{RG} \cdot p_e + p_v \\
 & \lambda_{RG} = \frac{\lambda_R - 1}{3} \frac{b}{D_v} + \frac{4 - \lambda_R}{3} \quad \text{za} \quad 1 \leq \frac{b}{D_v} \leq 4 \\
 & \lambda_R = \frac{\lambda_{max} \cdot V_s + \frac{E_1 \cdot 4K_2}{E_2} \cdot \frac{\lambda_{max} - 1}{3} \cdot \frac{E_1/E_2 - 0,25}{E_1/E_2 - 0,25}}{V_s + \frac{E_1 \cdot 3 + K_2}{E_2} \cdot \frac{\lambda_{max} - 1}{3} \cdot \frac{E_1/E_2 - 0,25}{E_1/E_2 - 0,25}} \leq 4 \\
 & \lambda_{max} = 1 + \frac{\frac{h}{D_v}}{\frac{3,5}{E_1} + \frac{2,2}{E_2} + \frac{2,2}{E_2} \cdot \frac{h}{D_v} + \frac{0,62}{E_1} + \frac{1,6}{E_2} \cdot \frac{1}{E_2} \cdot \frac{E_1 - 0,25}{E_2}} \\
 & V_s = \frac{8 \cdot SN}{|c_p| \cdot E_2} \\
 & p_e = \chi_\beta \cdot \gamma \cdot h \quad \text{za} \quad \chi_\beta \leq 1 \\
 & p_v = \varphi' \cdot p_F \cdot a_F \\
 & p_F = \frac{F_A}{r_A^2 \pi} \cdot \left\{ 1 - \left[\frac{1}{1 + (r_A/h)^2} \right]^3 \right\} + \frac{3F_E}{2\pi h^2} \left[\frac{1}{1 + (r_E/h)^2} \right]^5 \\
 & a_F = 1 - \left[\frac{0,9}{0,9 + (4h^2 + h^6)/1,1D_m^2/3} \right] \quad \text{za} \quad h \geq 0,5m \quad i \quad D_m \leq 5,0m \\
 & D_m = \frac{D_v + D_u}{2} \\
 & \chi_\beta = 1 - \frac{\beta}{90} + \frac{\beta}{90} \left[\frac{1 - e^{-2(h/b)K_1 \tan \delta}}{2(h/b)K_1 \tan \delta} \right]
 \end{aligned}$$

The value of the modulus of elasticity E1 and E20 for characteristic soil groupings

LEGEND:

S1: gravelly, sandy soil;
 S2: gravelly, sandy soil with clay binder;
 S3: gravelly, sandy soil with clayey and organic binder;
 S4: clayey, loamy soil. Under normal conditions pipe installation, the vertical load (qv) is higher from horizontal load (qh).
 The load difference (qv - qh) causes a decrease vertical and increase the horizontal diameter pipes.

5.2.4. Horizontal pipe load qh

The horizontal load (qh) is defined by the expression:

$$q_h = K_2 \left(\lambda_B \cdot p_e + \gamma \cdot \frac{D_v}{2} \right)$$

where λ_B [1] is the concentrated load factor in the ground next to the pipe defined by the expression:

$$\lambda_B = \frac{4 - \lambda_R}{3}$$

5.2.5. Stress calculation

In this particular case it is required that the voltage of tension on the inner part of the pipe wall (σ_i) pri merodavnom opterećenju ne bude veći od dopuštenog napona zatezanja (σ_{dop}) tj.

- $\sigma_i < \sigma_{dop}$

The magnitude of the allowable tensile stresses is given by the expression:

- $\sigma_{dop} = 50 - 60 \text{ MPa}$

The tensile stress is given by:

- $\sigma_i = \frac{N}{A} + a_{ki} \frac{M}{W}$

where are:

σ_i (kN/m²) - Tension voltage at internal side of the pipe wall
 σ (kN/m²) - computational (maximum) value pipe tensioning voltage
 F_s (1) - coefficient value adopted safety where they are, expressed by the length of the meter tubes:

N (kN/m) - normal force
 A (m²/m) - surface (longitudinal) cross section of the pipe
 a_{ki} (1) - correction coefficient
 M (kNm/m) - bending moment
 W (m³/m) - resistance torque

The following are physical quantities with their corresponding parameters defined by the following expressions:

- $A = 1 \cdot s$
- $W = \frac{1 \cdot s^2}{6} = \frac{s^2}{6}$
- $a_{ki} = \frac{3D_u + 5s}{3D_u + 3s}$
- $N = \sum_{i=1}^5 N_i$
- $N_{qv} = n_{qv} \cdot q_v \cdot r_m$; $N_{qh} = n_{qh} \cdot q_h \cdot r_m$; $N_{qh}^* = n_{qh}^* \cdot q_h^* \cdot r_m$;
 $\gamma_m \cdot s \cdot r_m = 13,8n_g \cdot s \cdot r_m$; $N_w = n_w \cdot \gamma_w \cdot r_m^2$
- $M = \sum_{i=1}^5 M_i$
- $M_{qv} = m_{qv} \cdot q_v \cdot r_m^2$; $M_{qh} = m_{qh} \cdot q_h \cdot r_m^2$; $M_{qh}^* = m_{qh}^* \cdot q_h^* \cdot r_m^2$;
 $r_m^2 = 13,8m_g \cdot s \cdot r_m^2$; $M_w = m_w \cdot \gamma_w \cdot r_m^3 = 10m_w \cdot r_m^3$
- $r_m = \frac{D_v + D_u}{4}$; $q_h^* = (q_v - q_h) \cdot K^*$



where are:

n_i, w_e (1) - coefficients of normal force and moments bending depending on the angle of contact of the pipe (2α) (Table 3.6)
 r_m (kN/m²) - mean pipe radius
 γ_m (kN/m³) - volume weight of pipe material

