euroSewer

TECHNICAL MANUAL
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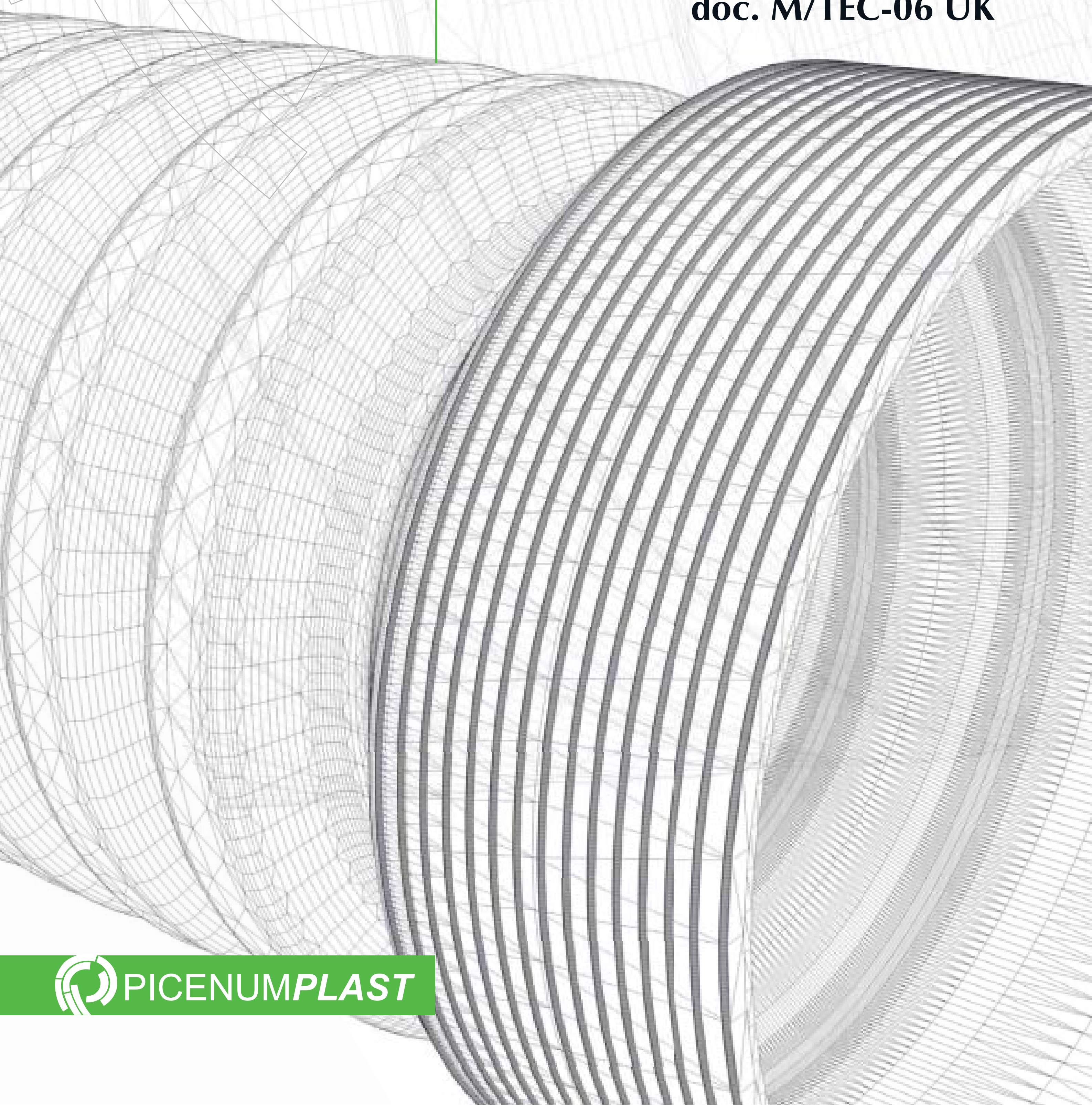

PICENUMPLAST

FOREWORD

***EuroSewer, PE** structured wall pipe for non under pressare underground sewerage and drainage, is the result of 40 years of experience in the plastic material processing field.*
*This know-how lead **Picenum Plast** to reach a leading rank in **PVC** and **PE** pipes production.*
*In the framework of the corrugated pipes (this is how structured-wall pipes are commonly called), **EuroSewer** is the first product which is provided with double-wall in-line extruded cuff (thus without any further process than extrusion).*
This pipe is available in sizes up to 1200 mm (DN/OD 1200).
*Thanks to the product performances and the tests carried on the production process and on the raw materials it was possible to obtain the prestigious P-IIP certification issued by the third-party certification Institute **Istituto Italiano dei Plastici** on august 2002.*
This second edition is an updated version of the first successful issue dated 2003.
It is the result of Picenum Technical Department cooperation with many design offices and it is enriched with information coming from our customers who give us precious and useful feedback from installation and working sites.
*This edition aims to give technical data about **EuroSewer** system and its features.*
This manual contains also many information (taken by relevant technical norms and international rules) for a correct use and installation of this product and its ancillaries.

*In addition to the present manual, the section "Specifications" of **Picenum Plast**'s **website www.picenumplast.com** contains technical information and data about **EuroSewer** and other **Picenum Plast**'s products.*
*The **www.eurosewer.it website** gives the granted users the possibility to make calculations for design and verification of **EuroSewer** pipe, in addition to comparison data with other types of materials.*

Relevant docs and specs:
For further information and concerns please read the following norms and documents:

- ***DM LLPP 12.12.85 (Italian law)** Technical norms concerning piping.*
- ***UNI EN 1610** Construction and testing of drains and sewers*
- ***ENV 1046** Plastic piping and ducting systems – Systems outside building structures for the conveyance of water and sewage –Practices for installation above and below ground.*
- ***EN 476** General requirements for components used in discharge pipes, drains and sewers for gravity systems.*
- ***ISO/TR 10358** Plastic piping and fittings – combined chemical resistance classification table*
- ***prEn 13476-1** (will be called as "norm" or "standard") – Plastic piping system for non-pressure underground drainage and sewerage – Structured-wall piping system of unplasticized polyvinyl chloride (PVC-U), poly propylene (PP) and polyethylene (PE) – Part 1: Specification for pipes, fittings, and system*
- ***prCEN/TR 1295-3** Structural design of buried pipelines under various conditions of loading – Part 3: common method*
- ***UNI 10968-1** Sistemi di tubazioni in materia plastica per scarichi interrati non in pressione - Sistemi di tubazione a parete strutturata di policloruro di vinile non plastificato (PVC-U), polipropilene (PP) e polietilene (PE) - specifiche per i tubi, i raccordi ed il sistema.*
- ***I/CO-100** (**Picenum PLast** internal operating instruction) – **EuroSewer** pipe joint*
- ***I/CO-101** (**Picenum PLast** internal operating instruction) – Installation steps for **EuroSewer** quick-joint GO-IN.*
- ***I/CO-103** (**Picenum PLast** internal operating instruction) – Installation of **EuroSewer** manhole with moulded base*
- *Miscellaneous information by technical reviews and technical manuals*
- *Technical documentations iussed by Istituto Italiano dei Plastici (IIP)*
- *Other relevant norms and documents*

SUMMARY

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1.1 Sewage networks

Generally speaking, pipe networks which are correctly designed, produced and installed can bring to successful results in use. Instead of going deep in the subject of the various materials which are used for pipe production, this chapter aims to underline some aspects which should be taken into consideration by sewage networks designers and end-users.
The main requirements for sewage pipes are listed below:

- **Hydraulic performances (roughness) at short and long term;**
- **Resistance to internal pressure, in standard conditions and in case of hydraulic overloads as well;**
- **Structural resistance to external loads;**
- **Tightness of the joint system in both directions of the flow and at long term;**
- **Insensitivity to chemical and electro-chemical aggressions;**
- **Wear resistance;**
- **Adhesion of the incrustations;**
- **Cleaning by means of modern technologies (jet)**
- **Easy and quick assembly, joint and installation**
- **Cost effectiveness**

These aspects above mentioned must be clarified:

- The reliability of each material to the design requirements must be checked upon **realistic bases;** this must be done in particular for the hydraulic performances such as the inner size and hydraulic roughness
- **The resistance to wear and chemical / electro-chemical aggressions** must be checked according to the chemical and physical **characteristics of the drainage and sewage**
- **The resistance to the internal pressure** and the **long-term tightness** must be ensured regardless to the type of pipe; this requirement must be specially taken into consideration for pipes with joint by sleeve, for which the length and the characteristics of the sealing ring are the most important features.
- The **joint** tightness must work in **both directions** (from inside to outside and vice versa). Many problems on existing sewage networks arise from underground water which penetrates into the pipe or because of leakage through the joints. These problems have big consequences on the effectiveness of wastewater treatment plants. The leakage from the joints is often due to mistakes while installing the pipe, even if the structure of the joint and the sealing gasket type may add further problems to this situation.
- **The high-pressure or mechanical cleaning systems** may have dangerous consequences on some types of materials, by giving origin to joint movements or to breaks on the pipe indeed

For what concerning the costs, it is important to highlight the total cost of the sewage network rather than making only an economical comparison of the cost of the pipes itself. This overall cost must be inclusive of the expected costs for maintenance and the time-life, which shall be as long as possible.
EuroSewer shows best features for all the above mentioned aspects.

1.2 Most commonly used materials for piping production

Historically, sewage networks, if existing, were made by open-pit stone handworks, like bricks.
For what concerning the use of plastic materials for modern sewage pipe production, the Poly-Vinyl chloride (PVC-U) has been the first plastic material to be employed for sewage and drainage pipe production, because of its cost effectiveness and easy installation.
Unfortunately, this material not always gives the expected performances.
While the use of Polypropylene (**PP**) is limited to special applications (especially for industrial and high-temperature applications), pipes made with extruded smooth high-density Polyethylene (**HD-PE**) did not have a successful diffusion in the market for not under pressure pipe networks, especially for small-size pipes.
This low success is mainly due to the high cost of the pipes.

On the 80's **HD-PE** structured-wall have been successfully introduced in the market, with sizes up to 3,6 m.
The basic principle which gave origin to the development of these "new-concept" pipes is the possibility to join the features of polyethylene (such as the excellent resistance to wear and aggressive water) to the lightness and high structural resistance (stiffness), thus lowering the cost.
In this framework, many pipe brands were born, such as BAUKU, HENZE, KWH. These pipes are produced by using patented technologies and can be bought at the latest versions.After the development of new technologies, many "last-generation" structured-wall types have been created, among which **EuroSewer** is the latest product.
Thermoplastic structured-wall pipes are widely entering the Italian market of sewage pipes.
That's why **Picenum Plast** decided to issue documents and pubblications regarding this subject. These documents are distributed by **Picenum Plast**'s promoters and are available through Picenum Plast's Technical Department.
Structured-wall pipes show an excellent resistance to wastewater aggressions and to external loads due to installation and use.
They are easy to install and they have a long life-time with reduced maintenance, in addition to an unbeatable ratio cost/effectiveness for the installed pipe. All these features make it a forward-looking pipe.
For a sewage network, factors like the overall cost and the lifetime of the installation must have the priority for a correct management of public works.
According to this, designers and end-users shall try to optimize the "project", intended as a set of steps like a detailed design, a correct material choice, a proper and cheap installation method definition, and the choice of the contractor, in order to obtain a technically and economically effective work

1.3 Rigid and flexible pipes

While dealing with pipes, The first difference which must be made is between rigid and flexible pipes.

Rigid pipes are pipes for which a deformation of the cross-section must not be achieved without damaging the pipe.

According to the AWWA (American Water Works Association) "rigid" pipes are damaged by applying a 0,1 % deformation, while "semi-rigid" pipes can bear a deformation up to 3%.

Flexible pipes are pipes for which a high deformation (for AWWA > 3%) can be applied without damaging the pipe.

For these pipes, both the short-term and long-term deformation can reach high rates -which are not compatible with the correct functioning of the pipe- without any visible damages or possible structural collapse
Pipes made in concrete, fiber cement, cast iron, gres must be considered as rigid pipes; plastic pipes belong to flexible pipes category instead.

The ring stiffness (or rather the resistance to defomation) is the "key-parameter" which influences the performances of flexible pipes.
This parameter is dependent to geometry (such as momentum of inertia) and physical characteristics of the raw material (such as elasticity modulus).
It can be calculated either mathematically for solid-wall pipes,by using a correct elasticity modulus, or experimentally for structured-wall or composite-wall pipes, by performing a test.
Technically speaking, the ring stiffness of the pipe is identified by the parameter **SN**, defined as:

$$SN = E \cdot \frac{I}{Dm^3} \quad (Pa)$$

E = elasticity modulus of the material (Pa)
Dm = Mean diameter of the pipe (m)
I = momentum of inertia (m4/m)

In the framework of sewage pipes, the term "flexible" must be intended as able to be deformed in vertical direction.
While evaluating the concept of "flexibility", the elasticity modulus of the material is widely important.
Rigid pipes have an elasticity modulus **E** which is widely higher than the one found for flexible plastic pipes, as shown in the table below:

tab. 1 Elasticity modulus for different materials

Material	Elasticity modulus (average values, MPa)
Fiber cement	$2,5 * 10^4$
Concrete	$3,0 * 10^4$
Gres	$5,0 * 10^4$
Cast iron	$10 * 10^4$
Ductile cast iron	$17 * 10^4$
PVC	$3,6 * 10^3$
HD-PE	$1,0 * 10^3$

An high value for **E** can lead to a brittle behaviour of the material, unless this parameter is balanced by a high impact resistance, like for **PE**. The second parameter which influences the stiffness is the momentum of inertia **I** of the cross-section of the pipe. For pipes, in order to achieve a suitable ring stiffness with low **E** values it is necessary to work on the momentum of inertia of the cross-section of the pipe, **$I = s^3/12$,** which is dependent form the **s** (pipe wall thickness) value. This value can be either "real" or "apparent" (this second case is better defined as "equivalent thickness").
A method to increase the **I** value is often obtained by creating ribs or corrugations, in order to avoid high wall thicknesses and high weight and costs.

Plastic pipes must be considered as flexible pipes.
Pipes made of PVC, PE and PP are produced with thermoplastic materials, either both with solid-wall and with structured-wall type. These pipes have a high resistance to chemical aggression and low roughness values. The type of material is homogeneous throughout all the wall thickness and the corrugations (this is not true for multi-layer wall type).
PVC pipes are generally provided with cuff joint, while structured-wall pipes made of PE and PP are provided either with cuff or with sleeve joints.

1.4 Interaction between the pipe and the soil

EuroSewer, like all the other plastic pipes, must be considered as a flexible pipe.
A load acting on a flexible pipe brings to a deflection of the pipe itself. Because of this deflection, the pipe gets oval thus compressing the surrounding material at the sides of the pipe.
This compression gives origin to a side-reaction force which keeps under control the pipe deflection which generated it. The amount of the pipe deflection is determined by the precautions taken during installation and by the choice of the backfilling materials.

Trench geometry:	Trench width, Trench depth, protection system, Cross-profile of the trench (stepped trench, sloped walls)
Compaction methods:	of the side backfilling, of the final backfilling
Pipe bearings and trench bottom conditions	
Native soil & backfilling soil conditions:	Thermal (frost, melting), climatic (rain, snow)**,** humidity (trench flood, underground water)
Loads acting on the pipe installation:	Dynamic (traffic and temporary loads), Static (upper soil weight)
Loads acting on the pipe installation:	Dynamic (traffic and temporary loads), Static (soil weight)
Native soil type and relevant parameters:	Subsoil & native soil, Trench walls, backfilling soil
Special installation conditions:	Above-ground installations, Connections to rigid structures, Multiple pipelines in the same trench

In flexible pipes, the deflection can reach high values; the side reaction prevents this deflection to exceed the maximum limit. As a result of it, the vertical load keeps lower.
For what said above, it is important to achieve, while laying the pipe, a good side-reaction through a suitable backfilling soil compaction, in order to set the pipe deflection to safety limits.

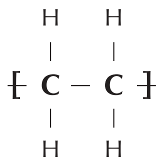
According to this foreword, it can be easily understood that the higher is the “stiffness” of the material surrounding the pipe, the higher is the resistance of the pipeline to external loads.
The reaction given by the set “native soil + backfilling material” can be defined as “side-stiffness” and it is strictly related to the elasticity modulus **e** of the backfilling soil.
This parameter is dependent on the backfilling soil compaction level and on the undisturbed soil of the side walls. It will be shown afterwards that the side-stiffness will be much more important than the pipe ring stiffness in order to reduce the deformations and the tensions on the pipe cross-section.
The calculation methods (found by Spangler, Watkins, Barnard) take into consideration that the **e** value (elasticity modulus of the backfilling material, which can be considered as the passive reaction of the surrounding soil) is not constant; instead, in practice, the **E’ = e · r** factor (**r** is the radius of the pipeline) keeps constant. **E’** is called “deformation modulus” or Soil Modulus (Pa).

Technical literature shows tables in which the **E’** value is given as a function of the soil type and the compaction rate (%); The pipeline designer shall choose a correct **E’** value according to the local conditions and the prescriptions stated for the backfilling.

