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1. The optimal sustainable solution for sewage networks

1.1. Sewage pipes in Spain

The development of water networks in general, and urban sewage systems in particular, have to take into account certain social and environmental requirements. A sewage system must be well designed and implemented to achieve the levels of sanitation and environmental protection that are required by society today, while at the same time helping to preserve as many of the available resources as possible for future generations.

These requirements have had a very significant impact on the development of modern sewage pipe systems, in which the composition and shape of the pipes and the design of the network's different components are aimed at achieving more watertight, longer-lasting systems with lower operating costs. The characteristics of these systems are also optimised by using materials that use less energy and therefore emit less CO_2 into the atmosphere over the entire life cycle of the system's components.

Ultimately, the choice of materials used in sewage networks must also support sustainable development for future needs.

The growing importance of the above criteria has led to very high levels of investment in sewage infrastructure in recent decades. As a result, modern pipelines come in a wide variety of materials and shapes.

One key distinction is between rigid and flexible materials, each of which have advantages and disadvantages. The former are essentially the traditional materials that have been used for a long time, while the latter are plastic materials, which have undergone the greatest development in recent decades. The most common materials are listed in **Table 1**.

It should be noted that while a sewage pipe, which is generally underground and has to support traffic loads, requires high rigidity, it should also have a certain amount of flexibility to transmit forces to the backfill of the trench in which it is installed, and to absorb any settlement of the ground and of the pipe itself.



SANECOR® wastewater pipe and manhole and concrete stormwater pipe



Reinforced concrete pipe

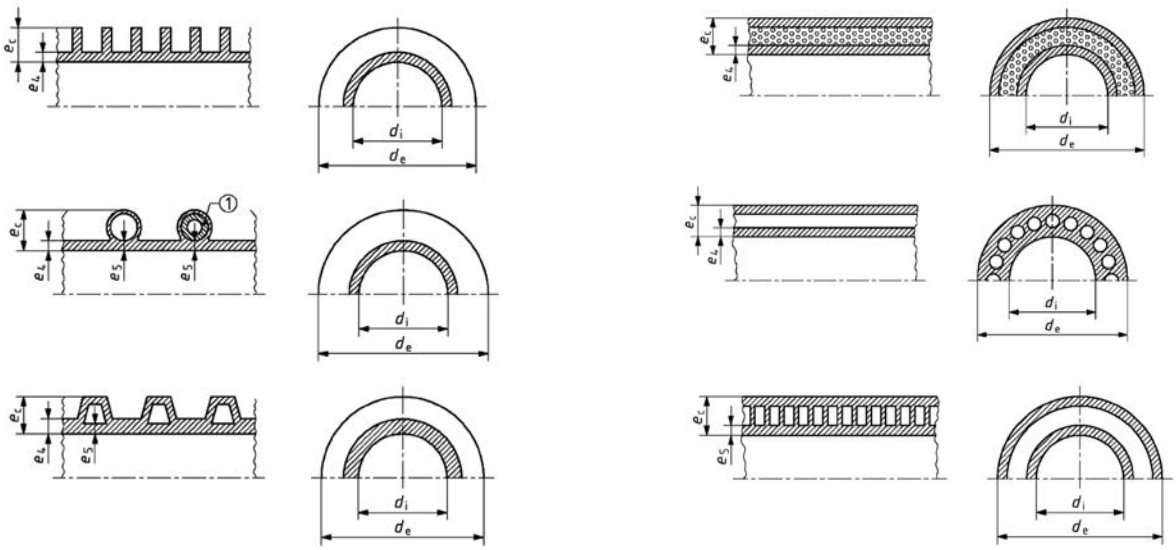


SN4® smooth PVC sewage pipes

Materials used in sewage pipes (Table 1)

Rigid materials	Plastic materials	
Mass concrete	Smooth compact PVC	Smooth compact PE
Reinforced concrete	Smooth honeycomb PVC	Corrugated PE
Fibre cement	Smooth multi-layer PVC	Corrugated PP
Vitrified clay pipe	Corrugated PVC	FRP filament winding
Nodular cast iron	Ribbed PVC	FRP centrifugally cast
Ductile iron	Helical PVC	Polymer concrete

Within plastic pipes, a distinction is made between compact smooth pipes, which are manufactured via simple tube extrusion of the plastic material, and what are known as structured wall pipes, which feature a more sophisticated pipe section in order to increase the stiffness of the pipe without increasing its cost. The following figure shows some of the most commonly used structured wall sections.



Main profiles used in plastic structured wall pipes



Corrugated PVC | Corrugated PE | Corrugated PP | FRP

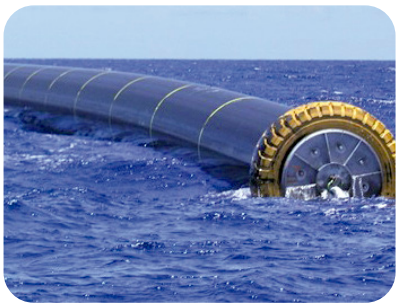
Most widely used plastics in sewage systems

Of all the materials listed in **Table 1**, only a few provide good value for money at a national level. For example, mass concrete, although very cheap, is falling into disuse because of its low mechanical strength. Clay and cast iron pipes are disappearing because of their high cost. The manufacture of fibre cement pipes ceased when the use of asbestos was banned, although they are still extremely common in existing networks.

Ribbed, honeycomb and multi-layer PVC pipes have become less common in Spain, as they are not sufficiently cost-competitive. Finally, there are pipes which, due to their high cost, are only used in special applications, such as compact polyethylene pipes, which are generally limited to submarine outfalls, or polymer concrete pipes, made of polyester resin reinforced with aggregates, which are only used as jacking pipes.



Clay



Smooth PE
(common in submarine outfalls)



Polymer concrete
(jacking pipes)

Materials not widely used in sewage systems

1.2. Characteristics of plastic sewage pipes

Using plastic materials in sewage pipes has numerous advantages, which are detailed below:

Chemical resistance

The specific properties of wastewater mean that sewage pipes need to cope effectively with the pH of the chemical constituents present in the flowing water. This is one of the most notable features of plastic pipes, whatever the material, as they are generally highly resistant to most of the products present in wastewater.

While PE and especially PP perform better at high temperatures, PVC is more resistant than PE and PP to the damage caused by grease, mineral oils and fuels, which are extremely common in urban runoff water.



Chemical resistance testing





Effects of external and internal corrosion on pipes

No corrosion

Plastic pipes are generally impervious to the effects of corrosion. This is an important advantage, as the pipeline material must not rust due to aerobic corrosion or suffer from anaerobic corrosion caused by components and micro-organisms in the water flowing through it and in the surrounding soil.

Pipes need to be resistant to electrochemical corrosion, i.e. to the corrosion currents that are created when the condition of the wall is different at two points on the surface of the pipe, or when the soil surrounding the pipe has different concentrations of oxygen or salts along its route (which is normally the case).

Corrosion currents only pass through pipes whose material is more conductive than the ground, and they corrode it in the same way as stray currents that occur in the vicinity of electrical installations. In the case of particularly aggressive effluents or soils, pipes made of materials resistant to such aggression and/or special protection systems or sufficiently thick, stable and resistant linings must be used.



Pipes that have been damaged by electrochemical corrosion

Abrasion resistance

Pipes need to be resistant to the abrasion to which they will be subjected by solid particles carried by the effluent.

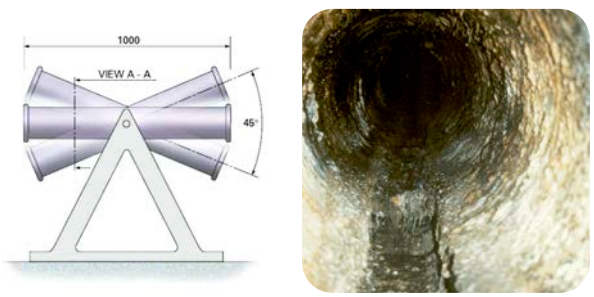
This is especially important in pipes used in networks where the sewage and rainwater systems are separate.