(usually taken $\gamma_m = 13.8$ kN/m³)
 γ_w (kN/m³) - volume weight of water (rounded at $\gamma_w = 10$ kN/m³)
 s (m) - thickness of pipe wall
 q_v (kN/m²) - vertical pipe load
 q_n (kN/m²) - horizontal pipe load
 K^* (1) - coefficient of reactive pressure of the substrate

| Angle lying tubes, 2α (°) | Normal force coefficient | | | | | Coefficient of bending moment | | | | |
|----------------------------------|--------------------------|--------|--------|--------|--------|-------------------------------|--------|--------|--------|--------|
| | nqv | nqh | nqh* | ng | nw | mqv | mqh | mqh* | mg | mw |
| 60° | -0,080 | -1,000 | -0,577 | -0,417 | +1,292 | +0,377 | -0,250 | -0,181 | +0,840 | +0,420 |
| 90° | -0,503 | -1,000 | -0,577 | -0,333 | +1,333 | +0,314 | -0,250 | -0,181 | +0,642 | +0,321 |
| 120° | -0,027 | -1,000 | -0,577 | -0,250 | +1,375 | +0,275 | -0,250 | -0,181 | +0,520 | +0,260 |

Table No.11: Values of the load coefficients of the bottom of the pipeline as a function of the angle of contact of the pipe 2α (°)

5.2.6. Symbols used in Eqs

p_e (kN/m²) - soil load
 p_v (kN/m²) - traffic load
 IR, IRG, I_{max} (1) - concentration factors loads above the pipe
 V_s (1) - strength coefficient
 K_2 (1) - pressure ratio dependent on the coefficient strength of VRB and soil grouping
 $c\beta$ (1) - correction factor (attenuation factor) ground loads
 K_1 (1) - horizontal and vertical pressure ratio the ground. Typically, $K_1 = 0.5$ is taken
 d (°) - friction angle on trench walls. Usually $d = 2/3j$ or $d = 1/3j$, depending on conditions pipe clogging
 j (°) - angle of internal friction of material
 g (kN/m³) - volume weight of soil. It is usually taken $g = 20$ (kN/m³)
 j '(1) - the carbon factor, depending on the type of vehicle
 p_F (kN/m²) - relevant load by means of transport
 a_F (1) - correction factor (impairment factor) traffic load
 D_m (m) - calculated pipe diameter
 FA, FE (kN) - influential load sizes by the relevant means of transport
 r_A, r_E (m) - radii of influence of load by the relevant traffic load.

| Group | K2[1] | |
|-------|---------|---------|
| | VRB>0,1 | VRB≤0,1 |
| S1 | 0,5 | 0,4 |
| S2 | | 0,3 |
| S3 | | 0,2 |
| S4 | | 0,1 |

| A group of soils | ϕ [°] |
|------------------|------------|
| S1 | 35 |
| S2 | 30 |
| S3 | 25 |
| S4 | 20 |

K2 values as a function of VRB and soil type

Internal friction angle as a function of soil type

| Traffic agent | FA [kN] | FE [kN] | rA [m] | rE [m] | ϕ' [°] |
|---------------|---------|---------|--------|--------|-------------|
| SLW 60 | 100 | 500 | 0,25 | 1,82 | 1,2 |
| SLW 30 | 50 | 250 | 0,18 | 1,82 | 1,4 |
| LKW 12 | 40 | 80 | 0,15 | 2,26 | 1,5 |

Table No.12 Traffic load parameter values

In the zone of over-filling the pipelines may be use all soil groups according to Table 2 while in the zone of the lateral backfill of the pipeline there can be used only loose and weakly bound soils, ie soil that can be compact (soil groups S1 and S2). More

detailed module selection soil elasticities E1 and E20 within their area values according to Table 2 are related to the installation method pipes and with the degree of compaction achieved, NW [%], which ranges from 90-97 [%].



6 INTERFERENCE

INTERFERENCE REMOVAL

During operation, with each pipe system interference is possible. Interference with sewers divorces are possible in the form of clogging and pipeline leaks, and therefore during installation inspection openings should be provided for inspection piping and cleaning if needed.



7 MAINTENANCE

In terms of maintenance, we differentiate regularly and emergency maintenance. As already mentioned in Chapter 6, there should be anticipate situations in case of emergency maintenance happen, replacement of individual pipeline elements or cleaning pipeline when it gets clogged. Regular maintenance includes pipeline cleaning of deposited deposits on the pipe walls. Only pipeline cleaning and disinfection should be performed by an organization or institution certificated for that kind of works.

8 DISASSEMBLE

Disassembly and removal of the pipeline is performed as follows way or according to the following procedure:

- Drain water from the system
- Disassemble the pipeline by disassembling the joints
- Cut the dismantled pipeline as short as possible pieces, for easy manipulation

Disassemble and cut pipeline to transport vehicle and take to the dump provided for plastics so that the material can recycle.

9 POST USE

As mentioned earlier PVC masses can be recycled. PVC recycling does not lose its physicochemical properties so material that is recycled can be used for lining the motor housing, manufacture of laundry baskets and any items of plastic. Pestan for the production of its PVC production pipe and fitting programs exclusively use the original materials from renowned world manufacturers. Plastic masses are recycled by material code, so the code for PVC is:



PVC



10 SHORTCUTS

In the document it is used a metric metering system unit (SI), e.g. unit of force Newton (N) instead pounds (p) and power unit Watt (W) instead of kcal/h.

Conversion:

$$t (^{\circ}\text{C}) = T - T_0 = T - 273.15 \text{ K.}$$

$$1 \text{ kp} = 9.80665 \text{ N or } 1 \text{ kp} \approx 10 \text{ N}$$

$$1 \text{ Mp} = 9806.65 \text{ N or } 1 \text{ Mp} \approx 10 \text{ kN and } 1 \text{ Mp/m} = 10 \text{ kN/m}$$

$$1 \text{ kp/cm}^2 = 9.80665 \text{ N/cm}^2 = 0.0980665 \text{ N/mm}^2 = 0.0980665 \text{ Mpa or } 1 \text{ kp/cm}^2 \approx 0.1 \text{ N/mm}^2$$

$$1 \text{ m water stubs} = 0.0980665 \text{ bar or } 1 \text{ m water column} \approx 0.1 \text{ bar}$$

$$1 \text{ kcal/mh degrees} = 1.16 \text{ W/mK (Thermal conductivity) or } 1 \text{ kcal/mh degrees} \approx 1.2 \text{ W/mK}$$

Thermal conductivity is given in W/mK. It's a stretch the same for K and $^{\circ}\text{C}$ since the difference is only at the beginning of the scale. In this sense, 1 W/m $^{\circ}\text{C}$ is identical to 1 W/mK. K (Kelvin) is the SI unit of temperature. Temperature in Celsius (t) is different from the temperature in Kelvin (T) for 273.15 K.

$$t (^{\circ}\text{C}) = T - T_0 = T - 273.15 \text{ K.}$$

In this document, 10 m / s was adopted for g, error of about 2% is ignored, the DN mark is nominal diameter, PN is the nominal pressure.