The relevant norm contains requirements about the impact resistance of the pipe. These requirements allow the pipe to be handled in the working site and to be protected during compaction.
A difference must be done between initial (short-term) **deflection** (d_i) and **long-term deflection** (d_{LT}) of the flexible pipe; the first is achieved (and can be checked) once the pipe is installed, because of the static loads due to the upper soil and dynamic loads due to external actions; as time passes, the deflection in the pipe grows step by step, until it reaches –after several years- an asymptotic value defined as (d_{LT})

CHAPTER 1 General

2.1 The polyethylene – General



It's a thermoplastic resin, belonging to polyolephyne's family, which is obtained through ethylene polymerization.

The polymerization process consists on joining together ethylene molecules thus forming a long chain called macromolecule or polymer.
According to the various synthesis processes it's possible to obtain polyethylene chains with different crystallinity.
This characteristic is defined as the ratio between the amorphous zones and the crystalline zones in the plastic mass).
It's possible to find many polyethylene grades in the market, according to their rheological properties.
According to this difference, High-density Polyethylene (HD-PE), Medium-density Polyethylene (MD-PE) or Low-density polyethylene (LD-PE) can be used for many applications:

- Transport of water under pressure;
- Gas distribution;
- Discharge water and sewage conveying;
- Miscellaneous applications;

Polyethylene pipes have many outstanding advantages, which determined their success in the market throughout these years. These advantages are:

- **Lightweight and flexibility**
  Which means easy handling and installation

- **Excellent impact resistance**
  Polyethylene pipes have low risk due to overload collapse and an unbeatable resistance to rapid crack propagation (RCP)

- **Total tightness for gasses and vapours:**
  In addition to it, PE pipes don't release substances which may affect the taste or the smell of the conveyed fluid (see Italian norm UNI EN 1622)

- **High resistance to weathering and UV-rays alterations:**
  Owing to this feature it is possible to stock PE pipes for quite a long time before installing it

- **Outstanding resistance to chemicals and bacteriological proliferation:**
  This feature makes PE pipes suitable for aggressive fluids conveyance (such as industrial process fluids or discharge waters). PE resistance to chemicals can be found in details in the Doc. ISO/TR 10358. PE is also electrically idle and insensitive to enzymes and molds aggression.

- **Insensitivity to low temperatures**
  It is possible to use PE pipes at temperatures much lower than 0 °C.
  For pressure applications, the operative temperature upper limited at 40 °C (for further details please read the European norm UNI EN 12201).

Temperature influences the mechanical properties of the pipe such as the thermal elongation.
This phenomenon can affect the installation effectiveness because of pull-out problems.
PE shows a linear elongation coefficient (1,7 ÷ 2,2) $\cdot 10^{-4}$ C^{-1}; however, the structured-wall geometry distributes any thermal elongation both in an axial (like for smooth-wall pipes) and in a radial direction, thus limiting the effects. Studies carried out at temperatures respectively from -10 °C and +70 °C to the ambient temperature demonstrated that the elongation/shrinkage undergone by the pipe doesn't exceed ± 5%.
For a safe installation in order to prevent pipe from pull-out problems, the **EuroSewer** cuff joint system is provided with cuff lengths much higher than the as-per-norm minimum values.

- **Flexible and wide-choice production (diameters and lengths):**
  The easy and flexible production process allows a wide choice pipe production, with customizable lengths (the length is only limited by the possibility to be transport the pipes). **EuroSewer** is produced either in 6m + cuff joint or in 12 m + sleeve joint standard lengths.

- **Excellent wear resistance:**
  This features makes polyethylene unbeatable for production and internal coating of pipes for hydraulic/ pneumatic transport of solid matters and for the sewage and discharge waters applications.
  Studies carried out in order to evaluate the wear resistance of different raw materials commonly used for sewage pipes production show the supremacy of PE, as indicated in the table below ***(tab.2)***:

tab. 2 Removal time of a fixed wall thickness

Raw material	Removal time (hrs) of a fixed wall thickness
Concrete	20
Steel	34
PVC	50
Grès	60
PE	100

2.2 Polyethylene – Technical properties

The polyethylene grade used for **EuroSewer** production shows technical properties common for all thermoplastic resins, such as elasticity modulus **E** and deflection under a fixed load.
These values are time and temperature dependent

The norm gives indication of further standard properties of the raw material:

- Elasticity modulus E × 800 MPa;
- Average mass-density é 940 kg/m^3;
- Thermal elongation coeff. é 0,17 mm/mK;
- Thermal conductivity (0,36 ÷0,50) W K^{-1} m^{-1};
- Thermal capacity (2300 ÷2900) J kg^{-1} K^{-1};
- Surface electrical resistance > 10^{13} á

The raw material used for **EuroSewer** production is 1st quality material which fulfils the technical requirements listed below:

tab. 3 Requirents on PE raw material according to the relevant norm

Characteristic	Requirements	Test parameters		Test method
		Parameter	value	
Mass-density	× 930 kg/m^3	Temperature	(23±2) °C	ISO 1183
Mass flow Rate	MFRÖ1,6 g/10'	Temperature Load	190 °C 50 N	ISO 1133
Long-term hydrostatic strength (carried on solid-wall samples produced with the same raw material)	No break during test time	Sample holder N. of samples Temperature Hoop stress Test type Test time Temperature Hoop stress Test type Test time	Types A-B 3 80 °C 3,9 MPa Water/Water 165 h 80 °C 2,8 MPa Water/Water 1000 h	EN 921
Thermal stability (OIT)	× 20'	Temperature	200° C	EN 728

3.1 The profile

The EuroSewer production is the latest result of the production equipments for the production of a particular large-corrugation structured-wall type, which was first tuned in Canada and then successfully applied in anglo-saxon countries. Similar profiles can be found in German and Scandinavian technology.

The **EuroSewer** special profile, belonging to type **B** of prEN 13476-1, is the latest result of technological development for structured-wall production equipments, which allow to turn the traditional shape (with a flat or arch-shaped top) into a double-arch structure.

As a further advantage, The **EuroSewer** production technology is provided with an integrated pneumatic system which creates an enlargement of the two layers of the pipe, thus joining them.
Through this shaped enlargement it is possible to create a cuff zone, which is a completely integrated part of the pipe and "one-pack" joined with it.

Owing to this system it is possible to avoid joint systems obtained with further processes (such as, for example, joint with sleeve and gasket or by welding).

fig. 1a

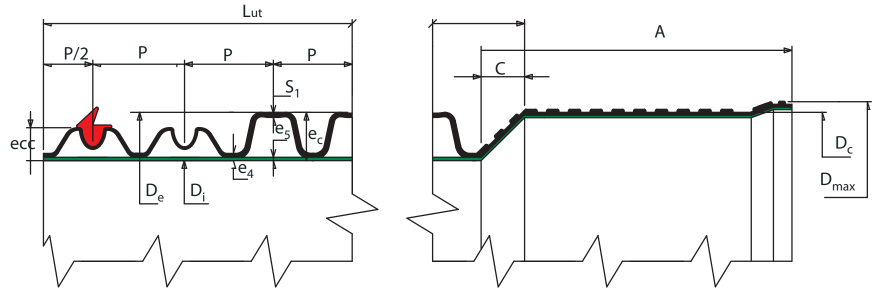
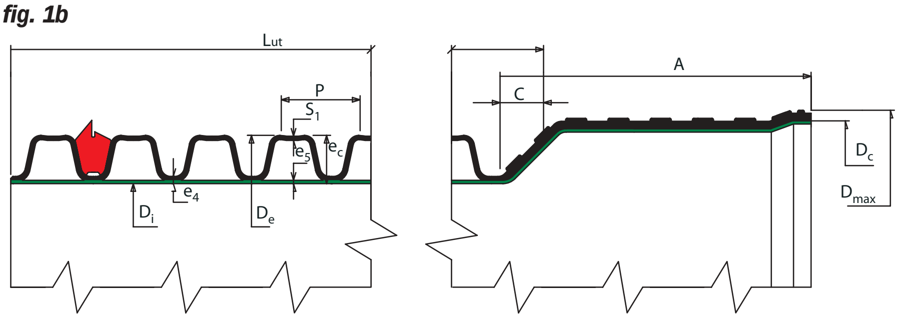


fig. 1b



Eurosewer axiel profile - (*fig.1a) DN/OD Ö 1000;* ***(****fig.1b) DN/OD = 1200*

Symbols

L_{ut}	Useful length (mm)
P	Corrugation pitch (mm)
C	Length of the cone trunk cuff zone
A	Pull-out length (mm)
S_1	External layer wall thickness (mm)
e_5	Standard minimum wall thickness (mm)
e_4	Joint zone wall thickness (mm)
e_c	Structured-wall height (mm)
D_i	Internal diameter, larger than the minimum required by the norm (mm)
D_e	Standard external diameter according to prEN 13476-1 (mm)
D_c	Cuff External diameter (mm)
D_{max}	Maximum pipe diameter (corresponding to the cuff flare) (mm)

This features makes **EuroSewer** joint system more safe and reliable with respect to the other joint systems in the market.
This advantage leads to an easy installation and stocking of the bars as well.

The double-arch typical shape of the upper side of the external layer is created by a special production equipment based on an advanced technology.
This structure allows the possibility to change the ring stiffness SN of the pipe from 4 to 8 KPa, by changing mainly the thickness of the corrugation.
The smooth shape of the inner layer provides, through its physical and geometrical features, the required hydraulic performances of the systems.
The external layer is involved in the structural properties of the system instead. The norm doesn't fix a minimum value for the outer layer wall thickness **S1**, which must be designed in order to guarantee a requested **SN** value, as marked on the pipe.

By changing the thickness of the external layer during production (thus increasing the weight of the pipe) it is possible to change the ring stiffness of the pipe, which is produced in the ring stiffness classes **SN4** and **SN8.**

The norm sets a minimum value for the inner layer wall thickness **e_5**, in order to protect the conveyed flow from wear and load dangers (such as the ones which arise while cleaning the pipeline by hydro-jet equipments).

3.2 Technical characteristics

The table below ***(tab.4)*** contains average production dimensions (mm) for the ring stiffness class **SN = 4 KPa**, which is the most commonly used in the European market.

For each stiffness class, the **EuroSewer** standard inner sizes are bigger than the minimum ones required by the norm; this can be achieved because it is possible to obtain different ring stiffness classes by simply changing the wall thickness of the profiled layer.
This cannot be obtained for other pipe types production, in which the ring stiffness is changed by changing the height or the pitch of the structured wall.

Any fluctuation of the wall thicknesses which may be found are caused by process tolerances and shrinkage while cooling down, which are physiological phenomena in PE pipe production. These fluctuations don't affect the main properties of the pipe anyway.
The process standards allow to keep the inner diameter constant within the physiological shrinkage tolerances, thus giving designers trustworthy references to perform hydraulic calculations and designs.
The production systems are equipped with moulds which allow the production of standard and constant-shaped profiles, thus guaranteeing the compliance with the dimensions given in the table above.
The shape of the corrugation doesn't change any case but because of the shrinkage during the cooling process in production.

tab. 4 Eurosewer dimensions

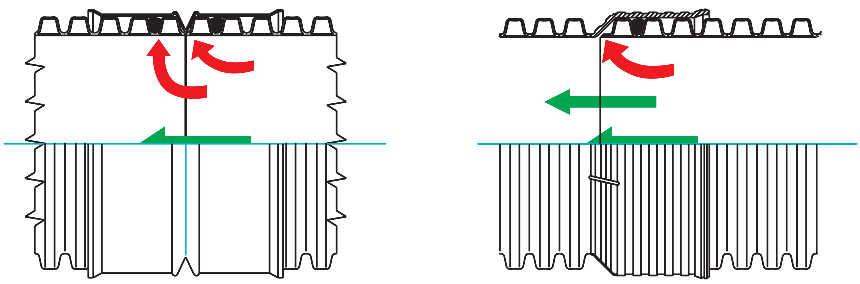
DN OD	Diametres		structured-wall geometry			cuff zone geometry		Lenghts (mm)	
	De min - max	Di reale - STD	P	e_5	e_c	C	A	useful	total
125	124,3 - 125,4	107 > 105	18	× 1,0	8,9	-	-	6000	6000
160	159,1 - 160,5	136 > 134	33	× 1,0	11,8	14	70 > 42	6050	6130
200	198,8 - 200,6	174 > 167	33	× 1,1	13,1	20	75 > 50	6990	6080
250	248,5 - 250,8	214 > 209	40	× 1,4	18,0	22	90 > 55	6050	6150
315	313,2 - 316,0	273 > 263	42	× 1,6	20,8	28	110 > 62	6000	6150
400	397,6 - 401,2	343 > 335	48	× 2,0	28,2	38	130 > 70	6005	6180
500	497,0 - 501,5	427 > 418	56	× 2,8	36,1	48	155 > 80	5940	6130
630	626,3 - 631,9	533 > 527	100	× 3,3	48,2	84	170 > 93	6005	6205
800	795,2 - 802,4	673 > 669	98	× 4,1	62,9	88	275 > 110	6100	6380
1000	994,0 - 1003,0	849 > 837	98	× 5,0	74,9	100	250 > 130	6060	6350
1200	1203,6 - 1192,8	1040 > 1015	130	× 5,0	50	65	220 > 150	6065	6285

3.3 The cuff-joint system

Picenum Plast decided to provide **EuroSewer** pipe with cuff-joint system and rubber gasket, for the following reasons:

- **The production process is essentially safer than the one employed for welded-sleeve solution:**
  The overall production process is formed by the single one-step extrusion of the "system cuff+pipe", without any additional process, thus increasing the reliability of the joint system;
- **Safer and easy installation:**
  From the point of view of the reliability, since the system is formed only by pipe and gasket, less items must be handled, joined and stocked, thus decreasing any trouble with respect to the set formed by pipe + joint system + gasket
- **Theoretical Higher reliability of the joint system with respect to the "double gasket + sleeve" joins solution:**
  The cuff shape in place of the sealing gasket eliminates all the leakage risks which may arise in the most critical zones form the hydraulic point of view (see fig. 2)
- **Ribbed double-layer cuff: Stiffness increases in the most critical zone**
  The **EuroSewer** joint system is designed in a way that the spigot (which is the part of the pipe which fits into the socket) of the pipe has the same stiffness of the pipe itself. Therefore, the (high) stiffness of the double-layer ribbed cuff is added to the the stiffness of the pipe, thus giving origin to a high-stiffness joint zone (much higher than the pipe stiffness). This zone is the most critical zone of the whole piping system from the hydraulic point of view. The stability of the geometry of the joint tightness surface, both at a short-term and at a long-term (creep phenomenon).

fig.2



Joint system
with double gasket
+ sleeve

Joint with
ribbed double-layer
Eurosewer cuff

3.4 Reference norm

In European countries, the reference norm for **EuroSewer** is represented by the project of norm **prEN 13476-1:**
Thermoplastic piping systems for non-pressure underground drainage and sewerage - Structured-wall piping systems of unplasticized polyvinyl chloride, (PVC-U), polypropylene (PP) and polyethylene (PE) - part 1: Specification and Requirements for pipes, fittings and the system.
This norm contains definitions and requirements for pipes, fittings and the system of structured-wall pipes made of PVC-U, PP and PE employed in underground sewage and drainage.
EuroSewer is defined as:
Structured-wall co-extruded double-layer pipe, provided with ring corrugation type B according to prEN 13476-1.
The Italian reference norm is the **UNI 10968-1:**
Sistemi di tubazioni in materia plastica per scarichi interrati non in pressione - Sistemi di tubazione a parete strutturata di policloruro di vinile non plastificato (PVC-U), polipropilene (PP) e polietilene (PE) - specifiche per tubi, i raccordi ed il sistema

This norm is the Italian translation of the European project of norm prEN 13476-1, with further normative & informative appendixes containing some restrictions about the use of raw materials. The information which will be later given can be considered as valid for both reference norms.
According to this norm, many requirements must be accomplished. These requirements involve:

- Raw material properties;
- General requirements about: appearance, colour, geometry, mechanical performances and physical properties;
- Requirements for fittings and ancillaries;
- Use compatibility, requirements and tests;
- Marking;
- Prescriptions for use of re-processed or recycled raw material;
- PE raw material properties (informative appendix);

According to the definitions, pipes in keeping with prEN 13476-1 can be divided in three categories, depending on the shape of their structured-wall:

tab. 5 Structured-wall type classification

A1	multi-layer or axial hollow cross-section wall type
A2	hollow walls with spiral or radial reinforcement
B	Solid spiral or ring or hollow ribbed wall

A difference in the project of norm is made for what concerning the application area of the pipes.
This application area is defined by the following codes:
tab. 6 Area code

Cod. U	Outside the building structure
Cod. D	Inside the building structure

The performances, the physical properties, the field of application and the production data are permanently marked on the corrugation of the pipe; in particular, the following data are marked:

- The name of the producer and/or the commercial name of the product (**EuroSewer)**;
- The quality certification logo **P-IIP**, issued by Istituto Italiano dei Plastici, together with the IIP quality membership number (131)
- The reference norm, **prEN 13476-1**;
- The application area code (**U**)
- The structured-wall type (**B**)
- The geometrical data (**DN/OD**) and the minimum declared ring stiffness class **SN**;
- The production data.

In addition to the requirements for the raw material, high attention must be paid on the tests which are carried on the product in order to achieve and maintain the required performances. These test methods are described in related norm, such as:

- **EN ISO 9969: Pipes made with thermoplastic material: ring stiffness test method.**
  This test method gives as output the ring stiffness value SN (expressed in KPa) of the, which can be considered as an indication of the resistance against pipe deflection. This parameter is very important in order to guarantee a suitable long-term resistance to external loads (upper soil, traffic) according to the installation conditions, thus preventing damages to the pipeline (deflection over the limits, leakage or infiltration through the joints). The prEN 13476-1 norm provides for the ring stiffness class SN 2 (for sizes over 500 mm), SN4, SN8 and SN16 KPa.