Because the internal roughness of plastic pipes is lower, their abrasion resistance is higher.

In fact, abrasion progresses very slowly on the internal surface of any plastic pipe.

One thing that is sure is that at normal speeds, the abrasive wear is negligible and, therefore, the lifetime of the pipe is virtually unlimited.

This has proven to be so for PVC pipes which have been shown to be extremely resistant to abrasion, since these are the plastic pipes that have been installed for the longest amount of time.



Test method and effect of abrasion

Deposits and fouling

The lack of porosity of the internal surface of plastic pipes prevents any fouling caused by materials contained in the wastewater and rainwater. However, this effect is far more pronounced in pipes made of materials that contain cement: concrete, fibre cement and cast iron (cement mortar lining).

As far as deposits are concerned, the higher flow velocity achieved by water in a plastic pipe minimises this effect, which is more noticeable in highly porous pipes, i.e. pipes made from conventional materials. However, in the case of plastic pipes, depending on the material, it should be noted that pipes can exhibit pronounced longitudinal flexibility and buckle excessively. This effect can lead to backfalls and, therefore, unforeseen deposits.

With sewage pipes made of PVC, which has a high elastic modulus, this problem does not occur.



Sewage pipe with material deposits

Watertightness in joints

Nowadays, it is essential that there are no leaks in a sewage network that could pollute the natural environment. Moreover, it is vital to prevent subsoil water from infiltrating the pipes. If a significant amount enters the pipes, this increases energy consumption and treatment costs in general, and may even hinder the normal operation of the networks and treatment plants. Therefore, it is vital to ensure that pipelines are completely watertight, especially around gaskets, connections, manholes, etc., which are critical to ensuring that this essential requirement is met.



Manual connection of corrugated pipe



Joint leakage in concrete pipe

With this in mind, prefabricated coupling systems based on elastic joints, whose watertightness can be guaranteed by the manufacturer's testing, are highly recommended, as opposed to on-site joints, which require very stringent *in situ* testing to ensure that they are watertight, which is difficult to carry out in practice. It is necessary to perform *in situ* hydraulic pressure testing (at 0.5 atmospheres) to check that the system is completely watertight.

The watertightness of plastic pipes is generally greater than that of rigid pipes, since a flexible pipe accommodates any deformation to ensure a better seal with the elastic joint. However, this will depend on the design of the chosen joint. Often, in order to save costs, the joint is of poor quality and therefore does not provide a good seal. The types of joints most commonly used in plastic pipes are discussed below.

Finally, it should be noted that, in addition to the pipes, there are other elements in the network through which water infiltration can occur, the most obvious of which are the manholes. Such infiltrations occur when the sewage system is installed below the water table.

The requirement for watertightness must therefore be extended to all parts of the network, especially in the presence of a water table, and particularly to manholes, where connections to pipes and connection points are areas where leaks and water ingress frequently occur.



Smooth PVC pipe socket joint



Watertight connection on SANECOR® manholes



Sleeve joint on large-diameter FRP pipes

Hydraulic capacity

This property is closely linked to the need to convey wastewater quickly, without any blockages. Sewage networks are affected by factors that are not present in clean water pipes, such as deposits on the bottom and walls of the pipes, manholes, a greater number of joints, etc.

Therefore, these effects are factored into the equivalent uniform roughness **(K)** of the pipes (Prandtl-Colebrook), with different values being assigned to the pipe depending on the type of fluid that flows through it (clean water, rainwater, sewage, industrial water, etc.).

The effect on equivalent roughness of the use and maintenance of the pipeline is also taken into account.

The following values are commonly used in wastewater pipelines.

K factor values for different materials (Table 2)

Pipe type	K (mm)
Clay Smooth PVC inner wall	0.10-0.25 0.10-0.25
Smooth HDPE inner wall FRP centrifugally cast	0.10-0.25 0.10-0.25
FRP filament winding Fibre cement	0.20-0.50 0.25-0.40
High-quality smooth concrete Medium-quality smooth concrete	0.40-0.80 0.80-1.50
Rough concrete "In situ" concrete	1.20-4.00 2.50-6.00

The lower values in **Table 2** are especially applicable to new or well-maintained pipes with long straight runs between manholes, main pipes and outfalls. The higher values apply to pipes that are in service after several years of operation.



Inner surface of SANECOR® pipes





The internal friction factor of plastic pipes is minimal

Another key factor for the hydraulic capacity of a pipe is its inner diameter. In plastic pipes, the nominal diameter is almost always the same as the outer diameter.

This means that the inner diameter, and therefore the hydraulic capacity of each pipe will depend on the thickness it is given by the manufacturer. In the case of structured wall pipes, this thickness can be very considerable. Since this is a key distinguishing factor between different pipes of this kind, it is discussed further below.

Performance and installation costs Assembly safety

Plastic pipes are generally very light, and in the case of structured wall pipes even more so. This characteristic results in very low handling and assembly costs, as there are significant savings in the machinery and labour required during installation.





Left: SANECOR® pipe installation using discrete mechanical tools (medium and large diameters).
Right: manual connection (small diameters)

In addition to the above, the low weight significantly increases work efficiency, which leads to a reduction in lead times and therefore in fixed costs, which can be crucial for the economic viability of the project.

Last but not least, another major advantage of the light weight of these pipes is the increase in safety for workers carrying out the installation.

For deep pipelines, where shoring of the trench walls is necessary, the less time workers spend in the trench, the greater the safety on the site.



Installation of FRP pipes in a shored trench



1,200 mm SANECOR® pipe with angular deflection

Pipeline flexibility

The pipes in a network are often subjected to stresses and deformations caused by differential settlement of the ground, which must not be allowed to cause burst pipes or any kind of leakage.

This requires pipes to be flexible enough to accommodate deformations while minimising the local stresses that occur.

A plastic pipeline with elastic joints adapts to settlements, easily absorbs the stresses produced, whereas in a system with rigid parts, which is incapable of adapting to the same deformations, enormous stresses appear which can lead to burst pipes and, therefore, leaks.



The flexibility of plastic pipes is important to absorb ground movements

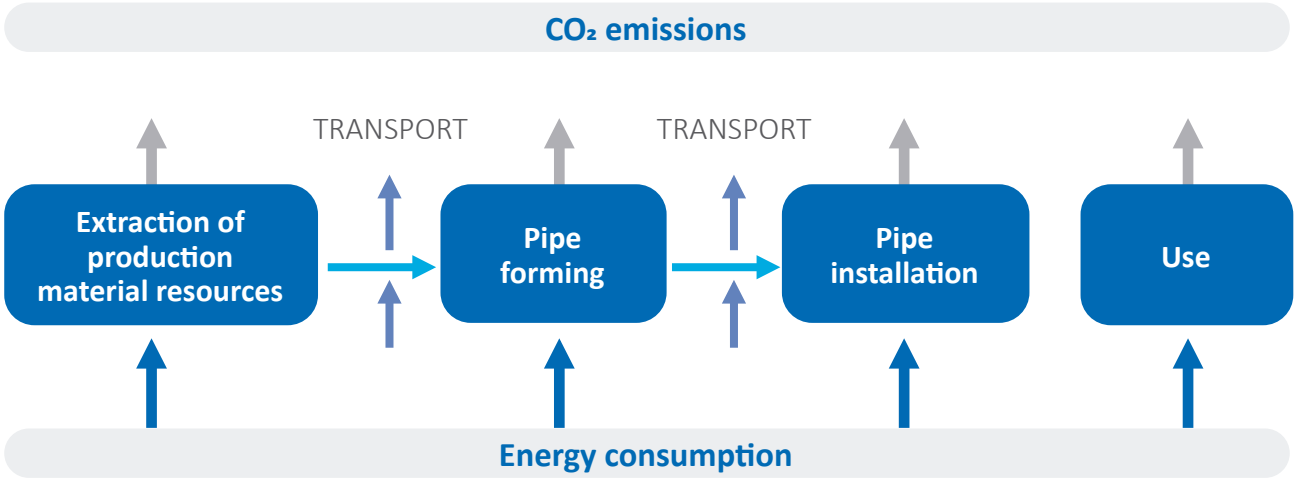
Energy consumption

According to a study (*) conducted by the Environmental Modelling Laboratory at the Polytechnic University of Catalonia's Department of Engineering Projects, throughout the entire life cycle of these products, energy consumption and CO_2 emissions to the atmosphere are very low in plastic pipes compared to the values attributed to reinforced concrete pipes.