Dimensions and units

The dimensions are expressed in mm and / or inches and are specified as nominal and standard sizes.

| | |
|---|---|
| d, d1, d2, d3, d4 Diameter | MFR Dissolved coefficient of flow according to ISO 4440 |
| DN Nominal diameter | SDR Standard Dimension Ratio: |
| SC Size of hexagon screws | OD / SDR S |
| AL Number of screw holes | OD / S SDR |
| s Hexagon head screw width | OD Outer diameter |
| g Weight in grams | S Wall thickness |
| SP Quantity in standard packaging | Explaining of abbreviations |
| GP Quantity in large pack | PB Polybutylene |
| e Pipe wall thickness | PE Polyethylene |
| PN Nominal pressure | PE-X Cross-linked polyethylene |
| Rp Parallel inner pipe thread according to ISO 7-1 | PP Polypropylene |
| R Conical outer pipe thread to ISO 7-1 | PVC Polyvinyl chloride |
| ppm Parts per million | PVC-C Chlorinated polyvinyl chloride (increased content chlorine) |
| 1 bar = 0.1 N / mm ² = 0.1 Mpa (Megapascal) = 14.504 psi | PVC-U Unplasticized polyvinyl chloride |
| C Design factor | PVC-O Oriental polyvinyl chloride |
| S Tube series | |
| SDR Standard dimension ratio | |

11 CHEMICAL RESISTANCE

11.1 Introduction

The table in this document summarizes the data chemical resistance of PVC, and is in use in many countries, and was created as a result of the practical experience and test results.

Source: ISO/TR 10358

The table contains an estimate of the chemical resistance of a large the number of fluids rated as aggressive or inert according to PVC. Valuation is based on values obtained from the results of PVC immersion tests into the fluid sample at temperatures of 20, 60 and 100 °C and atmospheric pressure, following characteristics tensile strengths under given conditions. The classification will be determined taking into account a limited number of fluids considered to be more technically or commercially important, using equipment which allows pressure testing and determination of the chemical resistance coefficient separately for each fluid. That way, these tests will provide more complete information on the use of PVC pipes for transport of mentioned fluids including their own use under pressure.

11.3 Definitions and Symbols as Abbreviations

Criteria for classifications, definitions, symbols and the abbreviations used in this chapter are as follows:

S - satisfactory L - partial or restricted.

Chemical resistance of polypropylene exposed of fluid activity is classified as partial satisfactory when the test results are confirmed in most countries that participated in the testing. Also this classification (L) is used for resistances on the activity of chemical fluids in which u parameter dependencies can be used by both S and NS.

NS - not satisfying

Chemical resistance of polypropylene exposed fluid activity is classified as not satisfactory when the test results are confirmed in most countries that participated in the testing.

This classification (NS) includes materials that depending on the parameters they are labeled either NS or L. Saturated solution - saturated aqueous solution, prepared at 20 °C

11.2 Field of application

This document contains the chemical classification resistance of polypropylene for about 180 fluids. It is intended to provide general guidance on the possibilities of using polypropylene fluid transfer tubes:

- At temperatures of 20, 60 and 100 °C
- In the absence of internal pressure and external mechanical stress (for example: flexural stress, stresses due to thrust, twisting load, etc.)

Solution - unsaturated aqueous solution at a concentration higher than 10%

Mild solution - Mild aqueous solution at a concentration of 10% or less

Working solution - An aqueous solution with the usual concentration for industrial use

Dilution concentrations were recorded in the text expressed in mass percent. Aqueous dilutions poorly soluble chemicals are used, which are chemical activities according to polypropylene concerns, consider with saturated solutions. Generally, in this catalog common chemical names were used. This one the spreadsheet was created as a user guide polypropylene. Just in case some chemical compound is not in the table or due to uncertainty related to chemical resistance in some applications, please to contact Pestan for advice and suggestion for testing.



| A chemical or product | Concentration | Temperature °C | | |
|-----------------------------|--------------------|----------------|----|-----|
| | | 20 | 60 | 100 |
| Acetic acid | Up to 40% | S | S | - |
| Acetic acid | 50% | S | S | L |
| Vinegar vinegar. glacial | >96% | S | L | NS |
| Acetic anhydride | 100% | S | - | - |
| Acetone | 100% | S | S | - |
| Acetophenone | 100% | S | L | - |
| Acrylonitrile | 100% | S | - | - |
| Air | - | S | S | S |
| Allyl alcohol | 100% | S | S | - |
| Almond oil | - | S | - | - |
| Stips | Solution | S | S | - |
| Ammonia, aqueous solution | Saturated solution | S | S | - |
| Ammonia, dry gas | 100% | S | - | - |
| Ammonia, liquid | 100% | S | - | - |
| Ammonium acetate | Saturated solution | S | S | - |
| Ammonium chloride | Saturated solution | S | S | - |
| Ammonium fluoride | Up to 20% | S | S | - |
| Ammonium hydrogen carbonate | Saturated solution | S | S | - |
| Ammonium metaphosphate | Saturated solution | S | S | S |
| Ammonium nitrate | Saturated solution | S | S | S |
| Ammonium persulfate | Saturated solution | S | S | - |
| Ammonium phosphate | Saturated solution | S | - | - |
| Ammonium sulfate | Saturated solution | S | S | S |
| Ammonium sulfide | Saturated solution | S | S | - |
| Amyl acetate | 100% | L | - | - |
| Amyl alcohol | 100% | S | S | S |
| Aniline | 100% | S | S | - |
| Apple juice | - | S | - | - |
| Imperial Water | HCl/HNOF3/1 | NS | NS | NS |
| Barium bromide | Saturated solution | S | S | S |
| Barium carbonate | Saturated solution | S | S | S |