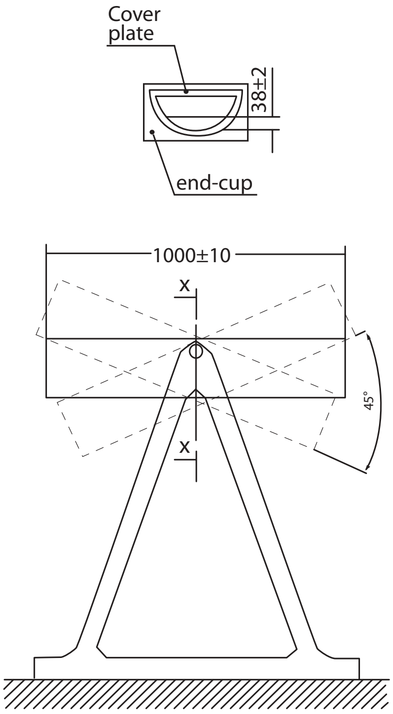
EuroSewer is produced in two ring stiffness classes:

SN 4 - SN 8

- **EN 1277 – Plastic piping systems: Thermoplastic piping systems for non-pressure underground applications: Test method for the evaluation of the tightness of the joints with rubber gasket**
  In this (pressure) test the joint system is subjected to high-deflecting loads, in order to reproduce the real use conditions, thus preventing leakage. In particular, this test is divided in two steps: in the first simulation, a different deflection is applied to the cuff zone (5%) and to the spigot zone (10%), in the latter the axis of the two pipes which form the joint are bended with a defined angle (this angle may vary, according to the pipe size, form 2° to 1°). In both simulations, a tightness test is carried on the system, first by using water at 0,5 bar then in vacuum by air at -0,3 bar).

The following table (**tab.7**) contains detailed information about the tests and test conditions which are carried on the pipe.

fig.3 - **Device for wear resistance test**



• Additional tests not contained in the norm: UNI EN 295-3-12. Wear resistance test

This test is important to give an indication of the high wearresistance of HD-PE with respect to the other stone-like raw materials (grès or concrete) or metallic (steel, cast iron). In this test, a 1 meter-length sample of pipe (half-pipe) is filled with a mixture of sand, gravel and water (wearing medium), then it is swung in order to simulate a wear action of the medium. Tests made by Istituto Italiano dei Plastici (see technical report No. 7/04 dated 24/06/04) carried on **EuroSewer** samples gave as a result, after 100.000 cycles, an average abrasion wall thickness value < 0,1 mm, while in literature the average values detected on samples made of grès are 0,2÷0,5 mm. It is also important to note that EuroSewer Polyethylene pipe keeps its wear-resistance features constant throughout the whole thickness; This cannot be achieved for other products in the market, in which the resistance to wear is given by special coatings at the inner surface of the pipe. After this coating is removed (this may happen for aggressive fluids or after several years of lifetime) the wearing fluids enter in contact with the "weak" part of the material. Therefore, the wear process increaseses exponentially. Several studies carried on polyethylene pipes demonstrate that the wear process keeps linear, thus giving more guaranteee about safety and long-lasting of the pipe against wear phenomenon.

tab. 7 - CONFORMITY REQUIREMENTS ON EUROSEWER PIPE

Specifications	Instruction	Testing parameters		Testing methods
Circumference thickness	× of the classificaation one	In keeping with EN ISO 9969		EN ISO 9969
Creep ratio	Ö 4 with a 2 year extrapolation	In keeping with EN ISO 9967		EN ISO 9967
Impact resistance	TIR Ö 10%	characteristics	readings	EN 744
		Percussion type Percussion mass Falling height Testing temperature Conditioning	prEN13476-1 prEN13476-1 prEN13476-1 (0 ± 1) °C Water/Air	
Ring flexibility	prEN 13476-1	Deformation	30% of the outer diameter	EN 1446
Oven test	Ö 3% without any cracks or delamination	Temperature Immersion type Ö 8 mm > 8 mm	(110 ± 2) °C 30 min 60 min	ISO 12091
Joint tightness test		Temperature Pipe deflection Cuff deflection	(23 ± 2) °C 10 % DN 5 % DN	EN 1277 Cond. B
	No loss for 15 min	Water pressure	0,05 bar	
	No loss for 15 min	Water pressure	0,5 bar	
	êP max Ö 10% for 15 min.	Air pressure	- 0,3 bar	
		Temperature Angular deflection	(23 ± 2) °C Dext Ö 315 2° 315 < Dext Ö 630 1,5° Dext Ö 630 1°	EN 1277 Cond. C
	No loss for 15 min	Water pressure	0,05 bar	
	No loss for 15 min	Water pressure	0,5 bar	
	êP max Ö 10% for 15 min.	Air pressure	- 0,3 bar	

3.5 Technical specification for purchase contracts

For any sewage pipe purchase and/or prescription, the designers or the winner of public/private tenders shall issue a clear technical specification list which may contain the characteristics of the pipe.
These characteristics shall involve prescription for raw material and the typical performances of the pipe as well.

EUROSEWER PURCHASE SPECIFICATION

Structured-wall HD-PE pipe for underground sewage and drainage not under pressure, in keeping with the european document prEN 13476-1:2002.

Structured-wall HD-PE pipe for underground sewage and drainage not under pressure, in keeping with the european document prEN 13476-1:2002.

Pipes shall be certified by IIP – Istituto Italiano dei Plastici, which will issue the P-iip certifi cation seal.

The pipes shall be produced in a factory provided with a Quality Mangement System (QMS) in keeping with the european norm UNI EN ISO 9001:2000, certified by authorized third party institute.
The structured wall of the pipe shall be formed by a corrugated outer wall (type B of prEN 13476-1) and a smooth inner surface.
The joint between pipes shall be made by elastomeric gasket (in keeping with EN 681-1 norm) and double-wall ribbed cuff, obtained by in-line extrusion during pipe production. The joint system performances shall be certified by a third party institute such as IIP.

The internal and external surfaces shall be clean and free from holes, scratches and any other defect which may influence the conformity to the norm.

The pipe ends shall be sharply cut perpendicularly to the pipe axis. Afetr cutting any sharp edge shall be chamfered.

TECHNICAL & QUALITY REQUIREMENTS:

- Nominal diameter: outer DN/OD..,inner min.Di.., (equal or above the minimum defined in the norm).
  Made using first quality granule, requirements such as those given by the norm.
  Supplied in 6 mt - cuff sticks, double-wall extruded in-line to increase the reliability of the system pipe-joint.

- Hydraulic water/air tightness of the joint system certified at 0,5 bar in pressure and 0,3 bar in depression carried out in accordance with the EN 1277 norm (conditions B and C).

- Ring stiffness class SN (4-8) KN/m2 taken from samples of the product according to EN ISO 9969.

- Colour: inner green (other colours on demand) to help visual inspection; outer black for more resistance to ultraviolet rays.

- Marking shall be made at least each 2 metres of pipe; it will be according to the norm, including:
  [normative reference] [producer or making] [nominal diameter] [nominal ring stiffness SN] [material] [wall type] [area code] [month/year of production] [control number and/or Italian Plastic Institute seal]

- Joint type by ribbed double-wall integrated cuff obtained directly during the extrusion of the pipe

- Certification on display and reference norms:

  - P-IIP/A seal of the pipe and joint system issued by IIP
  - European committee of standardization (Doc. prEN 13476-1)
  - EN ISO 9969
  - EN 1277
  - UNI EN ISO 9001:2000 third party certifi cation of Quality Management System
  - Other norms in connection with the testing parameters as indicated in the above mentioned norms.

The designer should also include in the product technical specifications any limit concerning the maximum hydrostatic load (pressure) of the pipe (these limits are prescribed in particular for joints with rubber gasket) in case it should exceed the limits of the norm. It should also be clarifi ed if the prescribed hydraulic load may be steady or occasional.

The pipes according to the prEN 13476-1 norm, despite to their resistance to internal pressure, must be considered (and used) as pipes not under pressure.

3.6 Quality product: The IIP certification

As said before, the conformity to the norm involves the compliance with the requirements herein included. Therefore, this compliance is an element of quality for **EuroSewer**.

This quality must be ensured to the customer; it must be also kept constant during all the steps of the production process, in order to guarantee the suitability for use and reliability throughout all the life time of the product.
In this aim, **Picenum Plast** decided to commit the quality product guarantee to a third-Party institute, through the conformity to the prEN 13476-1 norm.

The Third-Party Institute, **IIP** srl (Istituto Italiano dei Plastici) is a SINCERT-authorized testing, inspection and certification Institute, carrying out Quality promotion activities in services & manufacturing field, with particular reference to Plastic Material field of application.

The voluntary compliance to **IIP** protocol and the achievement of P-IIP/a Quality certification give the customer a complete guarantee about the following requirements:

- **Process control**, through periodical monitoring, recording and storage of the manufacturing parameters (temperature, pressure, extrusion speed, out-of-range events) and through a non conform product control as well;

- **Product control:** Tests according to prEN 13476-1 are carried out on the product at a steady intervals; the requirements contained in the test norms are the minimum values which must be withstood by the product in order to avoid the product to be declassed. The results of the tests are contained into an analysis certificate (test report), which is available for all customers and shows evidence of the performed tests successfully carried out on the product.

- **Periodical Audits**: IIP inspectors perform inspections and random tests on the products and on the factory documentation as well.

As a further and total guarantee of it, **Picenum Plast**'s Quality System Management is since many years IIP-certified in keeping with the **UNI EN ISO 9001:2000 norm.**

3.7 Laboratory tests

The whole **EuroSewer** production is steadily tested and controlled in laboratory, in order to ensure and maintain the product performances.
These performances are defined in the certificate of analysis, which contain the list of the tests defined by the norm.
Internal tests are also performed at steady intervals.
Each raw material lot is tested in order to check its properties which must be within the ranges defined by the standard.

For each production lot, the certificate of analysis contains test reports such as:

- Dimensional check on Internal diameter, outer diameter and the "e_5"wall thickness;
- Vertical deflection test according to EN ISO 9969 (Ring stiffness test)
- Ring flexibility test at high deflection rates without cracks or buckling (EN 1277);
- Impact resistance test without cracks (EN 744)

In addition to the above mentioned tests, other tests are carried out steadily on the products and are included in the technical production documentation.
Further tests and analysis (not required by the norm) have been set by **Picenum Plast** laboratory, who is at customer's disposal in order simulate and study all the possible aspects of EuroSewer's behaviour even in special applications.

4.1 Hydraulic design

4.1.1. General

Customers are kindly invited to have a look at the documentation contained in the **EuroSewer** software design, which offers the possibility to perform design & check for pipes.
It includes also many information and technical data.

Sewage networks defined in **EuroSewer**'s field of application are classified and designed as networks not under pressure.

The sewage/discharge water doesn't fulfil completely the cross-section of the pipe, but it rather flows into it as a channel.

The upper surface of the flow is in contact with the air, thus the stream is in atmospheric pressure conditions.
An approximate theoretical simulation of this type of flow conditions is defined as "free-flow".

The parameters which rules in this theory are:

- Pipe slope –i-; typical values for this parameter are between 0,001 and 0,1
- The channel cross-section (which is supposed to be prismatic). **EuroSewer** cross-section is circular.
- The roughness of the material of the channel which is in contact with the flow.

For sewage networks and for pipelines in general, the **absolute roughness K** (mm) contained in the Colebrook formula (or in the other related applicable formulas) is a widely discussed term.

Every pipe producer tried to advertise its pipes as they were "smooth", thus suggesting **K** values as lower as possible ***(tab.8)***.

The following table ***(tab.8)*** shows a partial example of the differences for **K** among the various raw materials used for pipe production.

tab. 8 Absolute roughness values for different materials

Raw material	K	
	min	max
Steel	0,01	0,1
Cast iron	0,01	1
Cast iron with concrete or bitumen internal coating	0,03	0,2
Plastic materials	0,01	0,1
HD-PE	0,007	0,5
New centrifuged concrete	0,03	
Smoothed new concrete	0,2	0,5
Rough new concrete	1	2
Grès	0,1	1
Old / Used pipelines	2	

The table shows that different **K** values/ranges are given for the same raw materials; these values are often given by the producers without any further application limit or indication, and without taking into consideration the physiological ageing and wear of the pipes while in use.

Therefore, designer shall take into account the conditions of use and shall use **K** ranges homogeneous for the same raw materials while choosing the appropriate type of pipe.
K values shall be chosen in order to give a suitable safety limits, at a short term and at a long term as well, in order to take into account all the unknown or un unpredictable aspects of the installation.

For safety reason, **Picenum Plast** suggests to adopt **K** values as they are indicated in the **EuroSewer** calculation software, that means 0,25 mm for "clear waters" (discharge and drainage waters) and 0,5 mm for "dark waters" (sewage), as prescribed in the ATV German rules.

In addition to the **K** roughness values, other important parameters are the critical speed rate V_{CRIT} and the critical slope pipe J_{crit}, which must be checked in order to avoid sedimentation into the pipe.

These values are listed in a table according to the internal size Di of the pipe, and they vary from V_{CRIT} = 0,50 m/s, J_{crit} = 0,204% for D_i = 200 mm a V_{crit} = 1,12 m/s, J_{crit} = 0,126%for D_i = 1000 mm.

Owing to pipe deflection the ellipse area is lower than the initial circular area; Since the perimeter keeps constant, the hydraulic radius **R** decreases in a direct proportion.

From the hydraulic point of view, a deflection rate which is within 5% - 6% can be negligible and doesn't affect the hydraulic performances.

4.1.2. Flow rates calculation according to free-flow theory

According to this theory, it can be assumed that the pipe behaves like a circular channel, which is not completely wet by the flow. As known, the relevant formula used for the free-flow constant-speed streams is the **Chézy** formula:

$$\boxed{v = c\sqrt{R \cdot i}}$$

- **v** is the average flow speed (m/sec)
- **c** is a coefficent depending from the equivalent roughness, ©in mm; from the Reynolds number **Re**, and from the shape coefficent of the cross-section of the channel (this coefficent is 1 for circular cross-section)
- **i** is the pipe slope m/m
- **R** is the hydraulic radius of the channel; it is defined as the ratio between the wet area **A** (m^2), and the wet perimeter, **P** (m)
- Ù is the dynamic viscosity of the flow at the operative temperature T (T = 5°C 4 Ù =1,52 · 10^{-6} $m^{2/s}$; T = 40°C 4 Ù = 0,661 · 10^{-6} $m^{2/s}$)

For each cross-section all the dimensional parameters are joined one-by-one to the hydraulic height (filling rate) -h-. The table contains the methodical relationship between the geometrical parameters h, R, A, P, r (see table 9 for symbols and details).
This physical quantity represents at best the geometry of the cross-section flow, as long as all the other physical quantities joined to it are known.
The following table shows all the analytical formulas of the geometrical parameters for the circular cross-section. It also includes the non-dimensional physical quantities values corresponding to different filling rates.