(*) "Estimation of energy consumption and CO_2 emissions associated with the production, use and final disposal of PVC, HDPE, PP, cast iron and concrete pipes." (Dec. 2005). Authors: Dr José María Baldasano Recio, Dr Pedro Jiménez Guerrero, Dr María Gonçalves Ageitos and Dr René Parra Narváez.

This life cycle includes all phases of the product's service life:

- Extraction of the raw materials that form the pipe.
- Transportation of the raw materials to the pipe production plant.
- Manufacture of the pipes.
- Transportation of the pipes to the site where they are being installed.
- Installation of the pipes.
- Use of the pipes: maintenance and repair work.



Life cycle diagram of an underground pipe (excluding the recycling phase)

Sewage pipes - energy consumption and CO_2 emissions for 3 m of pipe

	Energy consumption (kW/h)	CO_2 emissions (kg of CO_2)
SN4 DN315 smooth PVC (80% recycled)	69.0	22.0
SN8 DN315 corrugated PVC (80% recycled)	34.7	11.5
SN8 DN400 corrugated PE (80% recycled)	64.4	21.0
SN8 DN400 corrugated PP (80% recycled)	60.4	21.6
SN4 DN315 PVC (0% recycled)	262.2	76.9
SN8 DN315 corrugated PVC (0% recycled)	121.3	36.1
SN8 DN400 corrugated PE (0% recycled)	211.0	58.6
SN8 DN400 corrugated PP (0% recycled)	191.0	61.5
DN400 concrete	345.0	129.4

The results of this study are summarised in the table above. As can be seen, the values for plastic materials are lower than they are for concrete, due to the light weight and low raw material content of the former compared to the latter. This difference is much greater if plastics with a high recycling rate are used. We can also see that both PVC pipes have a diameter of DN315 mm, while for the others, a larger equivalent diameter of DN400 mm has been considered. The reason for these differences will be explained below.

1.3. Optimisation of sewage pipes: SANECOR® pipes

Up until the mid-1970s, pipes for gravity sewage networks in Spain were mainly made of concrete or fibre cement, the materials traditionally used for many years. After that, the first PVC pipes appeared, representing a qualitative leap due to the properties of the material, as described in the previous section. However, due to the cost of PVC, these pipes, which are smooth, are only manufactured with a specific wall thickness for each diameter, which ensures a minimum initial ring stiffness of 4 kN/m^2 (nominal stiffness SN4), which, under certain installation conditions, is insufficient to avoid excessive deformations in the medium and long term. For this reason, in the 1980s, PVC pipes with structured walls began to be developed to increase rigidity without making the pipes more expensive. This was a major conceptual leap forward, since a structural improvement was achieved while optimising the consumption of raw materials and therefore energy over the entire life cycle of the pipe.

Following this criterion, the **SANECOR®** pipe was launched at the end of the 1980s, with a wall composed of two layers, the outer one corrugated and the inner one smooth. From the outset, this pipe was created with the aim of achieving a highly sustainable product designed to meet all of the needs of a sewage network, while optimising the energy consumption associated with its production, installation and operation, and minimising any environmental impact.

As such, it offers significant advantages over the majority of plastic pipes, the most important of which are summarised below.



SN8 corrugated PVC pipe

Maximum stiffness in the short and long term

As we have seen above, the flexibility of plastic pipes has a positive impact on their ability to adapt to ground settlement. However, this is counterbalanced by an even more important factor: the pipe must be sufficiently stiff in the short and long term, i.e. it must be able to withstand the external loads during the entire lifetime of the pipeline.

Such loads are not only exerted on the pipe, but also on the surrounding soil, so it is essential for the pipes to be installed correctly. But is it possible to have complete control over the installation? Normally no.

However, the quality of the pipe can be easily assured, as its characteristics, e.g. stiffness, are subject to standardised tests. In practice, the degree of importance of the pipe's ability to withstand external loads depends on the conditions of the soil surrounding the pipe. These conditions will largely depend on how the pipe has been installed, i.e. the dimensions of the trench, and the type of backfill and its compaction.

This can be quantified based on the deformation formula for underground pipes:

$$\frac{\Delta Y}{D} = \frac{K_1 \cdot Q_{vt}}{K_2 \cdot E_s + K_3 \cdot RCE}$$

This deformation, which is measured as a % of the pipe diameter, is a direct function of the vertical loads Q_{vt}, which are offset by 2 factors:

- E_s = modulus of elasticity of the soil surrounding the pipe, which depends on the trench, the type of backfill and its compaction, i.e. the quality of the installation.
- R_{CE} = specific circumferential stiffness of the pipe, which is defined as:

$$RCE = \frac{E_c \cdot I}{D_m^3}$$

Where:

- E_c = the modulus of elasticity of the pipe material.
- I = moment of inertia per unit length, which depends on the thickness of the pipe.
- D_m = mean diameter of the pipe.

The deformation formula shows that, if the soil component is sufficiently high (high E_s value), the stiffness of the pipe does not need to be high. However, if the modulus of elasticity of the soil E_s is not high enough, the deformation of the pipe depends largely on the stiffness of the pipe.

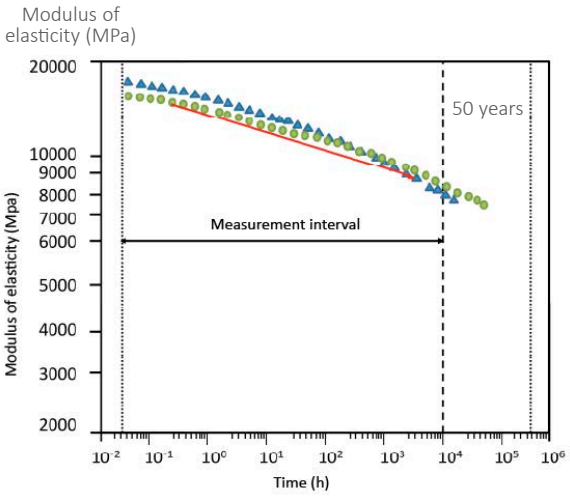
On the other hand, when using plastic pipes, the most widely applied technical documents (in Spain, the General technical specifications for sewage pipes of the Ministry of Public Works and Town Planning or the UNE 53331 standard "Criteria for testing plastic pipes in pressure and non-pressure pipelines subjected to external loads") limit the deformation of plastic pipes to 5% of their diameter at 50 years.

This time limit is due to the well-known characteristic of plastic elements, and polymers in general: they experience a loss of elastic modulus over time when they are subjected to mechanical stress.

This loss, called creep, which is due to the deformation of the macromolecules of the polymers, is very acute at the beginning, eases over time and is asymptotic at the 50-year horizon.