| A chemical or product | Concentration | Temperature °C | | |
|----------------------------|--------------------|----------------|----|-----|
| | | 20 | 60 | 100 |
| Barium chloride | Saturated solution | S | S | S |
| Barium hydroxide | Saturated solution | S | S | S |
| Barium sulfides | Saturated solution | S | S | S |
| Beer | - | S | S | - |
| Benzene | 100% | L | NS | NS |
| Benzoic acid | Saturated solution | S | S | - |
| Benzyl alcohol | 100% | S | L | - |
| Borax Solution | Solution | S | S | - |
| Boric acid | Saturated solution | S | - | - |
| Boron Trifluoride | Saturated solution | S | - | - |
| Bromine, gas | - | NS | NS | NS |
| Bromine, liquid | 100% | NS | NS | NS |
| Bhutan, gas | 100% | S | - | - |
| Butanol | 100% | S | L | L |
| Butyl acetate | 100% | L | NS | NS |
| Butyl glycol | 100% | S | - | - |
| Butyl phenol | Saturated solution | S | - | - |
| Butyl phthalate | 100% | S | L | L |
| Calcium carbonate | Saturated solution | S | S | S |
| Calcium chlorate | Saturated solution | S | S | - |
| Calcium chloride | Saturated solution | S | S | S |
| Calcium hydroxide | Saturated solution | S | S | S |
| Calcium hypochlorite | Solution | S | - | - |
| Calcium nitrate | Saturated solution | S | S | - |
| Camphor oil | - | NS | NS | NS |
| Carbon dioxide, dry gas | - | S | S | - |
| Carbon dioxide, wet gas | - | S | S | - |
| Carbon disulfide | 100% | S | NS | NS |
| Oil monoxide, gas | - | S | S | - |
| Carbon tetrachloride | 100% | NS | NS | NS |
| Castor Oil | 100% | S | S | - |
| Caustic soda | Up to 50% | S | L | L |
| Chlorine, aqueous solution | Saturated solution | S | L | - |
| Chlorine, dry gas | 100% | NS | NS | NS |



| A chemical or product | Concentration | Temperature °C | | |
|--------------------------------|--------------------|----------------|----|-----|
| | | 20 | 60 | 100 |
| Chlorine, liquid | 100% | NS | NS | NS |
| Chloroacetic acid | 100% | S | - | - |
| Chlorine ethanol | 100% | S | - | - |
| Chloroform | 100% | L | NS | NS |
| Chlorosulphuric acid | 100% | NS | NS | NS |
| Chromium alum | Solution | S | S | - |
| Chromic acid | Do 40% | S | L | NS |
| Citric acid | Saturated solution | S | S | S |
| Coconut oil | - | S | - | - |
| Copper (II) chloride | Saturated solution | S | S | - |
| Copper (II) nitrate | Saturated solution | S | S | S |
| Copper (II) | Saturated solution | S | S | - |
| Corn oil | - | S | L | - |
| Cotton seed oil | - | S | S | L |
| Cresol | Up to 90% | S | - | - |
| Cyclohexane | 100% | S | - | - |
| Cyclohexanol | 100% | S | L | - |
| Cyclohexanone | 100% | L | NS | NS |
| Decalin (Decahydronaphthalene) | 100% | NS | NS | NS |
| Dextrin | Solution | S | S | - |
| Dextrin Dextrose | Solution | S | S | S |
| Dibutyl phthalate | 100% | S | L | NS |
| Dichloroacetic acid | 100% | L | - | - |
| Dichlor ethylene (A i B) | 100% | L | - | - |
| Diethanolamine | 100% | S | - | - |
| Diethyl ether | 100% | S | L | - |
| Diethylene glycol | 100% | S | S | - |
| Diglycolic acid | 100% | S | - | - |
| Diisooctyl | 100% | S | L | - |
| Dimethylamine, gas | - | S | - | - |
| Dimethyl formamide | 100% | S | S | - |
| Dimethyl phthalate | 100% | L | L | - |
| Dioxane | 100% | L | L | - |
| Distilled water | 100% | S | S | S |

| A chemical or product | Concentration | Temperature °C | | |
|----------------------------------|--------------------|----------------|----|-----|
| | | 20 | 60 | 100 |
| Etil alkohol | Up to 95% | S | S | S |
| Etil hlorid, gas | - | NS | NS | NS |
| Etilen hlorid (mono i di) | - | L | L | - |
| Etil etar | 100% | S | L | - |
| Etilen glikol | 100% | S | S | S |
| Etanol amin | 100% | S | - | - |
| Etil acetat | 100% | L | NS | NS |
| Gvožđe hlorid | Saturated solution | S | S | S |
| Gvožđe hlorid formaldehid | 40% | S | - | - |
| Mravlja kiselina | 10% | S | S | L |
| Mravlja kiselina | 85% | S | NS | NS |
| Mravlja kiselina, anhidrid | 100% | S | L | L |
| Fruktoza | Solution | S | S | S |
| Voćni sok | - | S | S | S |
| Benzin, alifatični ugljovodonici | - | NS | NS | NS |
| Želatin | - | S | S | - |
| Glukoza | 20% | S | S | S |
| Glicerin | 100% | S | S | S |
| Glikolna kiselina | 30% | S | - | - |
| Heptan | 100% | L | NS | NS |
| Heksan | 100% | S | L | - |
| Bromovodonična kiselina | Up to 48% | S | L | NS |
| Hlorovodonična | Up to 20% | S | S | S |
| Hlorovodonična | 30% | S | L | L |
| Hlorovodonična | From 35 to 36% | S | - | - |
| Fluorovodonična kiselina | Razblažen rastvor | S | - | - |
| Fluorovodonična kiselina | 40% | S | - | - |
| Vodonik | 100% | S | - | - |
| Hlorovodonik, suvi gas | 100% | S | S | - |
| Vodonik peroksid (hidrogen) | Do 10% | S | - | - |
| Vodonik peroksid (hidrogen) | Do 30% | S | L | - |
| Vodonik sulfide, suvi gas | 100% | S | S | - |
| Jod, u alkoholu | - | S | - | - |