4.1.3. Geometrical quantities for free-flow formula (circular cross-section)

In general, the **c** value is given by Colebrook-Marchi formula:

$$\boxed{c = 5{,}7 \log [(c / j\, Re) + (e / 13{,}3\, R_j)]}$$

In case of completely turbulent flow, the previous expression can be simplified and replaced by many empirical formulas. The most used ones are the following:

a) Bazin $\boxed{c_R = 87 / (1 + g / R)}$

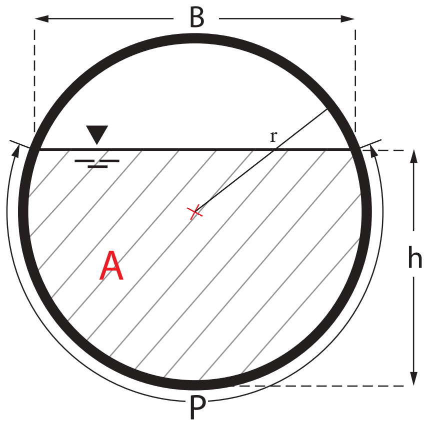
b) Gauckler-Stricker $\boxed{c_{GS} = K_s \sqrt[6]{R}}$

Where **g** and **Ks** are parameters connected to the channel roughness. As a result of it:

$$\boxed{v_B = c_B\sqrt{Ri}} \qquad \boxed{v_{GS} = c_{GS}\sqrt{Ri}}$$

The roughness parameters **(g, Ks)** for the constant-speed flow must be chosen according to the nature, the state of maintenance and the employment of the material of the channel.
The following table ***(tab. 10)*** contains the suggested roughness parameters values for "clear waters"

tab. 9 - Geometrical properties for free-flow in circular cross-section



h/r	A/r^2	R/r	B/r
0,05	0,021	0,033	0,624
0,10	0,059	0,065	0,872
0,15	0,107	0,097	1,054
0,20	0,164	0,127	1,200
0,25	0,227	0,157	1,323
0,30	0,296	0,186	1,428
0,40	0,447	0,241	1,600
0,50	0,614	0,293	1,732
0,60	0,793	0,342	1,833
0,60	0,793	0,342	1,833
0,70	0,980	0,387	1,908
0,80	1,174	0,429	1,960
0,90	1,371	0,466	1,990
1,00	1,571	0,500	2,000
1,10	1,771	0,530	1,990
1,20	1,968	0,555	1,960
1,30	2,162	0,576	1,908
1,40	2,349	0,593	1,833
1,50	2,527	0,603	1,732
1,60	2,694	0,608	1,600
1,70	2,846	0,607	1,428
1,75	2,915	0,603	1,323
1,80	2,978	0,596	1,200
1,85	3,035	0,587	1,054
1,90	3,083	0,573	0,872
1,95	3,121	0,553	0,624
2,00	3,142	0,500	0,000

A	wet area [m^2] = 1/2 r^2 {[Ý/90 arcos (1-h/r)] - sen [2 arcos (1-h/r)]}
P	wet perimeter [m] = [Ý/90^2 arcos (1-h/r)]
R	hydraulic radius [m] = A/P
h	hydraulic height which is the depth of the lowest point of the cross-section flow [m]

tab. 10 - Roughness parameters for channels and pipelines

tipo di canalizzazione	Colebrook e(mm)	Bazin *g* ($m^{1/2}$)	Kutter *m* ($m^{1/2}$)	Gauckler-Strickler Ks($m^{1/3}s^{-1}$)	Manning n ($m^{1/3}s$)
1) Smooth concrete walls. Perfectly smooth wooden walls. Metallic wall without leaning parts in the joint zone	0,15 ÷ 0,20	0,06	0,12	100 ÷ 90	0,011
Same as 1) but with bends	0,2 ÷ 0,4	0,10	0,18	90 ÷ 85	0,012
2) Not smooth concrete. Brick walls well done. Metallic walls with standard nail-junction	0,4 ÷ 1,0	0,16	0,20 ÷ 0,25	85 ÷ 75	0,013
3) Concrete walls not in good conditions. Standard-quality brick walls. Rough wooden walls with slots	2 ÷ 5	0,23 ÷ 0,36	0,35 ÷ 0,55	70 ÷ 65	0,014 ÷ 0,015
4) Partially plastered concrete walls with some deposit at the bottom. Brick-made or stone-made rough walls. Well made soil-made walls without grass	8	0,46	0,55 ÷ 0,75	60	0,018
5) Regular soil-made walls. Ancient brick walls in bad conditions, with silt deposit at the bottom	15 ÷ 30	0,60 ÷ 0,85	0,75 ÷ 1,25	50	0,020 ÷ 0,022
6) Soil with grass at the bottom. Natural rivers with regular flow	70	1,30	1,50	40	0,025
7) Soil in bad conditions. Natural rivers with stones and gravel	120 ÷ 200	1,75	2,00	35	0,030
8) Abandoned channels with a lot of plants and grass. Rivers with gravel-made channel and bottom in movement, or rock channel with leaning edges	300 ÷ 400	2,0 ÷ 2,3	3,00	30	0,035

For what concerning sewage channels it is important to state that the new-conditions roughness are not significant.
In use, a biological coating is created at the bottom. This coating, together with the deposits, is at the origin of the real hydraulic roughness of the canalization.
The increase of the roughness during channel life, which is more or less a characteristic of all the materials, depends on the ability of the organic substances to grip to the walls of the channels and on the speed of the flow.
The homogeneous equivalent roughness **e** contained in the **Colebrook-Marchi** formula, which in new installation conditions depend strictly on the type of material and is contained into a range of a few mmm (e= 0,02 ÷ 0,1 mm), after a few days of use can reach values up to some mm and become dependent on the type of material and the flow speed of the canalization.
The following table (tab,11)contains a list of suggested roughness values for sewage networks.

tab. 11 - SUGGESTED ROUGHNESS VALUES FOR SEWAGE NETWORKS

Material	Colebrook e [mm]	Manning n [$m^{1/3}s$]	Gauckler-Strickler KS[$m^{1/3}s^{-1}$]
Monolitic concrete - with smooth casseforme - with rough casseforme	0,3 ÷ 1,5 1,5 ÷ 6	0,011 ÷ 0,014 0,014 ÷ 0,017	90 ÷ 70 70 ÷ 60
Brick walls	1,5 ÷ 6	0,014 ÷ 0,017	70 ÷ 60
Concrete pipes	0,3 ÷ 3	0,011 ÷ 0,015	90 ÷ 67
Grès pipes	0,3 ÷ 3	0,011 ÷ 0,015	90 ÷ 67
Plastic pipes	0,3 ÷ 3	0,011 ÷ 0,015	90 ÷ 67
Cast iron pipes with concrete internal coating	0,3 ÷ 3	0,011 ÷ 0,015	90 ÷ 67
Fiber-cement pipes	0,3 ÷ 3	0,011 ÷ 0,015	90 ÷ 67

Picenum Plast gives its customers a calculation software which allows to calculate the speed and the flow-rates according to various methods, according to the filling rate and the slope of the pipe.
This software adopts a suggested safety **Gauckler-Strickler** roughness value $K_s = 80\ m^{1/3}\ sec^{-1}$.

4.2 Resistance to internal pressure

According to common belief, sewage networks are not intended as pressure pipes. The relevant norms formalize this idea, by prescribing pressure tests of the joint at 0,5 bars for 15 minutes. This is generally true, because the gravity-flow hydraulic systems don't allow to reach hydraulic pressure over 5÷6 metres of water-column; anyway, the designers and users shall take care of extraordinary use conditions. The resistance to internal pressure can be checked through an admissible pressure calculation, based on the minimum wall thickness $\mathbf{e_5}$. This method is the same applied to calculate the stress acting on solid-wall pipes:

$$\boxed{s_R = (D_i + s) / (2 \cdot s)}$$

where:

- s_R = effective stress acting in the pipe wall thickness, Pa
- **P =** internal pressure, Pa.
- D_i = Inner diameter, m
- s = minimum resistant wall thickness e_5, m

For **EuroSewer**, the previous formula can be written as:

$$\boxed{P_{amm} = 2 \cdot e_5 \cdot s_{amm} / (D_5 + e_5)}$$

Where the “amm” suffix indicates the admissible internal pressure. The results which can be obtained by this formula are inaccurate and underestimated because the formula doesn't take into account the structural contribution given by the external layer.

4.3 Structural design

4.3.1. General

- **Ring stiffness –SN- choice:**
  As said before, a flexible pipe installation must deeply take into account the installation conditions and methods, such as the interaction between the pipe and the surrounding soil. After this foreword, the most important pipe property in order to evaluate its suitability for use in specific condition is the ring stiffness **SN** which gives an indication of its structural resistance to deflection. This value can be achieved by test (UNI EN ISO 9969) rather than theoretical formulas.
  The long-term resistance is an intrinsic property of the material instead. This property can be evaluated and checked by extrapolation methods through the determination of the creep modulus, according to (EN ISO 9967).

The UNI ENV 1046 norm suggests three possible ways to choose the suitable pipe according to the installation conditions:

- **Structural design based on theoretical models:**
  a list of the official calculation models is given in prEN 1295.
- **Empirical data retrieved by previous installations:**
  the previous installations used as reference shall be successful, reliable and shall show the same installation conditions
- **Practice tables:**
  these tables are the result of a statistical analysis over many installations.

tab. 12 - SN choice for non trafficked zones

Backfilling soil group	Compaction class	Pipe ring stiffness					
		For depth cover > = 1m and < = 3m					
		Undisturbed native soil group					
		1	2	3	4	5	6
1	W	1250	1250	2000	2000	4000	5000
	M	1250	2000	2000	4000	5000	6300
	N	2000	2000	2000	4000	8000	10000
2	W		2000	2000	4000	5000	5000
	M		2000	4000	5000	6300	6300
	N		4000	6300	8000	8000	*
3	W			4000	6300	8000	8000
	M			6300	8000	10000	*
	N			*	*	*	*
4	W			4000	6300	8000	8000
	M			6300	8000	10000	*
	N			*	*	*	*
For depth cover > = 3m and < = 6m							
1	W	2000	2000	2500	4000	5000	6300
	M	200	4000	4000	5000	6300	8000
2	W		4000	4000	5000	8000	8000
	M		5000	5000	8000	10000	*
3	W			6300	8000	10000	*
	M			*	*	*	*
4	W				*	*	*
	M				*	*	*

* REMARK: In case of installation conditions more severe than the predicted ones, a better compaction method shall be used.
A preventive structural verification shall be made in addition to it.
* A structural verification of the installation must be done in order to choose a correct pipe stiffness and trench geometry.

- **Soil analysis**
  The tables above ***(tab. 12 and 13)*** refer to different soil groups, which are respectively un-disturbed soils and backfilling soils. Different results will be achieved after installation according to the use of these different soil group, because of their different ability to be compacted.
  A parameter which is commonly used in order to evaluate a compaction-ability of a soil is called Standard Proctor Degree (SPD), which is influenced by the physical and rheological properties of the soil and by the compaction method **(W-well, M-moderate, A-bad or absent).** ***(See table)***

The following tables (contained in the ENV 1046 norm) bundle different types of soil into several soil groups ***(table 15)***. A different compaction-ability (SPD value) is assigned to every compaction class ***(table 14)***.

tab. 13 - SN choice for trafficked zones

Backfilling material group	**Compaction class**	**Pipe ring stiffness**					
		For depth cover < = 1m and > = 3m					
		Undisturbed native soil group					
		1	**2**	**3**	**4**	**5**	**6**
1	W	4000	4000	6300	8000	10000	*
2	W		6300	8000	10000	*	*
3	W			10000	*	*	*
4	W				*	*	*
For depth cover < = 3m and > = 6m							
1	W	2000	2000	2500	4000	5000	6300
2	W		4000	4000	5000	8000	8000
3	W			6300	8000	10000	*
4	W				*	*	*

* Structural design is necessary to determine trench details and pipe stiffness.

tab. 14 Consolidation class terminology

Description	**Degree of consolidation**			
% Standard Proctor (SPD) **(determinated in accordance with DIN 18127)**	**Ö 80**	**81 ÷ 90**	**91 ÷ 94**	**95 ÷ 100**
	0 ÷ 10	**11 ÷ 30**	**31 ÷ 50**	**> 50**
Expected degrees of consolidation achieved by the compaction classes in this prestandard	NOT (N)	NOT (N)	NOT (N)	
		MODERATE (M)	MODERATE (M)	
			WELL (W)	WELL (W)
Granular soil	loose	medium dense	dense	very dense
	Soft	firm	stiff	hard

Note: This table is meant to be an aid for interpretation of descriptions used in various sorces into the terms used for the degrees of consolidataion in this prestandard. Where detailed information of the undisturbed native soil is not available then it is usually assumed that it has a consolidation equivalent to between 91% and 97% Standard Proctor Density (SPD) *tab. 15 Soils classification according to ENV 1046*

Soil	Soil group					Use for backfilling
	#	Typical name	Cod.	characteristics	Examples	
Granular	1	Single-sized gravel	(GE) [GU]	Steep granulation line, predominance of one-grain-size zone	Crushed rock, river and beach gravel, morainic gravel, volcanic ash	YES
		WG gravel, gravel-sand mixtures	[GW]	Continous granulation line, several grain-size zones		
		PG gravel-sand mixtures	(GI) [GP]	Steplike granulation line, one or more absent grain zones		
	2	Single-sized sands	(SE) [SU]	Steep granulation line, predominance of one grain size zones	Valley sand, drift and basin sand, dune, beach sand	YES
		WG sands, sand-gravel mixtures	[SW]	Continous granulation line, several grain size zones	Morainic sand, terrace sand, beach sand	
		PG sand-gravel mixtures zones	(SI) [SP]	Steplike granulation line, one or more absent grain zones		
	3	Silty gravel, PG gravel-sand-silt mixtures	[GM] (GU)	Broad/intermittent granulation line with fine grained silt	Weathered gravel slope debris, clayey gravel	YES
		Clayey gravels, PG grevel-sand-clay mixtures	[GC] (GT)	Broad/intermittent granulation line with fine grained clay		
		Sifty sands, PG sand-silt mixtures	[SM] (SU)	Broad/intermittent granulation line with fine grained silt	Liquid sand, loam, sand loess	
		Clayey sands, PG sand-clay mixtures	[SC] (ST)	Broad/intermittent granulation line with fine grained clay	Loamy sand, alluvial clay, alluvial marl	
Cohesive	4	Inorganic silts, very fine sands, silty or clayey fine sands	[ML] (UL)	Low stability, rapid reaction, nil to slight plasticity	Loess, loam.	YES
		Inorganic clay, plastic clay	[CL] (TA) (TL) (TM)	Medium to very high stability, no to slow reaction, low to medium plasticity	Alluvial marl, clay	
Organic	5	Mixed grained soils with admixtures of humus or chalk	[OK]	Admixtures of plant or non-plant type, decay smell, light weight, large porosity	Top soils, chalky sand, tuff sand	NO
		Organic silt and organic silt clay	[OL] (OU)	Medium stability, slow to very quick reaction, low to medium plasticity	Sea chalk, top soil	
		Organic clay, clay with organic admixtures	[OH] (OT)	High stability, nil reaction, medium to high plasticity	Mud, loam	
	6	Peat, other highly organic soil	[Pt] (HN) (HZ)	Decomposed peats, fibrous, brown to black coloured	Peat	NO
		Muds	[F]	Siudges deposited under water, often interspersed with sand/clay/chalk, very soft	Muds	

The symbols used are taken from two sources. Symbols in square brackets [..] are taken from British Standard BS 5930. Symbols in rounded brackets (..) are taken from the German Standard DIN 18196.

4.3.2. The Spangler method

- **General:**
  The theoretical structure formed by the pipe and the surrounding soil involved for the calculation of pipe deflection is simplified by the following assumption: The pipe deformations are plan; the pipe can be schematized as an infinite-length cylinder with negligible wall thickness; the soil reaction behaviour is elastic. The following formula doesn't contain any direct reference to the trench geome try, which influences the load formula instead. With regard to this subject, a difference must be made between narrow trench and wide (or infinite) trench, according to the shape of the trench dimensions, such as the filling height **H** and the trench width **B**.

narrow trench condition:	**H × 2B**	**and**	**B Ö 3DN**
wide trench condition:	**H × 2B**	**and**	**3DN < B Ö 10DN**
infinite trench condition:	**H Ö 2B**	**and**	**B > 10DN**

The so-called "modified **Spangler Formula**" is the following:

1
$$\Delta v = \frac{(d_1 \cdot p_o + p_t) \cdot Kx}{[(8 \cdot SN) + (0{,}061 \cdot E')]}$$

Deflection = (Load acting on the pipe)/(pipe stiffness+soil stiffness)

where:

$\hat{e}_v$ = vertical deflection, m;
d_1 = self-compaction factor (1,5 for moderate compaction, 2 for low-medium compaction with low installation height)
p_o = soil load, $N{\cdot}m^{-1}$
p_t = traffic load, $N{\cdot}m^{-1}$
K_x = coefficent depending on distribution of bedding reaction;;
SN = long-term pipe stiffness, Pa;
E' = soil soil modulus, Pa. E'=e·r
e = elasticity modulus of the soil;
r = pipe radius, m.

- **Soil load in narrow trench:**
  The soil load acting on a 1 meter-length pipe can be calculated by the following formula:

2
$$p_o = (C \cdot g_t \cdot D_e \cdot B)$$

where:

C = soil load coefficient;
g_t = mass density of the upper backfilling soil, N/m^3;
D_e = external diameter of the pipe, m;
B = trench width, measured in correspondence of the upper side of the pipe, m

In the following Formula:

3
$$C = \frac{1 - e^{\left(\frac{-2k \cdot H \cdot m}{B}\right)}}{(2 \cdot K \cdot m)}$$

where:

H = filling height, measured at the upper side of the pipe, m;
m*=** **tg *q = friction coefficient between the filling material and the side walls of the trench;
K = Rankine coefficient = $tg^2\left(\frac{\pi}{4} - \frac{J}{2}\right)$
ratio between the horizontal pressure and the vertical pressure given by the filling material (j is the "internal" friction angle of the filling material).