Creep is usually represented by the material's regression curve, which is presented on a logarithmic time scale, as in the figure below:

General diagram of the regression curve of a plastic material



In the case of pipes that have to withstand internal pressure, the relevant product standards require pipes to be able to withstand the intended working pressure 50 years after commissioning.

This forces manufacturers to design pipes that initially withstand far higher pressures than necessary, to ensure that they maintain the desired strength in the long term.

In the case of non-pressure underground pipes, the acting loads are due only to external factors such as the weight of the soil above, the dynamic forces of vehicular traffic, the static load of specific elements on the surface, etc. As we have seen above, the stress caused by these loads is countered by the load-bearing capacity of the soil itself and the stiffness of the pipe.

If the soil conditions after installation are not expected to be good enough to achieve high $\mathbf{E_s}$ values, or if a proper installation cannot be guaranteed, then a sufficiently high initial pipe stiffness $\mathbf{RCE_0}$ must be ensured so that the long-term stiffness $\mathbf{RCE_{50}}$ is maintained at acceptable levels.



Stiffness testing of a flexible pipe

In this sense, the creep coefficient of a given plastic element **p** over a certain time **t** is defined as:

$$Cf = Ep_0 / Ep_t$$

i.e., as the ratio between the initial modulus of elasticity of the plastic **p**, and the modulus of said plastic **p** after time **t** has elapsed. The creep coefficient value for the time **t** under consideration (2 years, 50 years, etc.), will determine the initial stiffness of the plastic pipe. As we will see below, creep coefficients can vary greatly depending on the type of plastic in question.

Bearing in mind the importance of these concepts due to their impact on the durability of plastic pipes, we will examine how to choose the optimal type of pipe from among the most common options. For this purpose, we will refer to two standards:

1- The DIN 16961-2 German standard: Thermoplastic pipes and fittings with profiled outer surfaces and smooth inner surfaces.

It defines the initial moduli of elasticity of the three materials considered according to the following values:

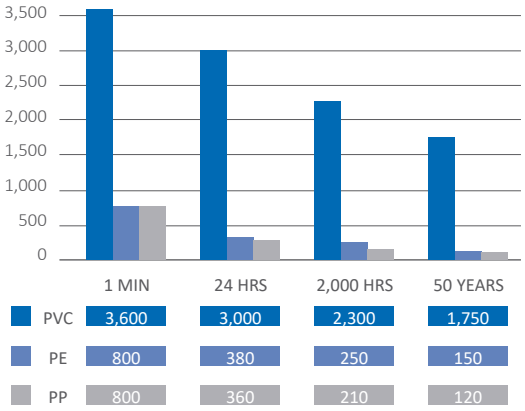
- PVC-U (unplasticised PVC): $\mathbf{E_0}$ = 3,600 MPa
- HDPE (high-density polyethylene) $\mathbf{E_0}$ = 800 MPa
- PP (polypropylene block copolymer): $\mathbf{E_0}$ = 800 MPa

If we apply these values to the stiffness formula seen above, it becomes clear that in order to achieve a certain initial stiffness, the moment of inertia **I** and therefore the thickness of PE and PP corrugated pipes needs to be considerably higher than that of PVC pipes, since the latter have a much higher $\mathbf{E_0}$ value.

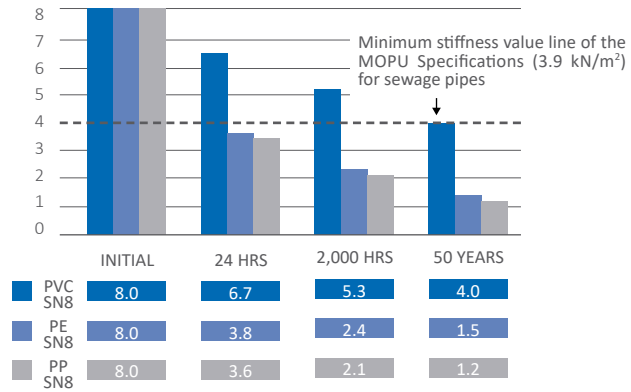
Moreover, due to the creep effect, for each material, the aforementioned standard defines a set of modulus of elasticity values that decrease over time when the pipes are subjected to stresses, as occurs in pipes buried under vehicular traffic.

The 1st of the following 2 graphs shows the drop in modulus $\mathbf{E_t}$, and in the 2nd, starting from SN8 pipes, the corresponding decrease in stiffness in the same proportion, since in the formula for the latter, the values of **I** and $\mathbf{D_m}$ remain invariable over time.

Comparison of moduli of elasticity over time according to DIN 16961



Changes in stiffness RCE = (Exl))Dm³ over time according to DIN 16961



From the $\mathbf{E_t}$ values we calculate the creep coefficients for the 3 materials in question.

Thus, for the $\mathbf{E_{50}}$ values at 50 years:

- $\mathbf{C_{PVC\ 50}}$ = 2.06
- $\mathbf{C_{PE\ 50}}$ = 5.33
- $\mathbf{C_{PP\ 50}}$ = 6.67

These exact coefficients would correspond to the loss of stiffness, if the loads experienced by the pipes were at the levels specified in this standard.

In SN8 PVC pipes, including the **SANECOR®** pipe, at 50 years the stiffness decreases to half the initial value, since these pipes were originally designed for a 50-year stiffness of 3.9 kN/m², which is in line with the minimum initial value specified in the General technical specifications for sewage pipes of the Ministry of Public Works and Town Planning (MOPU) from 1986. Although the specifications set this as the initial value, experience of numerous installations that were not performed correctly made it necessary to design sewage pipes to achieve this value at 50 years.

Thus, the initial stiffness required for PVC pipes was: $\mathbf{RCE_{min}}$ = 3.9 x 2.06 = 8 kN/m², i.e. SN8 pipes. Among other pipes, this led to the creation of the **SANECOR®** corrugated pipe, which has been widely used throughout Spain since the early 1990s.

If the same requirements had been applied to PE and PP pipes, their design would have resulted in minimum initial stiffness of: 21 kN/m² and 26 kN/m², respectively.

It is clear that SN8 stiffness in these pipes is obviously insufficient when the pipe installation is not performed correctly, which is why the use of these pipes in sewage networks generally leads to significant ovalities in the pipes.

However, because they are low in price, the have been used widely. This price is due to their extremely light weight and the fact that each pipe has very low raw material costs.

In the case of the SN4 PVC compact pipe, a situation where the trench conditions and the acting loads result in a decrease in the modulus of elasticity, as set out in the above standard, would result in a pipe with a residual stiffness of around 2 kN/m², which is insufficient to prevent significant long-term deformation.

2- The UNE-EN 13476 European standard: Plastics piping systems for non-pressure underground drainage and sewerage — Structured-wall piping systems of unplasticised poly(vinyl chloride) (PVC-U), polypropylene (PP) and polyethylene (PE).

In this more recent standard, maximum creep coefficients at 2 years and initial moduli of elasticity are defined for the 3 materials under consideration. They are:

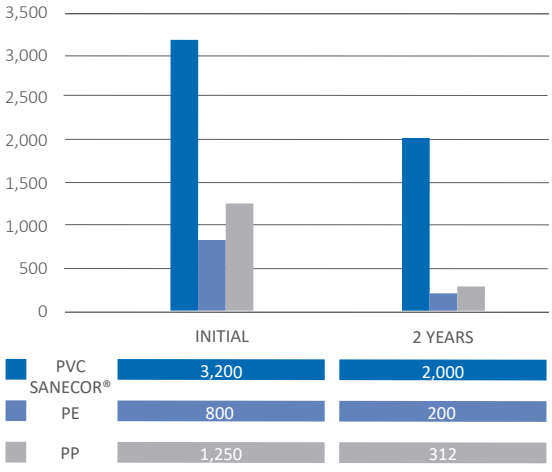
- $Cf_{PVC} \leq 2.5$ $E_{0,\,PVC} = 3{,}200$ MPa
- $Cf_{PE} \leq 4$ $E_{0,\,PE} = 800$ MPa
- $Cf_{PP} \leq 4$ $E_{0,\,PP} = 1{,}250$ MPa

This standard only covers coefficients at 2 years, since after this period of time the decreases in stiffness are small, and this makes it easier to carry out the creep test, which for 2 years requires an accelerated test of only 2 months (the 50-year test requires an accelerated test of 14 months).