| A chemical or product | Concentration | Temperature °C | | |
|---|--------------------|----------------|----|-----|
| | | 20 | 60 | 100 |
| Isooctane | 100% | L | NS | - |
| Isopropyl alcohol | 100% | S | S | S |
| Isopropyl ether | 100% | L | - | - |
| Lactic acid | Do % | S | S | - |
| Lanolin | - | S | L | - |
| Linseed oil | - | S | S | S |
| Magnesium carbonate | Saturated solution | S | S | S |
| Magnesium chloride | Saturated solution | S | S | - |
| Magnesium hydroxide | Saturated solution | S | S | - |
| Magnesium sulfate | Saturated solution | S | S | - |
| Maleic acid | Saturated solution | S | S | - |
| Mercury (II) chloride | Saturated solution | S | S | - |
| Mercury (II) cyanide | Saturated solution | S | S | - |
| Mercury (I) nitrate | Solution | S | S | - |
| Mercury | 100% | S | S | - |
| Methyl acetate | 100% | S | S | - |
| Methyl alcohol | 5% | S | L | - |
| Methyl amine | Up to 32% | S | - | - |
| Methyl bromide | 100% | NS | NS | NS |
| Methyl ethyl ketone | 100% | S | - | - |
| Methylene chloride | 100% | L | NS | NS |
| Milk | - | S | S | S |
| Monochloric Acetic Acid | <85% | S | S | - |
| Oil | - | S | NS | NS |
| Nickel Chloride | Saturated solution | S | S | - |
| Nickel nitrate | Saturated solution | S | S | - |
| Nickel Sulphate | Saturated solution | S | S | - |
| Nitric acid | Up to 30% | S | NS | NS |
| Nitric acid | 40 to 50% | L | NS | NS |
| Nitric acid, smokable (with nitrogen dioxide) | - | NS | NS | NS |
| Nitrobenzene | 100% | S | L | - |
| Oleic acid | 100% | S | L | - |

| A chemical or product | Concentration | Temperature °C | | |
|---|--------------------|----------------|----|-----|
| | | 20 | 60 | 100 |
| Oleum (sulfuric acid with 60% SO ₃) | - | S | L | - |
| Olive oil | - | S | S | L |
| Oxalic acid | Saturated solution | S | L | NS |
| Oxygen, gas | - | S | - | - |
| Paraffin oil (FL65) | - | S | L | NS |
| Peanut oil | - | S | S | - |
| Peppermint oil | - | S | - | - |
| Perchloric acid | (2N) 20% | S | - | - |
| Petroller (light gasoline) | - | L | L | - |
| Phenol | 5% | S | S | - |
| Phenol | 90% | S | - | - |
| Phosphine, gas | - | S | S | - |
| Phosphoric acid | Up to 85% | S | S | S |
| Phosphorus oxychloride | 100% | L | - | - |
| Picric acid | Saturated solution | S | - | - |
| Potassium bicarbonate | Saturated solution | S | S | S |
| Potassium borate | Saturated solution | S | S | - |
| Potassium bromate | Up to 10% | S | S | - |
| Potassium bromide | Saturated solution | S | S | - |
| Potassium carbonate | Saturated solution | S | S | - |
| Potassium chlorate | Saturated solution | S | S | - |
| Potassium chlorite | Saturated solution | S | S | - |
| Potassium Chromate | Solution | S | S | - |
| Potassium cyanide | Saturated solution | S | - | - |
| Potassium dichromate | Saturated solution | S | S | S |
| Potassium Iron Cyanide | Saturated solution | S | S | - |
| Potassium fluoride | Up to 50% | S | S | - |
| Potassium hydroxide | Saturated solution | S | S | S |
| Potassium iodide | Saturated solution | S | - | - |
| Potassium nitrate | 10% | S | S | - |
| Potassium perchlorate | (2N) 30% | S | S | - |
| Potassium permanganate | Saturated solution | S | - | - |
| Potassium persulfate | Saturated solution | S | S | - |



| A chemical or product | Concentration | Temperature °C | | |
|----------------------------|--------------------|----------------|----|-----|
| | | 20 | 60 | 100 |
| Potassium sulphate | 100% | S | S | - |
| Propane, gas | <50% | S | - | - |
| Propionic acid | - | S | - | - |
| Pyridine | 100% | L | - | - |
| Seawater | - | S | S | S |
| Silicone oil | - | S | S | S |
| Silver nitrate | Saturated solution | S | S | L |
| Sodium acetate | Saturated solution | S | S | S |
| Sodium benzoate | 35% | S | L | - |
| Sodium bicarbonate | Saturated solution | S | S | S |
| Sodium carbonate | Up to 50% | S | S | L |
| Sodium chlorate | Saturated solution | S | S | - |
| Sodium chloride | Saturated solution | S | S | - |
| Sodium chlorite | 2% | S | L | NS |
| Sodium chlorite | 20% | S | L | NS |
| Sodium dichromate | Saturated solution | S | S | S |
| Sodium hydrogen carbonate | Saturated solution | S | S | S |
| Sodium hydrogen sulfate | Saturated solution | S | S | - |
| Sodium hydrogen sulfite | Saturated solution | S | - | - |
| Sodium hydroxide | 1% | S | S | S |
| Sodium hydroxide | 10 to 60% | S | S | S |
| Sodium hypochlorite | 5% | S | S | - |
| Sodium hypochlorite | 10 to 15% | S | - | - |
| Sodium hypochlorite | 20% | S | L | - |
| Sodium metaphosphate | Solution | S | - | - |
| Sodium nitrate | Saturated solution | S | S | - |
| Sodium perborate | Saturated solution | S | S | - |
| Sodium phosphate (neutral) | - | S | S | S |
| Sodium silicate | Solution | S | S | - |
| Sodium sulphate | Saturated solution | S | S | - |
| Sodium sulfide | Saturated solution | S | - | - |
| Sodium sulfite | 40% | S | S | S |
| Sodium thiosulphate (hypo) | Saturated solution | S | - | - |
| Soybean oil | - | S | L | - |



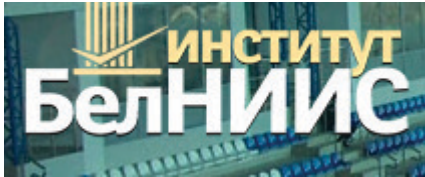
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Nothing is a guarantee here. Does not exist responsibility that can be accepted and relationships to use Pestan products in conjunction