The *j* and *q* values are related to the soil type, as shown in the following tables:

tab. 16 - Trench friction angle values for different soil types

Native soil	Filling soil	Angle *q*
mixture of clay and calcium minerals	Sand	30°
mixture of clay and calcium minerals	Gravel	35°
mixture of clay and calcium minerals	Stones	40°
Smooth rocks	Sand	25°
Smooth rocks	Gravel	30°
Layer-shaped rocks	Sand	35°
Layer-shaped rocks	Gravel	40°

The following practice tables, the value (K · *m*) is related respectively to the parameter *j* and *q* and the parameter (K · *m*)

tab. 17 - Internal friction angle values for different soil types

Filling soil	Angle *j*
Plastic clay	11° - 12°
Peat soil	12°
Normal clay	14°
Loess	18°
Sandy mixture of clay and calcium minerals	20°
"white" mixture of clay and calcium minerals	22°
Well compacted mixture of clay and calcium minerals	24°
"green" mixture of clay and calcium minerals	26°
Wet sand	30°
Fine sand not compacted	31°
Sand - gravel mixture	33°
Gravel - stones mixture	37°
Big stones	44°

tab. 18 - (K tg q) values calculated for different q and j values

q / *j*	25°	30°	35°	40°
12°	0,305	0,378	0,459	0,550
14°	0,284	0,352	0,427	0,512
16°	0,264	0,327	0,397	0,476
18°	0,246	0,304	0,369	0,442
20°	0,228	0,283	0,343	0,411
22°	0,212	0,262	0,318	0,381
24°	0,196	0,243	0,295	0,353
26°	0,182	0,225	0,273	0,327
30°	0,155	0,192	0,233	0,279
35°	0,126	0,156	0,189	0,227
40°	0,101	0,125	0,152	0,182
45°	0,080	0,099	0,120	0,143

tab. 19 - C values calculated for different (K tg q) e and (H/b) values

H/b / *K tg q*	2	4	6	8	10
0,110	1,618	2,660	3,331	3,763	4,041
0,130	1,559	2,486	3,037	3,365	3,560
0,150	1,503	2,329	2,782	3,030	3,167
0,170	1,451	2,186	2,558	2,747	2,843
0,190	1,400	2,056	2,362	2,505	2,572
0,220	1,330	1,881	2,110	2,205	2,244
0,250	1,264	1,729	1,900	1,963	1,986
0,300	1,164	1,515	1,621	1,652	1,662
0,350	1,076	1,341	1,407	1,423	1,427
0,400	0,997	1,199	1,239	1,247	1,249
0,450	0,927	1,080	1,060	1,110	1,110
0,500	0,864	0,981	0,997	0,999	0,999

- **Soil load in wide trench:**
  Under this condition, the soil load acting on the pipe can be expressed by the following formula:
  The symbols are the same as the ones used in the previous formula.

$$p_o = (g_t \cdot D_e \cdot B) \qquad (4)$$

- **Traffic and surface loads:**
  The traffic & surface load $\mathbf{p_t}$ must be added to the other loads acting on the pipe.
  This load is originated by the weight $\mathbf{Q_s}$ due to the heavy upper structures (such as walls, foundations) and the load **Qt** originated by traffic.

The following formula defines the vertical stress originated in a defined point of the underground soil by a surface load:

$$S_z = \frac{3Q \cdot D_e}{2\pi \cdot H^2} \cdot \left[\frac{1}{1+\left(\frac{r}{H}\right)^2} \right]^{\frac{5}{2}} \qquad (5)$$

where:

$\mathbf{s_z}$= vertical stress, Pa
Q= surface overall load = $Q_t + Q_S$, in N;
H= depth of the installation, m
R = horizontal distance from the load spot.

This stress il considered to be evenly distributed throughout the diameter of the pipe (assumed with unitary length).
Therefore, the load $\mathbf{P_t}$ per meter of pipes shall be:

$$p_t = \frac{3Q \cdot D_e}{2\pi \cdot H^2} \cdot \left[\frac{1}{1+\left(\frac{r}{H}\right)^2} \right]^{\frac{5}{2}} \qquad (6)$$

$$p_{cr} = \frac{8 \cdot (h^2 - 1) \cdot SN}{1 - \mu^2} \qquad (7)$$

The concentrated loads Q_t due to traffic are generally standardized.
Their values are listed in the following table ***(tab.20)***:

tab. 20 Traffic loads

Traffic condition	Total load Q (kN)	Load per wheel Q_t (kN)
Heavy	600	100
Medium	450 300	75 50
Light	120 60	20 20
Cars	30	100

The previous formulas show that the load rate decreases by the square of the installation depth, and it reaches its maximum at depths Ö 1,5 ÷ 2 m.
The traffick load can be either permanent or occasional. In general it should be considered as permanent even if only the Q_t share is present.
Theoretically, the Q_t load should be considered as occasional (unless for parking areas), thus giving origin

to elastic reaction both for stress and for strain.
In fact, the traffic load can bring to failure for cyclical loads (this failure takes origin by fatigue cracks), and not for exceeding the allowed stress / strains.
For this reason, while defining the safety conditions during design and verification of plastic pipes it's recommended to consider Q_t as a permanent load.

- **Strenght modulus of the soil:**
  As said in the previous chapters, according to Barnard's theory, the calculation formulas for determining the deflection of a flexible pipe contains the strength modulus of the soil (so-called soil modulus **E' = e r** (where **e** is the elasticity modulus of the soil, and **r** is the radius of the pipe).
  This modulus **E'** so defined is constant for all the sizes of the pipe, and it is a function of the type of the soil and the used compaction method.

The most commonly used reference norm to classify the different soils according to their properties is the ASTM 2487.
The following table ***(tab.21)*** (derived from the norm) is also contained in the **EuroSewer** calculation software.

tab. 21 E' values for different soil types

	Loose material	Compacted material		
STANDARD PROCTOR		< 85 %	85 ± 90%	> 95 %
RELATIV DENSITTY		< 40 %	40 ± 70%	> 70 %
SOIL TYPE	E' (N / mm2)			
little-size grain soil LL > 50 soil with high and medium plasticity	0	0	0	0
soil with medium and high plasticity	(an accurate analysis is requested)			
cohesive low-size grained soil LL > 50 soils with medium or low plasticity with bigger grains amount less than 25%	0,35	1,38	2,76	6,9
Low-size grained soil LL > 50. Soils with medium or low plasticity with bigger grains amount more than 25% high-size grained soils with little grains more than 12%	0,69	2,76	6,9	13,8
high-size grained soils with little grains less than 12%	0,69	6,9	13,8	20,7
crushed rock	6,9	20,7	20,7	20,7
Accuracy for the difference between the theoretical expected and real deflection (%)	± 2%	± 2%	± 2%	± 0,5%

Lower values in the table are suitable to calculate the initial (short-term) deflection, because at a medium and long term the soil compaction gets higher and higher owing to mechanical compaction (***e.g.*** vehicles and pedestrians are passing over the installation) and self-compaction (originated by the weight of the upper soil). The short-term and the long-term deflection are related to each other by a factor, called self-compaction factor d_1. For what stated above, the compaction degree, thus **E'**, increases as time passes. In the **EuroSewer** software the structural calculation includes also an amplification factor for of the total load **p**. According to the ASTM norm, this factor (set by default to 1,5) should be applied only to the soil load p_o. Higher values for this factor (**e.g**. 2) are recommended in case of non-coherent backfilling soils.

- **Support angle of the trench bottom:**
  The term K_x coefficent depending on distribution of bedding reaction contained in the deflection formula is related to thesupport angle of the trench bottom, 2⁄ (so-called support angle), as shown in the table below. ***(tab.22)***

tab. 22 Coefficent depending on distribution of bedding reaction

Angolo 2⁄	0°	90°	120°	180°
K_x	0,110	0,096	0,090	0,083

The table shows that by increasing the support angle the Kx value decreases, thus decreasing the deflection rate.
Kx values referred to 2⁄ - rates not contained in the table can be calculated by interpolation. The maximum decrease of the deflection from the “zero support” condition and the maximum support condition is 24,5%. This latter condition is obtained with an accurate compaction of the side-backfilling material up to 30 cm over the upper side of the pipe. Therefore, while installing flexible pipes (and rigid pipes as well, although this phenomenon is less important) it is recommended to create a laying bed which shall provide a support angle between 90° and 120°

- **Stresses acting on the wall thickness:**
  As said before, the pipe is subject to a series of loads after the installation. These loads give origin to a stress field on the walls of the pipe itself.
  These stresses are originated by the weight of the pipe, the weight of the internal fluid, the internal pressure (if present), the external loads, the bending moments (due to pipe bending) and shear stresses (if present).
  In a profiled-wall pipe the analysis of the internal stresses is more difficult than for a solid wall pipe.
  In many cases the main stress derives from the external loads, although other loads can give origin to significant stresses. For structured-wall pipes (which don't have a definite wall thickness) the analysis of the stress field should be based rather on an equivalent wall thickness, and the results could not be significant.

4.3.3. Critical external pressure (buckling)

A pipe (ring) subject to radial forces evenly distributed and directed towards the centre of the ring, first keeps round, then, as the force rate increases, it bends and gets oval (two-lobe deformation). The rate of the surface load which deforms the ring is called critical pressure or buckling pressure. The buckling pressure verification is not used for underground pipes, for which it's better to talk about buckling loads instead. The buckling verification is necessary in condition of external pressure, e.g. due to underground water.
The formula used for calculating the critical buckling pressure for flexible pipes:

$$p_{cr} = \frac{8 \cdot (h^2 - 1) \cdot SN}{1 - \mu^2} \quad (8)$$

where:

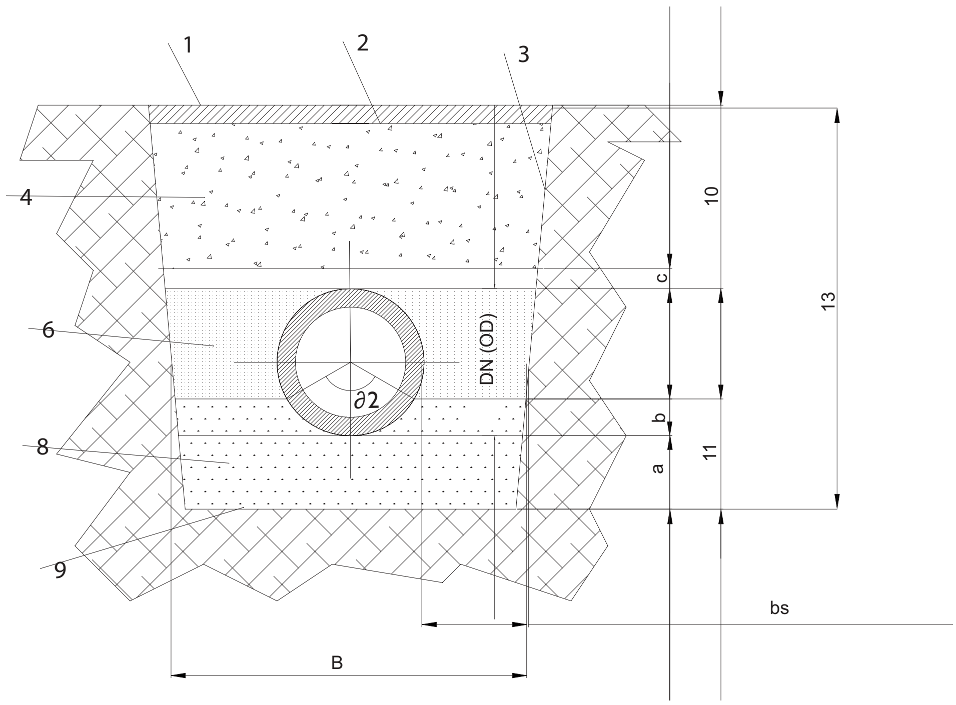
P_{cr} = critical (buckling) pressure, Pa
SN = ring stiffness, Pa
Ù = Poisson's modulus (Ù=0,4 for PE);
n= shape coefficient, corresponding to the number of lobes which are originated during the load (this value is = 2 in case of one lobe).

This formula is valid for solid-wall pipes; it is valid for structured-wall pipes only in the zone between the corrugations, in case this zone is wide. For **EuroSewer** the distance between the corrugations is very short (40% of the pitch of the corrugations), and it doesn't exceed anycase 100 mm, therefore this verification is useless. In addition to it, the production process ensures a perfect connection between the outer and inner layer, which work as one body.

5.1 General

In addition to the quality product and the characteristics of the material, a correct installation also plays an important role in determining the final results of the piping system. Thus, for a correct installation, it is very important to pay attention to the following elements (see figure 4)

fig. 4



Symbols

• **1** Surface • **2** Roadbed or railway base, if existing • **3** Trench walls • **4** Final backfilling • **5** Top filling • **6** Side filling (compaction zone) • **7** Upper bedding support • **8** Lower bedding support • **9** Trench bottom • **10** Installation depth • **11** Depth of bedding support • **12** Height of backfilling • **13** Trench depth • **a** Depth of lower support • **b** Depth of upper support • **c** Depth of initial backfill • **k** Dimensional coefficient that links the width of the side b to the DN • **DN (OD)** External (nominal) diameter of pipe (mm).

Geometry of the trench: Trench width B, depth (10, 13), Piling/ trench reinforcement system, Cross-section profile (stepped trench, with slopied wall, etc.)
Compaction degree: Of the backfilling (5, 6, 7), Of the final backfilling (4)
Pipe support and conditions of the bottom of the trench
Conditions of native & compaction soil: Thermal (hot, frost), Climatic (rain, snow), Hygrometric (flooding, presence of underground water)
Loads acting on the installation: Dynamic (highway traffic and temporary loads), Static
Type of soil and relevant parameters: Subsoil (9), Walls (3), Backfilling conditions (4÷8)
Particular installation contitions: Above-ground structures, Connections to rigid structures, Presence of other pipe networks into the same trench

This chapter will give some explanations and basic indications for a correct choice, transportation, installation and final check of the **EuroSewer** sewage & drainage system. In addition to it, ome information will be given about the fittings that complete the **EuroSewer** piping systems, joint methods and general instructions and rules for pipe laying and backfilling. For further details about the transportation, stocking, pipe laying and control processes, please refer to the international relevant norms and national rules and laws.

5.2 Transportation and preliminary checks

Pipe Format and packaging:

- The pipes will be supplied in standard bars (6 m + cuff). Other lengths may be supplied as per agreement with the customer. The pipes shall be packed in pallets or spare bars depending on the customer demand. Pipes up to DN/OD 500 mm can be supplied either as single bars or on pallets, while pipes from DN 630 mm and above are supplied only as spare.

tab. 23

DN/OD	N°. of bars per pallet	N°. of bars per 13 m truck
125	103	800 (4800 m useful)
160	60	480 (2880 m useful)
200	35	280 (1680 m useful)
250	24	176 (1056 m useful)
315	12	96 (576 m useful)
400	8	64 (384 m useful)
500	5	40 (240 m useful)
630	Spare	30 (180 m useful)
800	Spare	18 (108 m useful)
1000	Spare	10 (60 m useful)
1200	Spare	8 (48 m useful)

Pipe transportation:

- Use suitable vehicles with flat surface that cannot damage the pipes;
- Ensure that the pipes are safely secured on the truck;
- In order to avoid deflection of the cuffs, alternate the direction of pipes while loading the truck;
- Load larger diameters on the bottom and the smaller ones on top.

Preliminary checks on pipes and fittings:

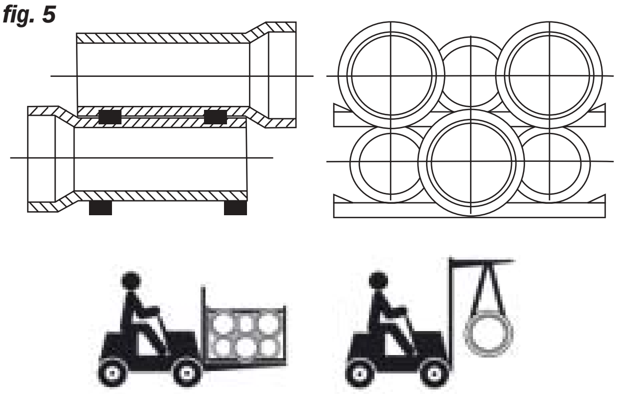
- While unloading, check the conformity of the goods with the purchase specifications or reference norms, with particular attention to:
- Marking on the pipes;
- Visible damages on the surface of the pipes (presence of abrasion, appearance of the surfaces);
- Check the functioning of the joint elements.

5.3 Downloading and storing on site

- **General:**
  In order to prevent pipe burst, cracks or any other damage on the pipes and to ensure the safety of the workers, the loading, transportation, downloading and any other operation connected to the movement of the pipes must be carried out with maximum care by making use of suitable devices.
  Avoid impact, deflections, excessive leaning, sliding and any contact with materials that can damage order form the pipes.

- **Downloading**
  The working site shall be provided with suitable means and a flat and safe surface where to stock the pipes, special fittings and accessories before their installation. Download spare bars or pallets according to the package or the means of transport.
  Avoid hooks at the ends of the pipes. Use a belt from non-abrasive material in order not to damage the spare pipes while downloading spare pipes.

fig. 5



- **Storage**

  Pipes should be placed on a flat, stable, protected and sheltered area to keep away dangers of fire and to protect from the sun rays and remarkable thermalvariations.
  The base of the stack shall bear either on spaced flat wooden bars or on a bearing bed. The height of the stacks shall be chosen according to the diameter of the pipes in order to avoid deformations on the base of the pipes and to allow an easy lifting and handling.
  Caution shall be made in order to avoid damages of pipe ends. Arrange the pipes in the stack alternating pipes with cuff and pipes with socket (see figure). Big sizes shall be separated at every layer by non-abrasive wooden bars with stoppers at each end in order to avoid rolling. Fittings, gaskets and other materials must be stored indoor until the installation.
  They must be kept in containers to protect from sunrays, heat and any contact with oil and grease; fittings and gaskets shall not be subject to loads durng storage. In case it'snecessary to lay the pipes along the trench path, follow the same criteria used for loading and unloading. Avoid pipe crawling while dragging them.
  While laying the pipes down on the side of the trench, make sure that they are on a steady balance.

5.4 TRENCH CONSTRUCTION

Trench morphology and general prescriptions:

Operations in trenches are carried out in potentially hazardous conditions.
Take precautions to prevent objects falling into the trench, or its collapse caused by the position or movements of adjacent machinery or equipment.
According to the relevant European and German norms, the The morphology shall comply to prescriptions. It is recommended to dig a trench with trench width max. 2-3 times the diameter of the pipe.
The trench depth shall be at least 1 m above the upper side of the pipe.
The trench walls should be as vertical as possible and should be strengthened by propping to protect the personnel working in the trench.
In case of embankment or wide trench, it is recommended to prepare a contrast zone with the backfilling material in order to create a narrow trench.
The sheet pile should be removed right after the partial backfill and before the compaction operations.