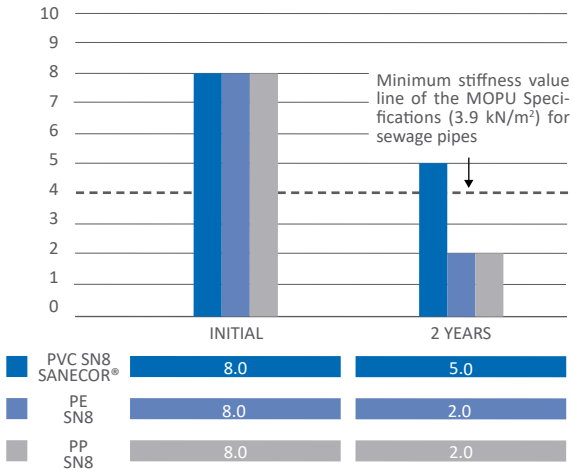
Furthermore, some of the initial moduli of elasticity defined in this standard vary due to the use of certain additives that improve the quality of the materials used in these pipes.

Since the Cf_{PE} and Cf_{PP} values are always very close to 4 because of their high requirements and the Cf_{PVC} value is around 1.6 for **SANECOR®** pipes, the graphs would be as follows according to this standard.

Moduli of elasticity over time according to UNE-EN 13476



Changes in stiffness over time according to UNE-EN 13476



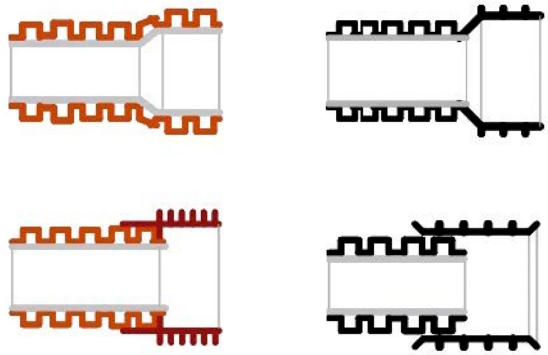
In this case, we can see that 2 years after the pipes have been buried under loads that decrease the modulus of elasticity to the extent outlined above, the **SANECOR®** pipe still has stiffness of 5 kN/m^2, while the PE and corrugated PP pipes only maintain stiffness of around 2 kN/m^2, which is insufficient to avoid significant deformations over this period of time.

From the above, we can conclude that, among the usual cost-competitive pipes, the **SANECOR®** SN8 PVC pipe is the one that performs best against external loads in the short and long term.

Optimal watertightness

The current regulations permit different types of joints for plastic pipes, although in the most common pipes this connection is always made using an elastic joint. In the case of SN4 PVC compact pipes, a standard joint is used, a bell socket coupling, but for structured wall pipes, the UNE-EN 13476 standard permits many different types of joint, limiting itself to specifying that the coupling system must maintain adequate watertightness. This standard makes specific reference to both socket and sleeve joints. In any event, watertightness tests are carried out in accordance with the UNE-EN ISO 13259 standard.

In the standard applicable to FRP pipes, the types of joints are also very varied, permitting not only elastic joints (both bell socket and sleeve joints), but also welded joints, flanged joints and metal couplings.



Different coupling systems for structured wall pipes

Of the solutions shown in the figure above, the two at the top are coupled with a socket joint at one end.

They are typically used for PVC and PP pipes. The two at the bottom are used for PE pipes that cannot use socket joints.

The model on the left is a welded socket and the one on the right is a sleeve joint.

The **SANECOR®** pipe is coupled using the first system, called the built-in socket mouth, while the pipe's other characteristics (corrugations and thicknesses) remain the same, making it the most reliable of all the various existing solutions.

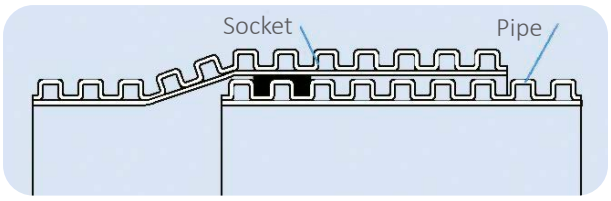
Another very important aspect that affects the watertightness of the joint is the elastomeric seal.

While in smooth pipes the seal is placed in a specially made groove inside the socket, in corrugated pipes, the corrugation grooves are used to fit the seal.

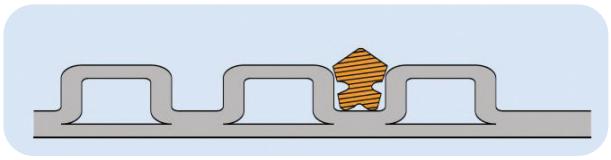


Corrugated PVC pipes (brick red colour) and corrugated PE pipes (black)

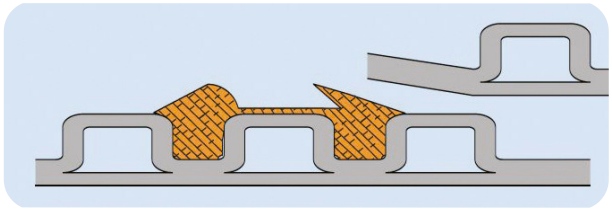
In **SANECOR®** pipes, this seal is double-lipped up to a diameter of DN500, with a profile that prevents the seal from slipping during installation, while also ensuring improved watertightness. In pipes with larger diameters (DN630-DN1200), the seal has a single lip, as the greater depth of the corrugations prevents the seal from easily slipping out of its seat.



SANECOR® pipe socket joint



Single anchor seal on SANECOR® DN630-1200



Double anchor seal on SANECOR® DN160-500



The SANECOR® pipe (on the right), is the only one that has a double-lipped seal to optimise the watertightness of the joint

The seal must be able to pass the watertightness tests described in the UNE-EN ISO 13259 standard, which requires watertightness to be maintained when subjected to internal pressure (0.5 bar), and negative internal pressure (-0.3 bar), and with differential deflection of the pipe with respect to the socket or sleeve (greater deflection in the former), or with an angular deflection determined according to the diameter. With **SANECOR®** pipe profiles, angular deviations are achieved as established by the standard.

Maximum angular deflection of joints between pipes

DN	Maximum standard angle
160	2°
200	2°
250	2°
315	2°
400	1.5°
500	1.5°
630	1.5°
800	1°
1000	1°
1200	1°

Maximum hydraulic capacity

The hydraulic capacity of a gravity sewage pipe is determined by two factors: the friction factor of the water in the pipe and the inner diameter of the pipe. As remarked above, the friction factor for plastic pipes is K = 0.10 according to the Prandtl-Colebrook formula for wastewater, which is 10 times lower than that of a concrete pipe.



Inside view of SANECOR® pipe with angular deflection

As for the inner diameter, most plastic pipes follow the DN = $Outer_{diam.}$ criterion, meaning that the inner diameter will depend on the thickness of the pipe and will vary depending on the manufacturer. This yields different flow rates for pipes that have the same nominal diameter, when the slope and internal roughness are the same. **SANECOR®** pipes only follow this criterion up to a diameter of DN500, because the pipes have to be compatible with the parts and fittings that are widely available on the market. However, from DN630 upwards, the diameter of **SANECOR®** pipes is optimised ($Outer_{diam.}$ > DN).