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12 CERTIFICATES



БЛНИИС – Belarus



KIWA-Netherlands



БЛНИИС – Belarus



VUPS- Czech Republic



MPA – Germany



IGH Croatia

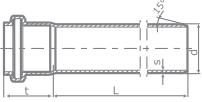

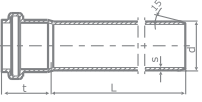

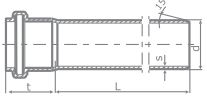



IMS Serbia



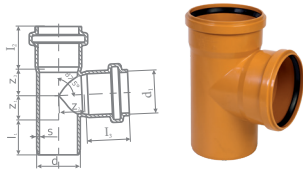
GOST R Russia

13 PRODUCT RANGE

| NAME | PICTURE | CODE | D | S | T |
|---|---|--------------------------|-----|------|-----|
| KG PIPE SDR51 SN2 | | | | | |
|  |  | 10400044 | 160 | 3,2 | 86 |
| | | 10400054 | 200 | 3,9 | 106 |
| | | 10400074 | 250 | 4,9 | 128 |
| | | 10400104 | 315 | 6,2 | 155 |
| | | 10400144 | 400 | 7,9 | 183 |
| | | 10400184 | 500 | 9,8 | 210 |
| | | 10410560 | 630 | 12,3 | 188 |
| KG PIPE SDR41 SN4 | | | | | |
|  |  | 10400304 | 110 | 3,2 | 61 |
| | | 10400324 | 125 | 3,2 | 72 |
| | | 10400344 | 160 | 4,0 | 86 |
| | | 10400364 | 200 | 4,9 | 106 |
| | | 10400384 | 250 | 6,2 | 128 |
| | | 10400404 | 315 | 7,7 | 155 |
| | | 10400444 | 400 | 9,8 | 183 |
| | | 10400484 | 500 | 12,3 | 210 |
| | | 10410360 | 630 | 15,4 | 188 |
| | | KG PIPE SDR34 SN8 | | | |
|  |  | 10400604 | 110 | 3,2 | 61 |
| | | 10400624 | 125 | 3,7 | 72 |
| | | 10400644 | 160 | 4,7 | 86 |
| | | 10400664 | 200 | 5,9 | 106 |
| | | 10400684 | 250 | 7,3 | 128 |
| | | 10400704 | 315 | 9,2 | 155 |
| | | 10400744 | 400 | 11,7 | 183 |
| | | 10400784 | 500 | 14,6 | 210 |
| | | 10410160 | 630 | 18,4 | 188 |



| NAME | PICTURE | CODE | D | S | Z1 | Z2 | L1MIN | L2 |
|-----------------------|---------|-----------|-----|-----|-------|-------|-------|------|
| KGB BEND 15° | | | | | | | | |
| | | 10401362 | 110 | 3,2 | 6,1 | 20 | 61 | 49,1 |
| | | 10401363 | 125 | 3,2 | 7,9 | 21 | 68 | 54,6 |
| | | 10401360 | 160 | 4 | 10,1 | 26,2 | 81 | 86 |
| | | 10401361 | 200 | 4,9 | 26 | 30 | 99 | 106 |
| | | *11500002 | 250 | 6,2 | 18 | 30 | 125 | 128 |
| | | *11500003 | 315 | | | | | |
| | | *11500005 | 400 | | | | | |
| *11500007 | 500 | | | | | | | |
| KGB BEND 30° | | | | | | | | |
| | | 10401020 | 110 | 3,2 | 14,7 | 27,1 | 61 | 49,6 |
| | | 10401021 | 125 | 3,2 | 16,7 | 29,1 | 68 | 54,6 |
| | | 10401022 | 160 | 4 | 24 | 30 | 81 | 86 |
| | | 10401023 | 200 | 4,9 | 30 | 39 | 99 | 106 |
| | | *11500102 | 250 | 6,2 | 37 | 49 | 125 | 128 |
| | | *11500103 | 315 | | | | | |
| | | *11500105 | 400 | | | | | |
| *11500107 | 500 | | | | | | | |
| KGB BEND 45° | | | | | | | | |
| | | 10401120 | 110 | 3,3 | 22,9 | 34,7 | 61 | 49,1 |
| | | 10401121 | 125 | 3,3 | 26 | 37,8 | 68 | 54,6 |
| | | 10401102 | 160 | 4 | 36 | 44 | 81 | 86 |
| | | 10401103 | 200 | 4,9 | 46 | 55 | 99 | 106 |
| | | 10401104 | 250 | 6,2 | 57 | 69 | 125 | 128 |
| | | 10401105 | 315 | 7,7 | 72 | 86 | 132 | 155 |
| | | 10401106 | 400 | 9,8 | 83,3 | 117,9 | 150 | 119 |
| *11500205 | 500 | | | | | | | |
| KGB BEND 87.5° | | | | | | | | |
| | | 10401320 | 110 | 3,3 | 53,2 | 62,8 | 61 | 49,1 |
| | | 10401321 | 125 | 3,3 | 60,4 | 70 | 68 | 54,6 |
| | | 10401302 | 160 | 4 | 83 | 89 | 81 | 86 |
| | | 10401303 | 200 | 4,9 | 105 | 114 | 99 | 106 |
| | | 10401304 | 250 | 6,2 | 131 | 143 | 125 | 128 |
| | | 10401305 | 315 | 7,7 | 165 | 180 | 132 | 155 |
| | | 10401326 | 400 | 9,8 | 193,3 | 121,2 | 150 | 119 |
| *11500405 | 500 | | | | | | | |