Trench width

The width of the trench depends on the type of installation, pipe diameter and the native soil conditions.
From a technical point of view, it is better to have a trench as narrow as possible.
In addition to it, the following conditions shall be guaranteed:

- guarantee the safety of the workers in the trench, especially in the case of crumbly ground;
- Protect from danger of collapse of the ground when heavy vehicles work near the trench;
- when more pipes are laid in the same trench, create a stepped bottom. In this case, a minimum distance of 0,35 m for DN =< 700, and 0,50 m for DN > 700 should be maintained between the pipes

Depth of the trench:

The depth of the trench depends on the configuration of the pipeline, the type of pipe, the characteristics and dimensions of the pipe, and local conditions (native soil, backfilling soil, static and dynamic loads, underground water). In case of road traffic, the min. depth shall not be less than 600 mm.
Particular attention should be given in extreme climatic conditions in order to guarantee a depth which may protect the pipeline from risks of frost.
The bottom of the trench shall be continuous, uniform and free of coarse particles.
Furthermore, the trench should be free from underground water and from rainwater

tab. 24 - Trench width with relation to the nominal diameter DN

DN (mm)	Minimum width of the trench (DN +2bs)		
	Supported trench	Non-supported trench	
		ß > 60°	ß Ö 60°
Ö 225	DN + 0,40	DN + 0,50	DN+0,40
225<DNÖ 350	DN + 0,50	DN + 0,70	DN + 0,40
350<DNÖ 700	DN + 0,70	DN + 0,85	DN + 0,40
700<DNÖ 1200	DN + 0,85	DN + 1,00	DN + 0,40

tab. 25 - Trench width with relation to the depth of installation

Depth of the trench P (m)	DN + 2bs (m)
< 1,00	n.d.
1,00 Ö P Ö 1,75	0,80
1,75 Ö P Ö 4,00	0,90
P > 4,00	1,00

5.5 Preparation of the laying bed

After the pipes, special parts & fittings have been carfully checked (and replaced in case they are damaged) the pipes will be laid into the trench.
First of all make sure the surface of the trench bottom shall be leveled off and free of anything that may damage the pipes.
This check must be made also if different soils from the native soil of the trench are used for the compaction zone or the laying bed.
It is absolutely forbidden to adjust the pipe inclination / direction by using stones or bricks or other discontinuous support. The level of pipe laying must guarantee a continuous support base.
In case of risk for ground settlement, special actions should be taken either with the suitable joints or special treatments should be applied to the bottom of the trench.
If the pipes were damaged during pipe laying, they should be repaired or replaced according to the degree of damage.
Check the inclination and the alignment of the bars each time they are joined.
If the bottom of the trench is soft, smooth and free of any sharp deposits and stones, **EuroSewer** can be laid directly on the bottom of the trench as long as the leveling is correct. Generally this condition occurs rarely on the work site.
Make a sand bed or put a layer of small pebble gravel without any material that may have a sharp edge.
The height of this layer should be at least 10 cm in order to keep the ribs away from direct contacts with the trench bottom.

Spread the bedding material evenl across the full width of the trench and level it to the gradient of the pipeline.
Do not compact the bedding layer.
The norm UNI EN 1610 defines the following minimal particles for the pipe laying bed:

22 mm for DN Ö 200
40 mm for 200 Ö DN Ö 630

While lifting and laying pipes into the trench, either raised or on supports, follow the same instructions given in the previous chapters.
It is important not to damage the pipe surfaces by using suitable vehicles and lifting devices according to the different diameters.
Avoid the penetration of deposits or any other material into the pipeline which might damage the internal surface.
Where appropriate to allow for proper assembly of the joint or to prevent the weight of the pipe from being carried on the joint, provide a jointing hole beneath the joint zone.
When the joint has been made, carefully fill and compact the join ting hole with bedding material to provide continuous support of the pipe throughout its entire length.

- **Presence of underground water**
  EuroSewer, just like any other PE structured pipes, shows buoyancy when submerged in water.
  The backfill, even if done with dry material, tends to lift the pipe. For this reason, particular attention shall be paid in this phase of the installation.
  Pipe laying in the presence of underground water should be carried out on a dry trench bottom in order to ensure secure the pipe laying bed and the correct in clination of the pipeline.
  Well-point systems shall be used to drain the water from the trench and to allow for pipe laying as described above.
  The backfill soil should prevent the pipes from floating; it should also prevent the sides of the trench from collapsing. Suitable granulometry of the backfill material should be chosen in order to prevent the migration of the particles throughout the soil.
  An appropriate filter (geo-textile membrane) can help to prevent this migration.

5.6 Pipe assembly

- **General:**
  The pipe joint must guarantee the hydraulic continuity and the static behavior in compliance to the design; it shall comply to the applicable norms and rules as well.
  Due to the lightweight of the pipes, the pipe joint outside of the trench even for long linear paths is a very common operation and an interesting option.
  Since the sewage systems are often interrupted with derivations and traps, the joints outside of the trench should be seen more as an option rather than as a standard.

- **Laying**
  Lay the pipe in the trench so that it bears evenly on the bedding throughout its length.
  Particular attention should be paid to the thermal elongation of the pipes even if this phenomenon for **EuroSewer** is widely lower (nearly 50%) with respect to solid-wall pipes.
  Pull-out phenomenon is theoretically possible, in case of jointing with coupling; in this case, it is suggested to block the pipeline at every 30/40 m with partial backfill.
  After eventual movement are checked and corrected, fill the trench in the freshest hours of the day.
  It is important to know that once the backfill has been carried out correctly, no longitudinal movement of the pipe is foreseen as the solid ground around the ribs stops the effect of the thermal elongation /shrinkage.

- **Joint with cuff**
  EuroSewer corrugated pipes are provided with a joint system by double-wall ribbed cuff, which is co-extruded during the production of the pipe.
  The cuff includes a flare at the edge in order to help the insertion of the spigot end, thus preventing eventual damages of the gasket in that phase.
  Its pull-out length **A** (much bigger than the min. required by norms) allows the insertion of 2 or 3 ribs of thespigot to ensure the co-axiality of the pipes and to prevent any accidental pull-out.
  The EPDM gasket is designed especially to fit the morphology of the ribs of **EuroSewer.**
  Moreover, the gasket complies the requirements contained into the relevant EN 681-1 norm.
  The gasket ensures the tightness of the joint from inside to outside for pressure higher than the minimum requested by norms even in conditions of deflection or under load.
  The lip shape (outside-oriented) ensures an optimal resistance to infiltration due to underground water, which are particularly dangerous for the management of wastewater treatment networks. The particular shape and position of the gasket and the length of the cuff prevent the gasket not to get damaged during insertion and no angular deflection to cause differential deformations, thus leakage.

  Description of the cuff-joint procedure (section from the internal operative instruction I/CO-100, available on ww.picenumplast.com)

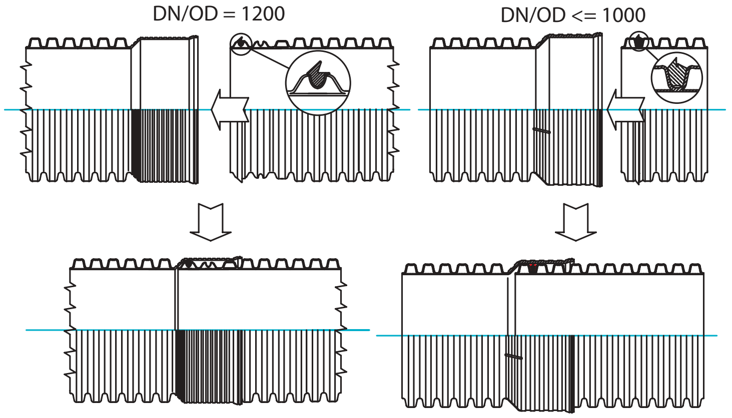
- Check the matching (DN, SN, package, fittings and gaskets) between the items and what written the packing list

- Previously check the appearance of the pipe, the fittings and gaskets. Verify the integrity and the absence of deformations, scratches, flaws and other damages which may compromise the correct work in use of the pipe

- In case of need, cut the pipes according to the desired lenght. The cut shall be perpendicular to the axis of the pipe and shall show no sharp edges or other defects.

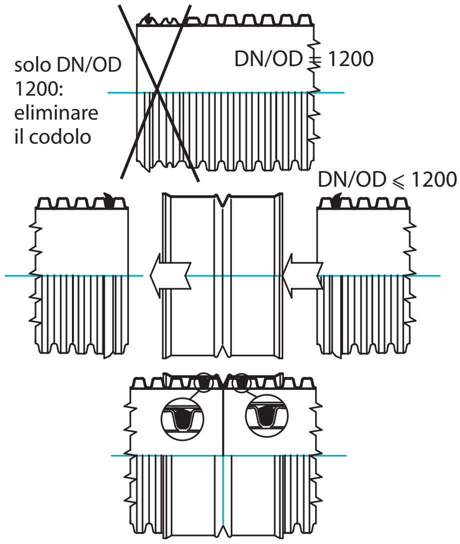
- Clean carefully the zone between the 1st and 2nd rib of the spigot / end of the pipe, removing dirt and incrustations due to outdoor storage
  REMARK: for pipes DN/OD Ö 1000 the term “spigot” must be intended as any section of the pipe, since the cuff-joint can be done with the cuff and and any point (section) of the pipe; for pipes DN/OD 1200 the cuff-joint must be necessarily done between the cuff and the “Low-raise spigot” at the end of the bar. In order to join DN 1200 pipes at any length a sleeve must be used.

fig. 6



Cuff joint

fig. 7



Sleeve joint

- Fit the elastomeric gasket between the 1st and 2nd rib. Make use of special lubricating grease to make the positioning easier.
  Avoid seal twisting while positioning it.
  Respect carefully the direction of the sealing gasket; the tightening lip shall have the direction as indicated in figure
  REMARK: For large sizes it could be helpful to lightly lubricate the first corrugation of the spigot; in order to make the fitting of the gasket easier, the operator can make use of special tools (levers), avoiding to damage the corrugations and the profile of the gasket.

- Align the bar to be installed with the one already installed, in the way that the spigot of the first is near the cuff of the latter.
  Leave a 10-20 cm gap between the bars.
  Put some wooden spacers (and remove them once the installation is completed) in order to provide a correct co-axiality between the two pipes. Keep in mind that for pipes DN 160 up to 1000 the outer diameter of the cuff is larger than the pipe diameter.

- After lubricating the joint zone (internal surface of socket and tightening lip of gasket) push the spigot into the socket manually or making use of mechanical/ hydraulic pusher.
  The insertion length L shall be evaluated so that the 1st rib of the socket will be in contact with the cuff tip (gap = 0, see fig.).
  Measure the insertion length L (which is the difference between the length of thecylindrical part of the cuff and the length of onecorrugation, see previous figure), and mark this length on the spigot of the pipe.

- During the insertion step, the pushing force shall be applied axially, in order to avoid misalignment of the pipes. The joint shall not be loaded radially.
  After making the connection, adjust the alignment of the pipes in order to make a straight line. Pushthe pipe until the socket fits the cuff over a length previously marked on it

- **Joint by sleeve**
  This joint method, although more difficult and less reliable, is a good way to join custom-lengtht pipes, pipes without cuff or, in general, pipes with fittings.
  EuroSewer sleeves are designed specificately for **Euro Sewer** piping system.

  They are tested in keeping with the prEN 13476-1 norm.

  The most important dimension is the inner diameter of the sleeve, which must fit the outer diameter (DN/OD) of the pipe.
  The norm contains the dimensions and relative tolerances for sleeves according both to the DN/OD and the DN/ID normalizations.
  Both the outer diameter of **EuroSewer** pipe and the inner diameter of **EuroSewer** sleeve are within the ranges given by the norm.

  The length of the sleeve is designed in order to fit at least 2/3 ribs of the spigot end, thus providing co-axiality of the pipes and avoiding pull-out risks.

Description of the sleeve-joint procedure (section from the internal operative instruction I/CO-100, available on www.picenumplast.com)

- Pipes DN/OD 1200 shall be cut through the section 1-1 in order to cut away the low-raise spigot (see fig.)

- Fit the elastomeric gasket between the 1st and 2nd rib of each end of the pipes which must beconnected. Make use of special lubricating grease to make thepositioning easier.
  Avoid seal twisting while positioning it.
  Respect carefully the direction of the sealing gasket; the tightening lip shall have the direction as indicated in figure.
  REMARK 1: For large sizes it could be helpful to lightly lubricate the first corrugation of the spigot; in order to make the fitting of the gasket easier, the operator can make use of special tools (levers), avoiding to damage the corrugations and the profile of the gasket.
  REMARK 2: Gaskets DN 1200 which shall be used to join pipes by sleeves are different from the gaskets which must be used to join pipes with cuff. Please note the difference between the two cross-sections shown in figures 6 and 7 regarding DN 1200.

- Position the sleeve fitting the flare onto the 1st rib of the pipe.
  REMARK: sleeves for DN × 630 show no difference between the two flares (sides), therefore they can be connected without any further care. Sleeves for DN > 630 have two different sides (flare).
  For these sleeves It is suggested to fit first the "SIDE B" (narrow) onto the pipe.

- Measure and mark on the pipe the insertion lenght of the sleeve.
  This lenght is approximately equal to half total lenght of the sleeve

- Apply lubricants on the lip of the sealing ring and on the internal surface of the sleeve.

- Push the sleeve onto the spigot of the pipe, manually or making use of mechanical/hydraulic pusher keep the pipe and sleeve aligned. Make sure that the sleeve may not damage or twist the gasket while pushing.

- Apply lubricants on the lip of the sealing ring of the other pipe and on the internal surface of the sleeve ("SIDE A" for sleeves DN > 630)

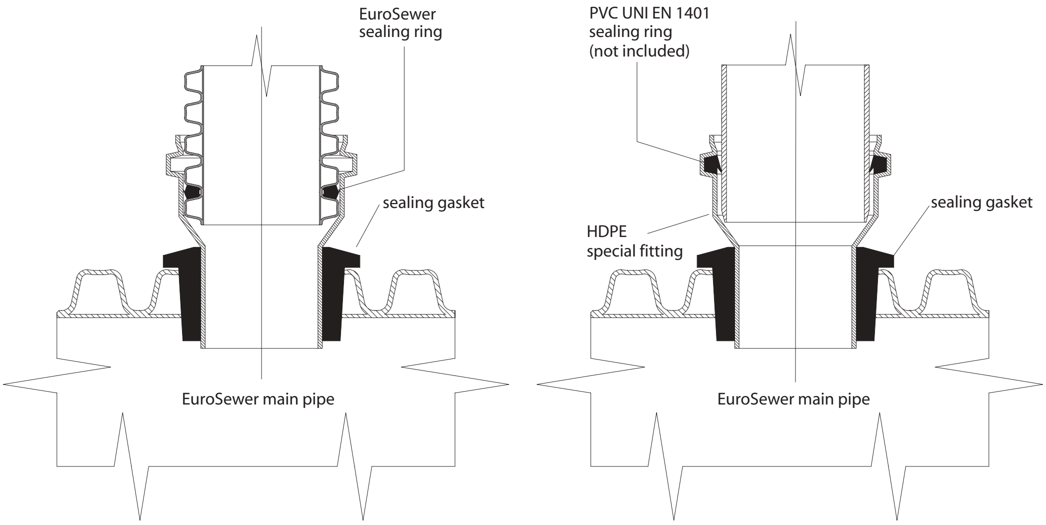
- Align the bar to be installed with the one already installed (onto which the sleeve has already been installaed) in the way that the spigot of the first is near the installed sleeve.
  Leave a 10-20 cm gap between the bar and the sleeve. Put some wooden spacers (and remove them once the installation is completed) in order to provide a correct co-axiality between the two pipes. Keep in mind that for pipes DN 160 up to 1000 the outerdiameter of the cuff is larger than the pipe diameter.

- Push the spigot into the sleeve manually or making use of mechanical/hydraulic pusher. Measure and mark the insertion length **L** on the second pipe, as mentioned before

- During the insertion step, the pushing force shall be applied axially, in order to avoid misalignment of the pipes. The joint shall not be loaded radially. After making the connection, adjust the alignment of the three elements in order to make a straight line. Push the pipe until the socket fits the sleeve over a length previously marked on it.

- **Joint by butt-welding**
  EuroSewer piping system offers the possibility to connect pipes by butt-welding, because the –e4- wall thickness are suitable for such process.
  Although theoretically applicable, butt-welding connection method is very rarely used and is less preferable with respect to the other joint methods described before, owing to technical difficulties related to the welding process for structured-wall pipes.
  The welding technology and the devices are the same as the ones used for solid-wall pipes, and they

fig. 8



EuroSewer connection ***PVC/ smooth connection***

give the same guarantees and reliability according to the welded wall thickness.

While choosing the correct joint method it is important to keep in mind that the butt-welding process guarantees a perfect tightness of the joint, but on the other side the stiffnes of the joint zone is lower than the one achieved by sleeve or cuff joint.

While welding the pipes, the heating process must be done carefully in order not to involve the contiguous ribs. The process parameters (temperatures, times and pressures) are the same as the one used for welding thin solid-wall pipes.