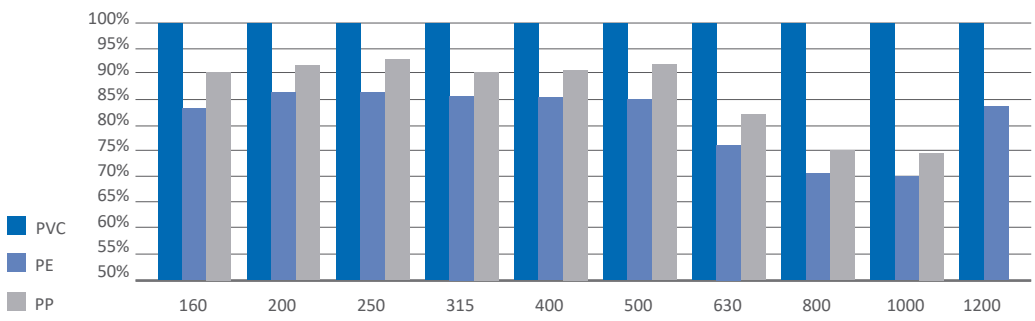
Furthermore, for any specific pipe stiffness (RCE), the thickness of the pipe depends on the type of material with which it is made, which, as it will have a specific modulus of elasticity $\mathbf{E_c}$, requires a moment of inertia value of **I** in the formula:

$$RCE = \frac{E_c \cdot I}{D_m^3}$$

As **I** is a function of thickness (in a smooth pipe **I** = e^3), in corrugated PE and PP pipes (low $\mathbf{E_c}$ value of 1/12), the thickness will have to be higher than in corrugated PVC (high $\mathbf{E_c}$ value) to achieve the same stiffness. Therefore, the hydraulic capacity of **SANECOR®** pipes is always higher than that of other thermoplastic materials, and even more so at diameters greater than DN500.

The following graph shows (as a percentage) the average flow rates at full cross-section of the different materials used in corrugated pipes, for the same slope (1.5%) and internal roughness (k=0.10) values.

Average flow rate (%) differences of SN8 corrugated pipes (100% baseline for SANECOR® pipes)

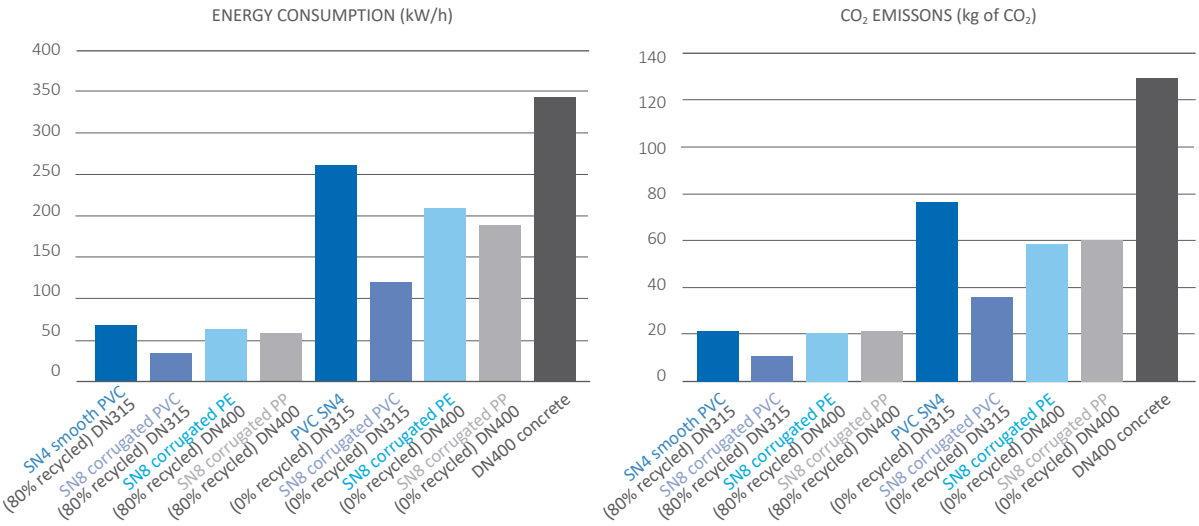


Minimal energy consumption

As we saw on page 9, according to the cited study, throughout the useful life of the pipe, plastic pipes consume far less energy than concrete pipes. In turn, of the plastic pipes analysed (the most widely used), PVC pipes have a smaller nominal diameter than PE and PP corrugated pipes, for the reasons outlined in the previous point, and than concrete pipes, due to their lower friction factor. Nevertheless, the SN4 PVC compact pipe leads to the highest consumption as it is the heaviest.

As regards corrugated pipes, the one that produces the greatest energy savings is the **SANECOR®** SN8 corrugated PVC pipe, since, although it weighs more than PE and PP pipes, its diameter is more optimised than the latter two, and less energy is consumed in the production of both the raw materials and the pipe. For the same reason, it is the most environmentally friendly pipe in terms of CO_2 emissions into the atmosphere. The values from the aforementioned study appear in the table on page 9 and are shown in the graphs below.

Graphs detailing energy consumption and CO_2 emissions to the atmosphere of the most widely used materials in sewage pipes



SANECOR®, the most sustainable solution

A product is sustainable when it meets the needs of present generations without jeopardising the ability of future generations to meet their own needs.

In this respect, it is important that such products have a long life cycle and, therefore, are durable, while at the same time consuming minimal resources during their life cycle - especially energy - as well as having a minimal impact on society and the environment.

In the case of **SANECOR®** pipes, in the above sections we have discussed a number of characteristics that help to make the product highly sustainable.

Moreover, the **SANECOR®** corrugated PVC system has an **Environmental Product Declaration (EPD)**, according to the requirements of the EN ISO 14025 standard, product category rules (PCR) for construction products outlined in the 15804:2012 + A2:2019 standard.

This voluntary certification demonstrates the company's firm commitment to sustainability and assessing the impact of its operations in the plastic pipes sector.

This declaration was developed in accordance with the EN ISO 14025 standard and is based on a product's Life Cycle Assessment (LCA) in accordance with the ISO 14040 and ISO 14044 standards, from cradle to grave, i.e. from the acquisition of raw materials, production, distribution, installation and use of the product, to its final disposal after long-term use.

The following table summarises the impact of each of the product's properties on the factors that help to improve sustainability.

SANECOR® pipe properties that increase the product's sustainability

Characteristics	Durability	Energy saving	Environmental friendliness
Raw materials	-	↑	↑
Pipe weight	-	↑	-
Material recyclability	-	↑	↑
Chemical resistance	↑	-	↑
Does not corrode	↑	-	↑
Abrasion resistance	↑	-	-
Deposits / fouling	↑	-	↑
Long-term stiffness	↑	-	-
Material flexibility	↑	-	-
Hydraulic capacity	-	↑	-
Installation costs	-	↑	-
Occupational safety	-	-	↑
Watertightness	-	↑	↑
Maintenance costs	-	↑	-

Dimensions of pipes in SANECOR® range

DN	I.D. pipe	O.D. pipe	Max. O.D. of socket	Average socket length
160	146	160	182	105
200	182	200	228	122
250	228	250	284	165
315	285	315	358	190
400	364	400	448	199
500	452	500	563	230
630	590	649	734	252
800	775	856	954	330
1000	970	1072	1222	495
1200	1103	1220	1379	547



View of SANECOR® pipe installed in trench



On-site handling of SANECOR® pipe

The SANECOR® system: outstanding versatility

The **SANECOR®** system has one of the widest ranges of plastic sewage pipes. The table to the left contains the dimensions of pipes with different diameters.