| NAME | PICTURE | CODE | D/D1 | S | Z1 | Z2 | Z3 | L1MIN | L2 | L3 |
|---|-----------|---------|------|------|-------|-------|-----|-------|------|----|
| KGEA BRANCH 87.5° | | | | | | | | | | |
|  | 10401630 | 110/110 | 3,3 | 52,7 | 67,3 | 67,3 | 61 | 49,1 | 49,1 | |
| | 10401631 | 125/110 | 3,3 | 52,4 | 67,6 | 67,6 | 68 | 54,6 | 49,1 | |
| | 10401632 | 125/125 | 3,3 | 59,9 | 75,1 | 75,1 | 68 | 54,6 | 54,6 | |
| | 10401603 | 160/110 | 4 | 58 | 86 | 64 | 81 | 86 | 61 | |
| | 10401604 | 160/125 | 4 | 66 | 87 | 71 | 81 | 86 | 72 | |
| | 10401605 | 160/160 | 4 | 83 | 89 | 89 | 81 | 86 | 86 | |
| | 10401606 | 200/110 | 4,9 | 62 | 105 | 64 | 99 | 106 | 61 | |
| | 10401607 | 200/125 | 4,9 | 69 | 75 | 101 | 75 | 106 | 72 | |
| | 10401608 | 200/160 | 4,9 | 86 | 108 | 90 | 99 | 106 | 86 | |
| | 10401609 | 200/200 | 4,9 | 106 | 111 | 111 | 99 | 106 | 106 | |
| | 10401619 | 250/110 | 6,2 | 90 | 132 | 100 | 120 | 128 | 61 | |
| | 10401620 | 250/125 | 6,2 | 90 | 132 | 100 | 120 | 128 | 72 | |
| | 10401610 | 250/160 | 6,2 | 89 | 132 | 91 | 125 | 128 | 86 | |
| | 10401611 | 250/200 | 6,2 | 108 | 134 | 111 | 125 | 128 | 106 | |
| | 10401612 | 250/250 | 6,2 | 131 | 138 | 138 | 125 | 128 | 128 | |
| | 10401618 | 315/110 | 7,7 | 93 | 162 | 104 | 134 | 155 | 61 | |
| | 10401617 | 315/125 | 7,7 | 93 | 162 | 104 | 134 | 155 | 72 | |
| | 10401613 | 315/160 | 7,7 | 93 | 164 | 104 | 134 | 155 | 86 | |
| | 10401614 | 315/200 | 7,7 | 111 | 165 | 113 | 132 | 155 | 106 | |
| | 10401615 | 315/250 | 7,7 | 134 | 169 | 139 | 132 | 155 | 128 | |
| | 10401616 | 315/315 | 7,7 | 165 | 173 | 173 | 132 | 155 | 155 | |
| | 10401621 | 400/110 | 9,8 | 106 | 206,5 | 131,8 | 150 | 124,2 | 51,3 | |
| | 10401622 | 400/160 | 9,8 | 106 | 209,7 | 131,8 | 150 | 124,2 | 65 | |
| | 10401623 | 400/200 | 9,8 | 106 | 214,5 | 131,8 | 150 | 124,2 | 77,5 | |
| | *11501232 | 400/110 | | | | | | | | |
| | *11501233 | 400/125 | | | | | | | | |
| | *11501234 | 400/160 | | | | | | | | |
| | *11501235 | 400/200 | | | | | | | | |
| | *11501236 | 400/250 | | | | | | | | |
| | *11501237 | 400/315 | | | | | | | | |
| | *11501239 | 400/400 | | | | | | | | |
| | *11501249 | 500/110 | | | | | | | | |
| | *11501250 | 500/125 | | | | | | | | |
| | *11501251 | 500/160 | | | | | | | | |
| *11501252 | 500/200 | | | | | | | | | |
| *11501253 | 500/250 | | | | | | | | | |
| *11501254 | 500/315 | | | | | | | | | |
| *11501256 | 500/400 | | | | | | | | | |
| *11501258 | 500/500 | | | | | | | | | |
| *11501056 | 500/400 | | | | | | | | | |
| *11501058 | 500/500 | | | | | | | | | |



| NAME | PICTURE | CODE | D(D/D1) | L1MIN |
|--------------------------|----------|------|---------|-------|
| KGU KLIZNA SPOJKA | | | | |
| | 10402720 | 110 | 122,2 | |
| | 10402721 | 125 | 131,2 | |
| | 10402702 | 160 | 158 | |
| | 10402703 | 200 | 158 | |
| | 10402704 | 250 | 250 | |
| | 10402705 | 315 | 293 | |
| | 10402706 | 400 | 244 | |
| *11502310 | 500 | | | |

| | | | | |
|--------------------------|-----------|-----|-------|--|
| KGU DOUBLE SOCKET | | | | |
| | 10402620 | 110 | 122,2 | |
| | 10402621 | 125 | 131,2 | |
| | 10402602 | 160 | 158 | |
| | 10402604 | 250 | 250 | |
| | 10402605 | 315 | 293 | |
| | 10402626 | 400 | 244 | |
| | *11502410 | 500 | | |


| NAME | PICTURE | CODE | (D/D1) | S | Z1 | L1MIN | L2 |
|------------------------------|----------|---------|--------|------|-----|-------|----|
| KGR EXCENTRIC REDUCER | | | | | | | |
| | 10401730 | 125/110 | 3,3 | 23,3 | 67 | 49,1 | |
| | 10401701 | 160/110 | 4 | 34 | 81 | 61 | |
| | 10401702 | 160/125 | 4 | 27 | 81 | 72 | |
| | 10401703 | 200/110 | 4,9 | 26 | 125 | 61 | |
| | 10401705 | 200/160 | 4,9 | 32 | 99 | 86 | |
| | 10401709 | 250/200 | 6,2 | 38 | 125 | 106 | |
| | 10401714 | 315/250 | 7,7 | 46 | 132 | 128 | |

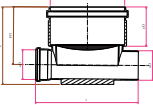

| | | | | | | | |
|-------------------------|-----------|---------|-----|----|-----|----|--|
| KGR FLAT REDUCER | | | | | | | |
| | *10401750 | 110/200 | 4,9 | 5 | 61 | 59 | |
| | *10401800 | 110/250 | 6,1 | 7 | 61 | 90 | |
| | *10401810 | 110/315 | 7,7 | 40 | 61 | 93 | |
| | *10401820 | 110/400 | 6 | 40 | 61 | 95 | |
| | *10401751 | 125/200 | 4,9 | 5 | 72 | 59 | |
| | *10401801 | 125/250 | 6,1 | 7 | 72 | 90 | |
| | *10401811 | 125/315 | 7,7 | 40 | 72 | 93 | |
| | *10401821 | 125/400 | 9,8 | 40 | 72 | 95 | |
| | *10401802 | 160/250 | 6,1 | 8 | 86 | 90 | |
| | *10401812 | 160/315 | 7,7 | 7 | 86 | 93 | |
| | *10401822 | 160/400 | 9,8 | 50 | 86 | 95 | |
| | *10401813 | 200/315 | 7,7 | 7 | 106 | 93 | |
| | *10401823 | 200/400 | 9,8 | 50 | 106 | 95 | |
| | *10401824 | 250/400 | 9,8 | 50 | 128 | 95 | |
| | *11503027 | 315/400 | | | | | |
| | *11503044 | 400/500 | | | | | |