The usual procedure is the following:

1. **Pre-heating:** in this phase the welding riddle is formed. The height of the riddle shall be (0,5 + 0,1 · e4) mm
2. **Heating step:** t2 = 15 · e4, sec;
3. **heating plate removal:** t5 < 3 + 0,01 · Di, sec
4. **Pipe ends compression:** t4 < 3 + 0,03 · Di, sec
5. **Welding:** t5 > 3 + e4, sec
6. **cooling:** t6 = complete cooling, depending on the wall thickness of the pipe and on the ambient temperature.

The welding machine suppliers will give tables containing all the recommended parameters (temperatures, times).
The Italian norm 9737 contains general prescriptions for qualification of personnel involved in welding process for gas pipes.
This requirements can be extended to all the plastic pipes in general as well.
This norm, together with the publication "polyethylene welding" issued by Istituto Italiano dei Plastici, are the basic references for a correct and safe use of this method.

5.7 Fittings – types and joint system

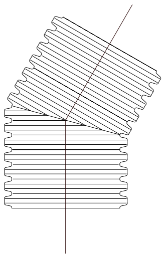
- **Fittings:**

  The **EuroSewer** system is completed by a wide range of special pieces and accessories, such as bends, fittings, reductions, tees, obtained from a pipe by welding or by moulding.

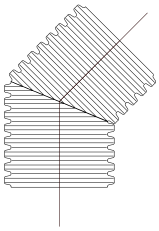
  The structure responds to the indications of the prEN 13476-1, in particular those concerning thetightness and impact resistance.
  The characteristics and indications for the special pieces are included in the prEN 13476-1.
  The connections between the fittings and the pipes are made by means of cuff and gaskets or by means of coupling (sleeve) and gaskets.
  Thanks to this wide range of accessories which have the same physical, mechanical and performance characteristics as those already mentioned for the pipes, it is possible to obtain any lay-out of the network or connection to pre-existant sewer system made by using other material types PVC, concrete).
  On request it is also possible to make special custom pieces according to the needs of the project.

ANCILLARES AND SPECIAL FITTINGS:

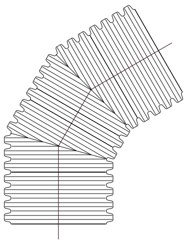
30° BEND



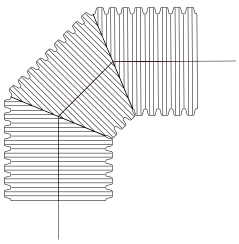
45° BEND



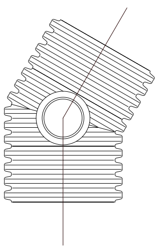
60° BEND



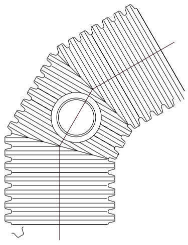
90° BEND



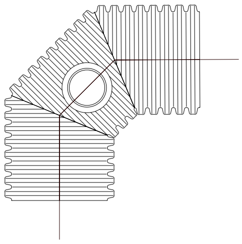
30° BEND (with inspection)



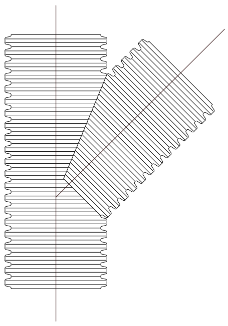
60° BEND (with inspection)



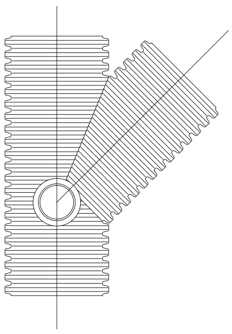
90° BEND (with inspection)



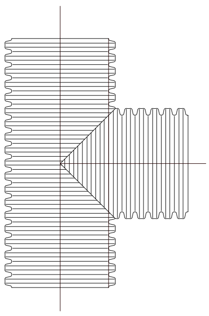
45° BRANCH



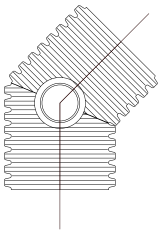
45° BRANCH (with left/right inspection)



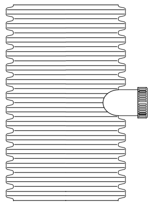
TEE



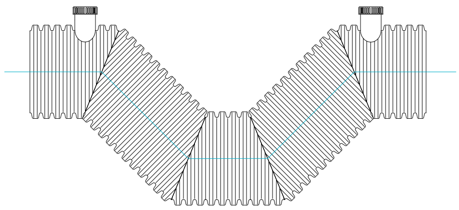
45° BEND (with inspection)



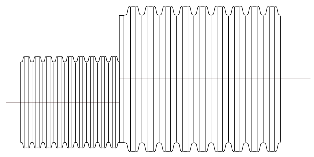
LINEAR INSPECTION



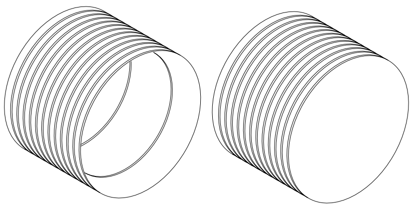
“FIRENZE” SYPHON



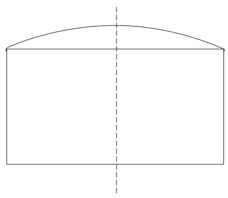
ECCENTRIC INCREASING



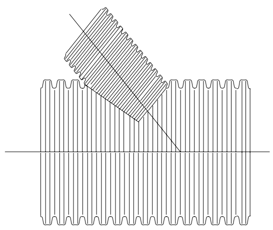
SLEEVE - SLIDING SLEEVE



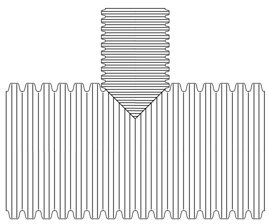
CAP



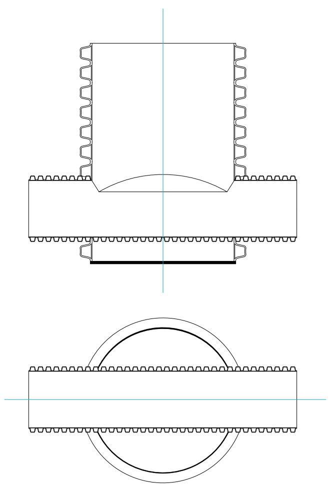
45° REDUCED BRANCH



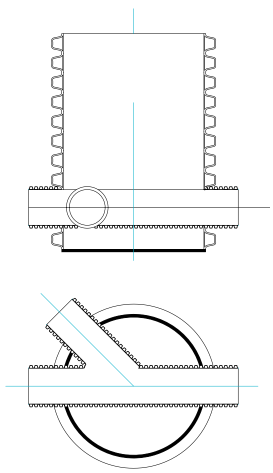
REDUCED TEE



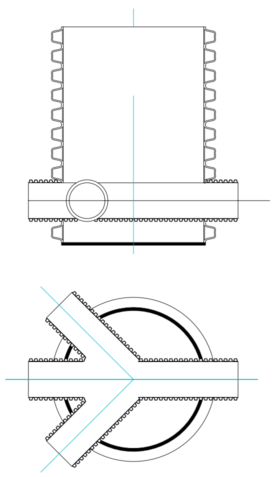
LINE FINAL
COLLECTING UNIT



LINE FINAL
COLLECTING UNIT 2



LINE FINAL
COLLECTING UNIT 3



- **End-user connections & side-branches connections:**
One of the problems that may arise on the working site is the connection of a branch in an unexpected position or new end-user connections to be created onto anexisting **EuroSewer** pipe network.
Therefore a GO-IN coupling kit has been designed.
It contains gaskets and joint elements. This solution permitsquickly and easily to make branches and end-user connections to corrugated or PVC pipes.
All these operations can be made directly on site in very fast and user-friendly way.

EASY INSTALLATION:
- no trouble even with exhisting network;
- no limit in positioning of the joint
- No mechanical device necessary for the branch connection (only drilling machine and special tool)

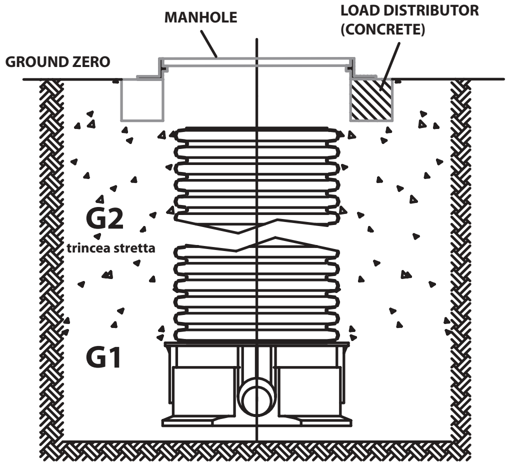
QUICK INSTALLATION:
- no sliding sleeve necessary
- no stop of the flow in the main pipe

COMPLETE ECONOMY WITH RESPECT TO OTHER JOINT SYSTEMS
- the advantages increase by incresing the DN of the main pipe.

- **Manholes:**
EuroSewer has proved to be ideal for the production of manholes. They are custom-made by welding or with a moulded base. The **EuroSewer** manholes are stand-alone structures inserted in-line. One model is made by creating a moulded bottom base with **EuroSewer** pipe as extension. Another is made from properly cut pipes welded to one another. The latter permits to satisfy particular requests. All are provided with the necessary way inlet-outlet connections and the bottom outline. Under request special manholes can be manufactured according to the project specs. The connection between the socket/spigot of the manholes and the in-line pipes is made, in general, with a coupling. For the connection to the moulded bottom base, suitable joints are provided in order to assure the hydraulic tightness between the pipe extension and the base. Other special fittings have been designed in order to join **EuroSewer** pipes to concrete manholes.
These fittings can be inserted into the inlet-outlet holes of the concrete manhole and then cemented to the wall of the manhole itself.

MATERIAL:	**COMPACTION:**
CI G1< 16 mm (gravel)	in layers 500/600 thick
CI G2< 32 mm (gravel)	mm (ATV - A 139)
(ATV 127)	

fig. 9



- **Connection to other types of pipes:**

EuroSewer can be connected to any other type of pipe by means of suitable fittings.
It is recommended to make the transition between the existing pipeline and the new **EuroSewer** pipeline by using a manhole.
Any case, the transition fittings shall provide different settlements according to thedifferent materials.
According to the norm ENV 1046, the connection type 1, a flexible fitting (***e.g.*** sealing gasket) is inserted into the walls of the manholes just when it is manufactured.
Another solution consists in cementing a sleeve to the walls of the manholes.
This second solution is commonly used because of its easy construction and safe watertightness.
A further method consistsin locking a piece of pipe to the walls of the manholes.
This piece shall lean out of the walls of the manholes not less than 400 mm.
The joint method shall be by sleeve.

5.8 Trench backfilling

The backfilling phase is a very important and critical step while installing flexible pipes.

A backfilling operation made without a correct compaction has a negative influence on both flexible and rigid pipes.
The backfilling phase (including side-backfilling and final backfilling) involves the following steps:

A - Choice of suitable backfilling soils:

- use for side-backfilling soil types described in tab. A1 (categories from 1 to 4);

- In case of imported material will be used, it shall be dry and low grain-sized, well graded and with maximum dimension of the particles as defined in the table below:

***tab. 26**- Maximum grain-size of the soil used for thebottom*

Nominal size DN	Maximum size of the grains (mm)
DN < 100	15
100 Ö DN < 300	20
300 Ö DN < 60	30
600 Ö DN	40

In case of native soil will be used, it shall fulfil the following requirements:

- Maximum size of the grains shall be in keeping with the previous table (no bigger sizes areaccepted)

- No frozen material

- No debris (asphalt, bottles, tins, wood);

- It shall be compactable (if required) according to the tables A1 and 6

B - Side-backfilling and compaction:
After the pipe is laid, place the pipe zone backfill in layers on each side of the pipe.
The height **c** of the side-backfilling shall be at least 150 mm over the upper side of the pipe and 100 mm over the upper side of the joint section.
Each layer shall be compacted according to the required compaction degree.
The height of each layer shall be defined according to the chosen compaction methods, as described in the table. This table gives the recommended maximum layer thickness and the number of passes required to achieve the compaction classes for the various types of equipment. Average thickness for backfill layer are 30 cm. Where it is expected that ground water may flow through the granular embedment the provision of barriers such as clay stanks should be considered.
For long-length installations, backfill the pipeline in more steps. Avoid to backfill during the hottest hours of the day in order to prevent excessive thermal elongations.

C - Remaining backfilling
The remaining part of the backfill may be made with excavated material.
No mechanical device should be used for the very first layer of the remaining backfill in order not to damage the pipe.
The rest of the backfill can be mechanically compacted (where required) as long as the thickness of the layer over the pipe shall be higher than the one specified in table
Excavated material may be used, as long as the following requirements will be fulfilled:

- maximum particle size = 300 mm;

- If compaction is required, it shall be suitable for compaction and shall have a maximum particle size not greater than 2/3 of the compaction layer thickness

- Under non-trafficked areas compaction class **N** is felt to be sufficient. Under trafficked areas compaction class **W** shall be used

D - Final check of the installation:

After the final backfilling is made, a check of the conformity of the real laying conditions to the the oretical ones (which were chosen, for example, to choose the suitable SN of the pipe) shall be made. This check shall involve the following aspects:

- Close monitoring of the backfill procedures (bedding, side & final backfilling)

- Verification of the initial deflection of the installed pipe;

- On-site verification of the degree of compaction
  After repair and additional connection procedures, care should be taken that when replacing sidefill and backfill the new density values the new density values are approximately equal to those immediately adjacent to the replaced zones.

tab. 27 Recommended layer thickness and number of passes for compaction

Equipment	Number of passes for compaction class			Maximum layer thickness, in metres, after compaction for soil group				Minimum thickness over pipe crown before compaction
	Well	Moderate	Absent	Gr. 1	Gr. 2	Gr. 3	Gr. 4	Gr. 1 - 4
Foot or hand min. 15 Kg	3	1	0	0,15	0,10	0,10	0,10	0,20
Vibr. temper min 70 Kg	3	1	0	0,30	0,25	0,20	0,15	0,35
Plate vibrator 50 Kg 100 Kg 200 Kg 400 Kg 600 Kg	4 4 4 4 4	1 1 1 1 1	0 0 0 0 0	0,10 0,15 0,20 0,30 0,40	- 0,10 0,15 0,25 0,30	- - 0,10 0,15 0,20	- - - 0,10 0,15	0,15 0,20 0,25 0,35 0,50
Vibrating roller 15 kN/m 30 kN/m 45 kN/m 65 kN/m	6 6 6 6	2 2 2 2	0 0 0 0	0,35 0,60 1,00 1,50	0,25 0,50 0,75 1,10	0,20 0,30 0,40 0,60	- - - -	0,60 1,20 1,80 2,40
Twin vibrating roller 5 kN/m 10 kN/m 20 kN/m 30 kN/m	6 6 6 6	2 2 2 2	0 0 0 0	0,15 0,25 0,35 0,50	0,10 0,20 0,30 0,40	- 0,15 0,20 0,30	- - - -	0,20 0,45 0,60 0,85
Triple heavy roller (no vibration) min. 50 kN/m	6	2	0	0,25	0,20	0,20	-	1,00

5.9 Final (hydraulic) check

- **General:**

After the installation the pipe it will be necessary to perform a final check of the pipeline. See the relevant laws and rules concerning this subject where applicable.
The norm EN 1610 contains two check methods:

- Water method (W)
- Air method (L)

The latter method can be performed according to 4 sub-methods (LA, LB, LC and LD).
Attention should be paid in order not to cause excessive initial deformations on the pipe during backfilling and compaction. It is suitable to perform the tightness check on the pipeline already installed.

The hydraulic check can be done by means of special balloons which are inflated thus plugging the line. This line is then put under pressure at 0,5 bars by using a suitable pump or a water column.
Until now no criteria have been established in order to check the tightness of structured-wall pipes.
Therefore, it is suggested to use the same criteria as the ones used for rigid pipes with cuff joint.
The test pressure, the pressure loss and the test time for air method check given for wet concrete pipe and all the other materials are given in the table below.

- **Air method (L):**

This procedure can be carried on more times. In case of negative result, the water method W shall be used.
This latter method will be decisive.
The four procedures (LA, LB, LC and LD) involves for steps:

- keep a pressure **pi** 10% higher than the test pressure $\mathbf{p_o}$ required.
  This pressure shall be kept for 5 minutes.