We also manufacture special parts for all diameters available in the range, using the same materials: smooth parts with SN4 nominal stiffness for diameters DN160- DN630 and parts with a corrugated outer surface and SN8 nominal stiffness for diameters DN500- DN1200.

The **SANECOR®** system features a variety of fittings for connections, each meeting certain specifications in terms of diameters, installation, regulations, etc.

Finally, the **SANECOR®** system has the widest range of manholes available in plastic materials. These components, which often play a key role in the watertightness and maintenance costs of a sewage network, have the same outstanding properties as **SANECOR®** pipes.

On pages 21 to 23 there is a list of special **SANECOR®** parts and fittings.

Additionally, from page 26 onwards there is a detailed description of **SANECOR®** manholes and their components.








The SANECOR® integrated system has a wide range of watertight fittings and components

1.4. SANECOR® pipe technical datasheet

The following table summarises the technical characteristics of **SANECOR®** pipes.

Physical and chemical characteristics	
Density:	1,350 ÷ 1,520 kg/m³
Coefficient of linear expansion:	8 x 10^{-5} m/m °C
Thermal conductivity:	0.13 kcal/mh °C
Specific heat:	0.2 ÷ 0.3 cal/g°C
Vicat softening temperature:	≥ 79 °C, according to UNE-EN ISO 2507-1
pH limits:	Between 3 and 9, at 20 °C
Average B-onset processing temperature:	≥ 185 °C, according to ISO 18373-1 (DSC)
Thermal performance:	According to standard ISO 12091

Mechanical characteristics	
Ring stiffness (also known as SCS = specific circumferential stiffness):	SCS ≥ 8 kN/m², according to UNE-EN ISO 9969. The actual value is almost always higher than 10 kN/m².
Creep coefficient at 2 years:	≤ 2.5, UNE-EN ISO 9967 The actual value is below 1.9
Impact resistance:	According to UNE-EN ISO 3127 (round-the-clock method)
Ring flexibility:	30% deformation in DN160 to D315, and 20% in DN400 to DN1200, according to UNE-EN ISO 13968

Hydraulic characteristics	
Watertightness with elastomeric seal under internal pressure:	Tests conducted at 0.5 bar with angular deflection and diametrical deflection, according to UNE-EN ISO 13259
Watertightness with elastomeric seal under negative internal pressure:	Tests conducted at -0.3 bar with angular deflection and diametrical deflection, according to UNE-EN ISO 13259
Equivalent roughness (Prandtl-Colebrook):	K = 0.01 mm (for clean water) K = 0.10 ÷ 0.25 mm (for wastewater)





Installation of SANECOR® pipes in trench and in tunnel

1.5. Note on the installation of underground pipes

To install pipes, the current regulations and codes of good practice should be followed, including the Technical specifications for sewage pipes by the Ministry of Public Works and Town Planning, the Technical guide on urban sewage and drainage networks by CEDEX, UNE CEN/TS 1046, UNE-EN 1610 and UNE 53331 (in addition to establishing criteria for mechanical calculations, it covers technical aspects for installations). The most essential aspects of these regulations are summarised below.

1 Trenches for pipe installation need to be wide enough to ensure a clearance between the pipe and the trench wall that enables the laying of the pipe and compaction of the backfill by workers. The trench width must be such that the width at the height of the upper pipe generatrix is A = D_{ext} + X, where D_{ext} is the outer diameter of the pipe and X ranges from 0.4 to 1.0 m depending on the diameter.

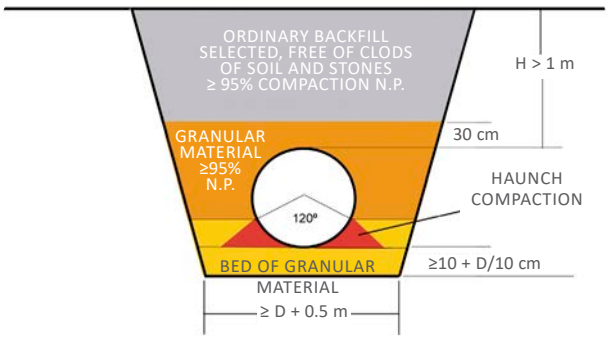
2 It is essential to lay a bed of granular material (sand or gravel with a grain size of approx. 5 - 10 mm) of sufficient height, H (cm) = 10 + D/10, to prevent any unevenness in the gradient of the base of the trench from causing specific points to rest on stones or clods of earth. Directly resting plastic pipes on a rigid concrete base is counterproductive since, firstly, all of the load exerted on the pipe, from backfill or traffic, will produce a reaction in the support bed that may cause the pipe to break, and secondly, any deformation or differential settlement will cause the concrete base to break and act as a shear on the pipe, causing bursts or leaks. When concreting a pipe due to special conditions, the pipe must be fully encased in concrete and left in place as a lost formwork. Failure to do so would result in significant stresses on the pipe generatrices where the pipe transitions from concrete to granular backfill. On very small slopes where concrete slabs have to be laid, a bed of backfill as described above must be placed on top of the concrete slab.

3 On the support bed, a lateral backfill should be laid in 25-30 cm layers, ensuring that the backfill material penetrates the difficult-to-reach areas (underside of the pipe) and is well compacted, providing the pipe with the necessary support angle (minimum 120º) along its entire length. The material used in the lateral backfill must reach a height of 30 cm above the crown of the pipe. It can be natural soil from excavation, provided that it fulfils the characteristics described in the calculations. The grain size of the material should be 5-15 mm, ideally it should be pea gravel or fine gravel that ensures natural compaction of at least 95% in a normal Proctor test without the need for additional equipment.

4 The rest of the backfill in the trench, up to the wearing course or ground level, can be natural soil from the excavation, free of stones and clods of soil, provided that its characteristics are suitable according to the current regulations. It should have at least 95% compaction, although if there is heavy traffic it should be 100% to prevent ruts and deformation of the wearing course itself. In any event, the latter layers must never be less than 90% compacted in a normal Proctor test.

For further information on the conditions for the installation of underground pipes, we recommend that you refer to our guide entitled “Pipe installation for supply, irrigation and sewerage according to current regulations”.

The following figure shows a typical trench, with key aspects that should be considered when installing the pipes.