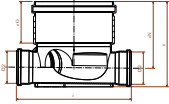

| NAME | PICTURE | CODE | (D/D1) | S | Z1 | Z2 | L1MIN | L2 |
|-----------------------------|-----------|---------|--------|------|-------|-----|-------|----|
| KGRE INSPECTION PIPE | | | | | | | | |
| | 10401920 | 110/110 | 3,3 | 51,7 | 52,68 | 67 | 49,1 | |
| | 10401921 | 125/110 | 3,3 | 51,7 | 51 | 72 | 54,6 | |
| | 10401902 | 160/160 | 4 | 83 | 89 | 81 | 86 | |
| | 10401903 | 200/160 | 4,9 | 86 | 111 | 99 | 106 | |
| | 10401904 | 250/160 | 6,2 | 89 | 91 | 125 | 128 | |
| | 10401905 | 315/160 | 7,7 | 93 | 104 | 134 | 155 | |
| | *11502603 | 400/160 | | | | | | |

| NAME | PICTURE | CODE | D | S | L |
|-------------------|-----------|------|------|------|---|
| KG END CAP | | | | | |
| | 10402904 | 200 | 4,9 | 51,5 | |
| | 10402900 | 250 | 6,2 | 90 | |
| | 10402901 | 315 | 7,7 | 92,5 | |
| | 10402902 | 400 | 9,8 | 95 | |
| | *11502504 | 500 | 12,3 | 120 | |

| NAME | PICTURE | CODE | (D/D1) |
|----------------|---|----------|---------|
| SAG K/K | | | |
| |  | 10799210 | 250/160 |
| | | 10799211 | 300/160 |
| | | 10799212 | 400/160 |
| | | 10799213 | 500/160 |
| | | 10799214 | 600/160 |
| | | 10799200 | 250/200 |
| | | 10799201 | 300/200 |
| | | 10799202 | 400/200 |
| | | 10799203 | 500/200 |
| | | 10799204 | 600/200 |

| NAME | PICTURE | CODE | (D/D1) |
|-----------------|---|----------|---------|
| SAG K/SW | | | |
| |  | 10799110 | 250/160 |
| | | 10799111 | 300/160 |
| | | 10799112 | 400/160 |
| | | 10799113 | 500/160 |
| | | 10799114 | 600/160 |
| | | 10799100 | 250/200 |
| | | 10799101 | 300/200 |
| | | 10799102 | 400/200 |
| | | 10799103 | 500/200 |
| | | 10799104 | 600/200 |

| NAME | PICTURE | CODE | (D/D1) | H | H1 | H2 | L |
|---|---|----------|---------|-----|-----|-----|-----|
| DRAIN MANHOLE STRAIGH THROUGH | | | | | | | |
|  |  | | 315/160 | 384 | 281 | 190 | 479 |
| | | 10799220 | 400/160 | 420 | 315 | 207 | 554 |
| | | 10799221 | 400/200 | 470 | 340 | 207 | 586 |

| | | | | | | | |
|---|---|----------|---------|-----|-----|-----|-----|
| DRAIN MANHOLE COLLECTIVE | | | | | | | |
|  |  | | 315/160 | 395 | 309 | 185 | 490 |
| | | 10799222 | 400/160 | 420 | 319 | 207 | 559 |
| | | 10799223 | 400/200 | 470 | 344 | 207 | 584 |



| NAME | PICTURE | D | D1 | S | Z1 | Z2 | L1MIN | L2 | L3 |
|---------------------------|---------|-----|-----|-----|--------|--------|-------|-------|-------|
| KGB BEND 110/45° | | 110 | | 3.1 | 33.02 | 33.02 | 58.53 | 58.53 | |
| KGB BEND 125/45° | | 125 | | 3.6 | 36.92 | 36.92 | 64.46 | 64.46 | |
| KGB BEND 160/45° | | 160 | | 4.5 | 45.46 | 45.46 | 79.42 | 79.42 | |
| KGB BEND 110/87.5° | | 110 | | 3.1 | 61.15 | 61.15 | 58.53 | 58.53 | |
| KGB BEND 125/87.5° | | 125 | | 3.6 | 68.85 | 68.85 | 64.46 | 64.46 | |
| KGB BEND 160/87.5° | | 160 | | 4.5 | 86.35 | 86.35 | 79.42 | 79.42 | |
| KGEA BRANCH 110/110-45° | | 110 | 110 | 3.1 | 24.94 | 133.47 | 58.53 | 58.53 | 58.53 |
| KGEA BRANCH 125/110-45° | | 125 | 110 | 3.7 | 16.07 | 146.47 | 64.46 | 64.46 | 58.53 |
| KGEA BRANCH 125/125-45° | | 125 | 125 | 3.7 | 26.07 | 152.53 | 64.46 | 64.46 | 64.46 |
| KGEA BRANCH 160/110-45° | | 160 | 110 | 4.7 | 1.15 | 173.97 | 90 | 79.42 | 58.53 |
| KGEA BRANCH 160/125-45° | | 160 | 125 | 4.7 | 11.15 | 178.53 | 88.85 | 79.42 | 64.46 |
| KGEA BRANCH 160/160-45° | | 160 | 160 | 4.7 | 36.15 | 195.57 | 88.85 | 79.42 | 79.42 |
| KGEA BRANCH 110/110-87.5° | | 110 | 110 | 3.2 | 79.94 | 91.47 | 65.06 | 58.53 | 58.53 |
| KGEA BRANCH 125/110-87.5° | | 125 | 110 | 3.7 | 68.07 | 93.65 | 140 | 64.46 | 58.53 |
| KGEA BRANCH 125/125-87.5° | | 125 | 125 | 3.7 | 83.07 | 95.61 | 71.93 | 64.46 | 64.45 |
| KGEA BRANCH 160/110-87.5° | | 160 | 110 | 4.7 | 66.15 | 123.62 | 88.85 | 79.42 | 58.53 |
| KGEA BRANCH 160/125-87.5° | | 160 | 125 | 4.7 | 69.15 | 111.65 | 88.85 | 79.42 | 64.45 |
| KGEA BRANCH 160/160-87.5° | | 160 | 160 | 4.7 | 101.15 | 120.57 | 88.85 | 79.42 | 79.42 |