- Decrease the pressure up to $\mathbf{p_o}$ according to the check method (LA, LB, LC and LD).

tab. 28

Test method	mbar (KPa)		Test time –t- (min)						
	Po	ê p	DN 100	DN 200	DN 300	DN 400	DN 500	DN 800	DN 1000
LA	10 1	25 (2,5)	5	5	7	10	14	19	24
LB	50 (5)	10 (1)	4	4	6	7	11	15	19
LC	100 (10)	15 (1,5)	3	3	4	5	8	11	14
LD	200 (20)	15 (1,5)	1,5	1,5	2	2,5	4	5	7
K_p values			0,058	0,058	0,040	0,030	0,020	0,015	0,012

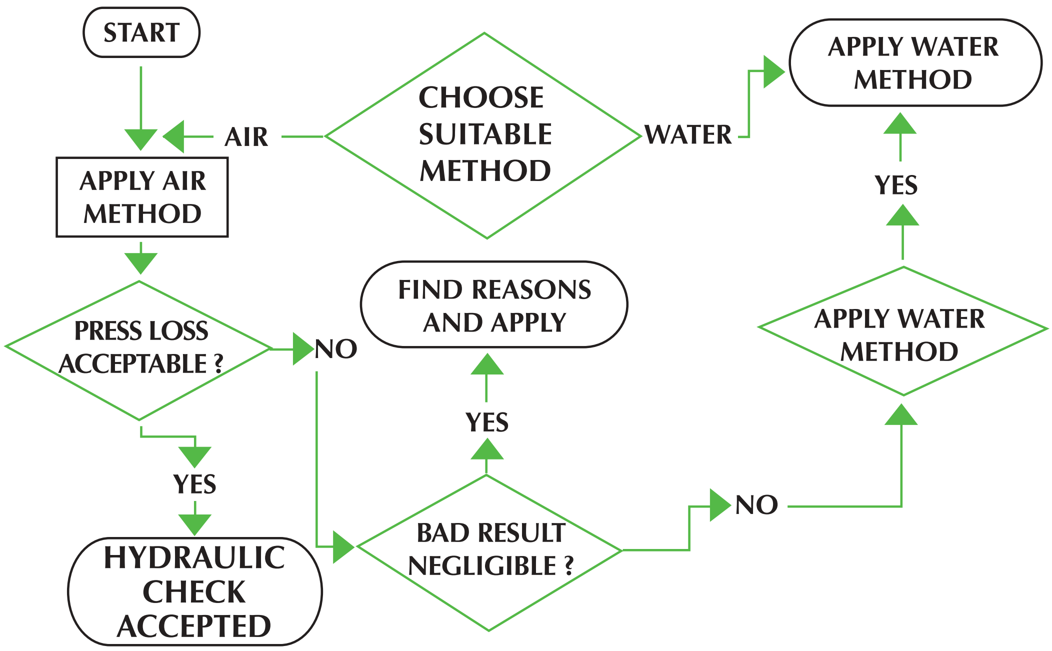
The necessary equipment for the air test consists on a set of rubber balloons with a suitable dimension according to the inner size of the pipeline under test, a compressor, a pressure gauge connected to a data-logger.
Put the balloons at the end of the pipeline, then inflate them thus plugging the pipeline.
One of the balloons is provided with an inlet valve to fill the pipeline with air.

The system is connected to a pressure gauge to measure the pressure trend inside the pipe.

Where

$$t = \frac{1}{K_p} \quad \text{in} \; \frac{p_o}{p_o - \Delta p} \qquad K_p = \frac{12}{DN}$$

With a maximum value of **Kp** = 0,058 and **t** rounded to the nearest half-minute when t Ö 1 min and rounded to the nearest minute when t > 5 minutes. If the pressure loss measured after the test time is lower than the ê**p** indicated in the table, the check shall be considered successful.The following diagram shows the basic procedure for the air method:



- **Water method (W):**

Fill the pipeline with water. Since EuroSewer is a plastic pipe, it doesn't need to be previously wet, so it is possible to start the hydraulic check just after a short stabilization time (this time is necessary in order to stabilize the test pressure inside the pipe).

- Apply the required test pressure for a test time of (30±1) minutes.
  The test pressure shall be obtaining by filling the pipeline under test up to the ground level in correspondence of the manholes situated at a upper or lower level. The maximum pressure test shall be 50 KPa (0,5 bars), the minimum pressure shall be 10 KPa (0,1 bars) measured on the upper side of the pipe.

- Keep this test pressure constant (± 1 KPa) during the test time.
  Add water to keep this pressure constant if necessary.

- Measure the water which is added to keep the pressure constant during the test time.
  The test shall be considered succesful if the added water quantity shall not higher than:

0,15 l/m2 for 30 minutes	for pipeline
0,20 l/m2 for 30 minutes	for pipelines with manholes
0,40 l/m2 for 30 minutes	for pipelines with manholes and inspection chambers

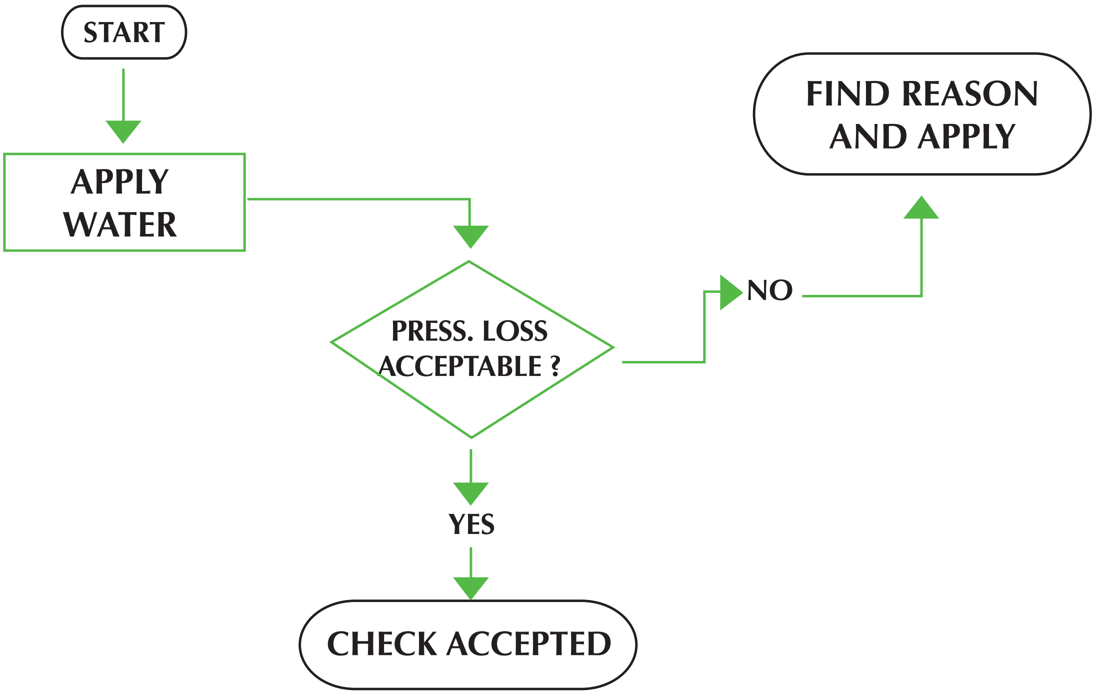
The m^2 are referred to the wet cross-section of the pipe.
Since during the test the pipe is fully filled with water, the wet section in this case is coincident with the cross-section of the pipe.

tab. 29 Cross-section Area of Eurosewer pipe

DN	160	200	250	315	400	500	630	800	1000	1200
Cross section (m^2)	0,015	0,024	0,036	0,059	0,092	0,143	0,223	0,356	0,566	0,857

The hydraulic check can be done by means of special balloons which are inflated thus plugging the line. This line is then put under pressure at 0,5 bars by using a suitable pump or a water column.

The necessary equipment for the water method test consists on a set of rubber balloons (or any other plugging device), a pump (or any other suitable device for reaching and keeping a constant test pressure),a pressure gauge connected to a data-logger. The following diagram shows the basic procedure for the application of the water method test



- **Qualification of the personnel involved in the installation**

With regard to this issue, the following aspects shall be taken in deep consideration:

- The supervision and execution of the installation design shall be carried out by suitably trained and expert personnel;
- The enterprises winner of the tender shall have the qualification and fulfil the necessary requirements to carry out the installation; The purchaser / owner of the tender shall implement a system in order to qualify the enterprises for such job / tender.

Flow rates & speeds obtained by Gauckler-Strickler formula

(safety coefficent K_S = 80 $m^{1/3}$ s^{-1})

Pipe filling = 50%		i = 0,5%		i = 1%	
DN (mm)	DN int. (mm)	speed (m/sec)	f-rate (m^3/sec)	speed (m/sec)	f-rate (m^3/sec)
125	107	0,506	0,002	0,715	0,003
160	136	0,593	0,004	0,839	0,006
200	174	0,699	0,008	0,989	0,012
250	214	0,803	0,014	1,135	0,020
315	273	0,944	0,028	1,335	0,039
400	343	1,100	0,051	1,555	0,072
500	427	1,272	0,091	1,799	0,129
630	533	1,475	0,164	2,086	0,233
800	673	1,723	0,306	2,437	0,433
1000	849	2,012	0,569	2,845	0,805
1200	1030	2,289	0,953	3,237	1,348

Pipe filling = 70%		i = 0,5%		i = 1%	
DN (mm)	DN int. (mm)	speed (m/sec)	f-rate (m^3/sec)	speed (m/sec)	f-rate (m^3/sec)
125	107	0,566	0,004	0,801	0,005
160	136	0,665	0,007	0,940	0,010
200	174	0,783	0,014	1,108	0,020
250	214	0,899	0,024	1,271	0,034
315	273	1,057	0,046	1,496	0,065
400	343	1,231	0,085	1,741	0,120
500	427	1,425	0,152	2,015	0,216
630	533	1,652	0,275	2,336	0,390
800	673	1,930	0,513	2,729	0,726
1000	849	2,253	0,953	3,186	1,348
1200	1030	2,563	1,596	3,624	2,257

Pipe filling = 95%		i = 0,5%		Riempimento = 50%	
DN (mm)	DN int. (mm)	speed (m/sec)	f-rate (m^3/sec)	speed (m/sec)	f-rate (m^3/sec)
125	107	0,554	0,005	0,783	0,007
160	136	0,650	0,009	0,919	0,013
200	174	0,766	0,018	1,083	0,025
250	214	0,879	0,031	1,243	0,044
315	273	1,034	0,059	1,462	0,084
400	343	1,204	0,109	1,703	0,154
500	427	1,393	0,196	1,971	0,277
630	533	1,615	0,354	2,284	0,500
800	673	1,887	0,658	2,669	0,931
1000	849	2,203	1,223	3,116	1,730
1200	1030	2,506	2,048	3,544	2,897

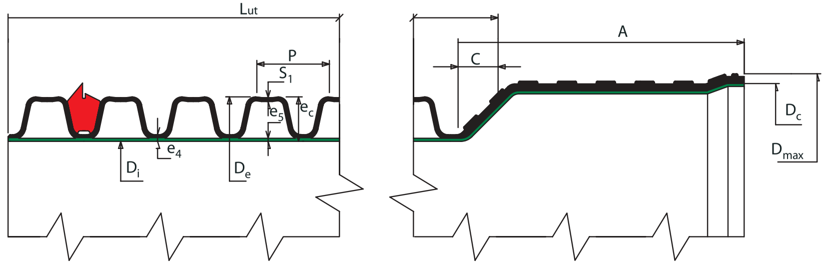
Pipe filling = 50%		i = 2%		i = 3%		i = 5%	
DN (mm)	DN int. (mm)	speed (m/sec)	f-rate (m^3/sec)	speed (m/sec)	f-rate (m^3/sec)	speed (m/sec)	f-rate (m^3/sec)
125	107	1,012	0,005	1,239	0,006	1,599	0,007
160	136	1,17	0,009	1,454	0,011	1,877	0,014
200	174	1,399	0,017	1,713	0,020	2,212	0,026
250	214	1,606	0,029	1,967	0,035	2,539	0,046
315	273	1,889	0,055	2,313	0,068	2,986	0,087
400	343	2,199	0,102	2,693	0,124	3,477	0,161
500	427	2,545	0,182	3,117	0,223	4,024	0,288
630	533	2,950	0,329	3,613	0,403	4,665	0,520
800	673	3,447	0,613	4,221	0,750	5,450	0,969
1000	849	4,024	1,138	4,928	1,934	6,362	1,800
1200	1030	4,577	1,906	5,606	2,334	7,237	3,014

Pipe filling = 70%		i = 2%		i = 3%		i = 5%	
DN (mm)	DN int. (mm)	speed (m/sec)	f-rate (m^3/sec)	speed (m/sec)	f-rate (m^3/sec)	speed (m/sec)	f-rate (m^3/sec)
125	107	1,133	0,008	1,387	0,009	1,791	0,012
160	136	1,329	0,014	1,628	0,018	2,102	0,023
200	174	1,566	0,028	1,918	0,034	2,477	0,044
250	214	1,798	0,048	2,202	0,059	2,843	0,076
315	273	2,115	0,093	2,590	0,113	3,344	0,146
400	343	2,463	0,170	3,016	0,208	3,894	0,269
500	427	2,850	0,305	3,490	0,374	4,506	0,482
630	533	3,304	0,551	4,046	0,675	5,224	0,871
800	673	3,860	1,026	4,727	1,257	6,103	1,622
1000	849	4,506	1,907	5,519	2,335	7,125	3,014
1200	1030	5,126	3,192	6,278	3,909	8,105	5,047

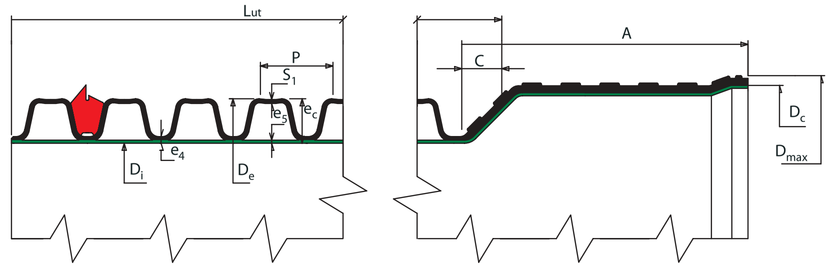
Pipe filling = 95%		i = 2%		i = 3%		i = 5%	
DN (mm)	DN int. (mm)	speed (m/sec)	f-rate (m^3/sec)	speed (m/sec)	f-rate (m^3/sec)	speed (m/sec)	f-rate (m^3/sec)
125	107	1,108	0,010	1,357	0,012	1,751	0,015
160	136	1,300	0,019	1,592	0,023	2,055	0,029
200	174	1,532	0,036	1,876	0,044	2,422	0,056
250	214	1,758	0,062	2,153	0,076	2,780	0,098
315	273	2,068	0,119	2,533	0,145	3,270	0,188
400	343	2,408	0,218	2,949	0,267	3,807	0,345
500	427	2,787	0,391	3,413	0,479	4,406	0,619
630	533	3,231	0,707	3,957	0,866	5,108	1,118
800	673	3,774	1,317	4,622	1,613	5,967	2,082
1000	849	4,406	2,447	5,397	2,997	6,967	3,869
1200	1030	5,012	4,096	6,139	5,017	7,925	6,477

EuroSewer Technical DataSheet prEN 13476-1 (UNI 10968-1)

Field of application	Sewage, drainage and discharge water not under pressure	Colour	Outer wall black, inner wall green	Area code	# U	Structured-wall type	# B



DN < = 1000



DN = 1200

DN/OD (mm)	Lenghts (mm)						Diameters (mm)						Structured-wall geometry (mm)							
	cuff (A)		cone (C)	pitch (P2)	Useful (L_{ut})	Tot.	outer (D_e)		inner (D_i)		Cuff Out. (D_v)	Cuffmax Dmax	Profile height ec (ecc)		Outer wall thick. (S_1)		Inner wall thick (e_5)		Welding thick. (e_4)	
	Meas.	STD					Min.	Max	prod.	STD			SN4	SN8	SN4	SN8	SN4	SN8	SN4	SN4
125	- > 35		-	18	6000	6000	124,3 - 125,4		107 > 105		-	-	8,9		-	0,6	-	1,0	-	1,4
160	80 > 35		14	33	6050	6130	159,1 - 160,5		136 > 134		168,5	174,5	11,8		0,7	0,8	1,2	1,2	2,2	2,2
200	90 > 50		20	33	5990	6080	198,8 - 200,6		174 > 167		211,5	215,0	13,1		0,7	1,2	1,3	1,4	2,3	2,4
250	100 > 55		22	40	6050	6150	248,5 - 250,8		214 > 209		261,0	264,0	18,0		1,4	1,7	1,6	2,0	3,4	3,5
315	150 > 62		28	42	6000	6150	313,2 - 316,0		273 > 263		326,0	335,5	20,8		1,5	1,9	2,2	2,4	3,9	3,9
400	175 > 70		38	48	6005	6180	397,6 - 401,2		343 > 335		412,0	425,5	28,2		2,0	2,3	2,5	2,7	4,7	4,8
500	190 > 80		48	56	5940	6130	497,0 - 501,5		427 > 418		516,5	529,5	36,1		2,1	2,5	3,4	3,6	5,2	5,2
630	200 > 93		84	100	6005	6205	626,3 - 631,9		533 > 527		650,5	656,5	48,2		2,4	3,0	4,0	4,2	6,8	7,0
800	280 > 110		88	98	6100	6380	795,2 - 802,4		673 > 669		827,0	841,0	62,9		2,7	3,5	4,9	4,9	8,6	8,7
1000	290 > 130		100	98	6060	6350	994,0 - 1003,0		849 > 837		1042,0	1049,0	74,9		3,5	3,7	5,9	6,6	10,9	10,9
1200	220 > 150		65	130	6065	6285	1203,6-1192,8		1045 > 1005		1200,0	1210,0	75 (62)		4,5	5,0	6,0	6,7	12,0	12,5

* average production values

Picenum Plast guarantees the conformity to the requirements defined in the prEN13476-1 norm. For other relevant characteristics, actual values may be different from the ones contained in this table.

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