Cross-section of typical underground pipe trench

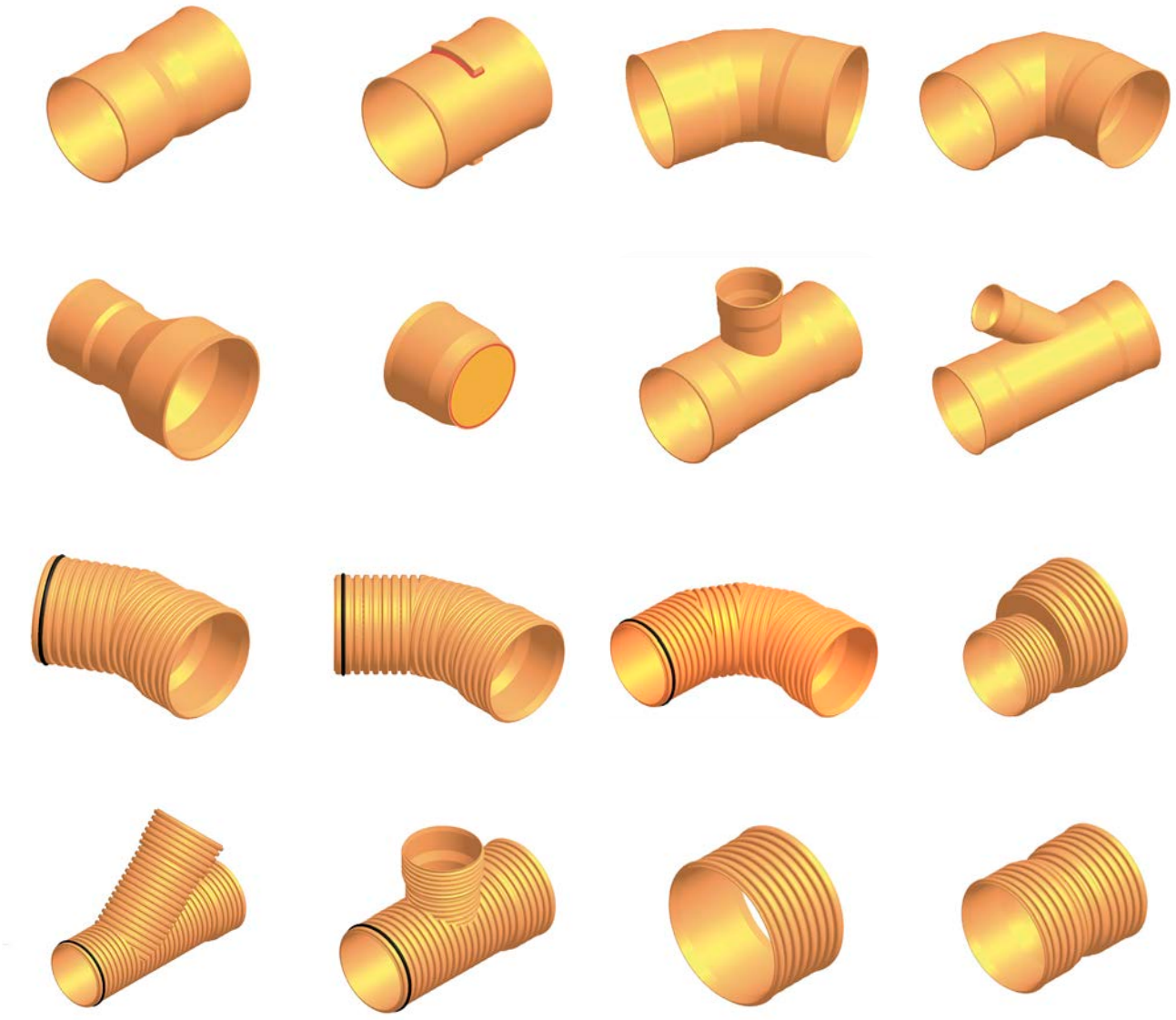
Finally, remember that in order to check the suitability of the pipes for the specific conditions of each installation, mechanical calculations must be performed based on current calculation standards. **Molecor** has a calculation programme for this purpose, designed for **SANECOR®** corrugated pipes, based on the UNE 53331 standard and the German ATV-DVWK 127E:2000 guidelines, which are included as part of the UNE-EN 1295 standard. This application provides results for the different forces and stresses that **SANECOR®** pipes will be subjected to, as well as their bursting and crushing safety factors.

1.6. SANECOR® system fittings

In any sewage network, all components should have similar characteristics in order to maintain the mechanical stability of the system, ensure optimal watertightness and facilitate maintenance of the network. **SANECOR®** pipes have a wide range of special parts and fittings that are made of the same material. The dimensions and detailed sketches of all these components are provided with **Molecor** Price Lists.

Special parts

The range of **SANECOR®** special pipe parts is manufactured in all diameters up to DN1200 and consists of two series: The SN4 smooth series for parts up to DN630 and the SN8 corrugated series up to DN1200. The usual standard parts are available: sleeve joints for socketless ends, pass-through sleeves to install dismantling joints, 30°, 45° and 87.5° elbows, expansion joints, 45° and 87.5° branches of the same or different diameters and plugs. However, a large number of custom parts can be made to order.



Standard special parts for SANECOR® pipes with SN4 smooth outer surface and SN8 corrugated outer surface

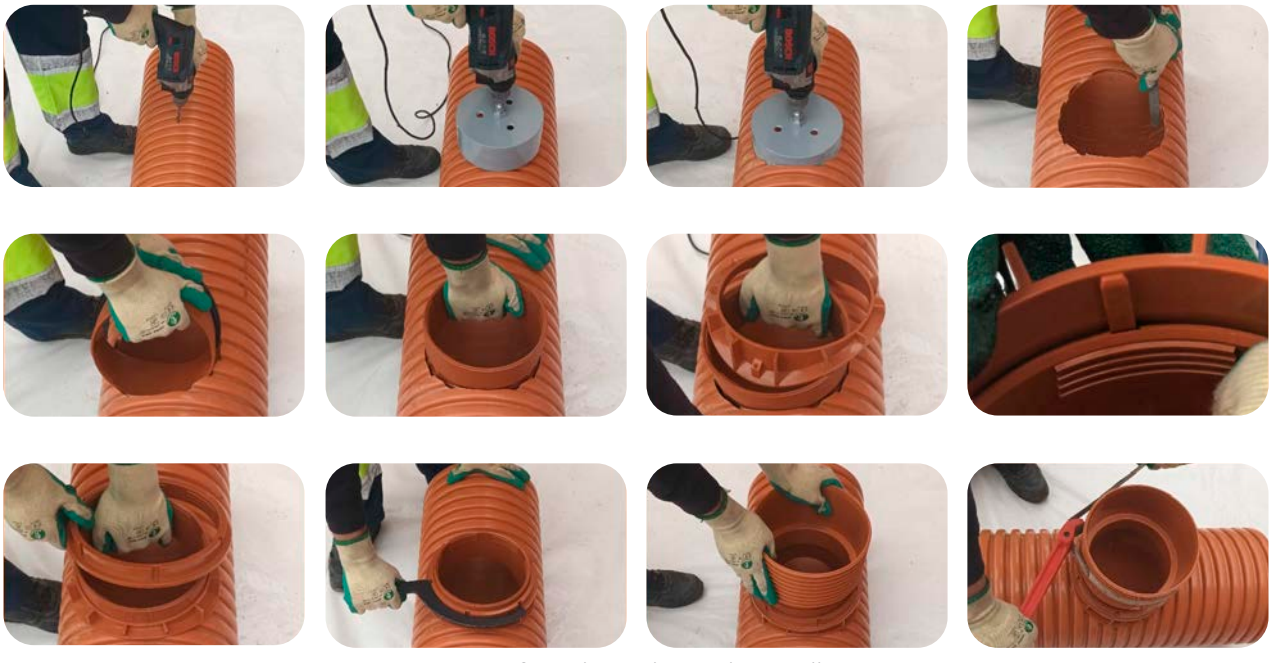


SANECOR® has a very wide range of special parts up to DN1200
(on the left, dismantling joints with pass-through sleeves)

Parts for connections

There are various solutions, but you should choose ones that are easy to install, ensure proper watertightness, and are cost-effective. The **SANECOR®** system includes the following connection types:

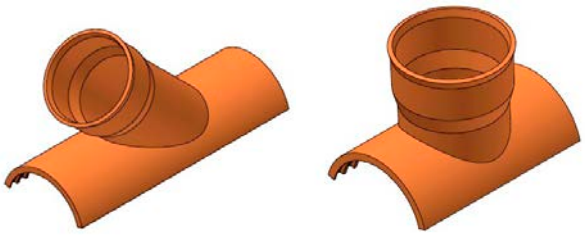
1 Mechanical clip connections. The photos below show the various stages of the installation of this type of fitting. They are a very high-quality PVC solution available for 160 and 200 mm diameter connections to 315 mm and 400 mm pipes. The range is limited due to the high levels of expenditure required to manufacture these parts. These connections are completely watertight, very easy to install and are not inserted inside the pipe.



SANECOR® mechanical pipe clip installation

2 Branch connections. These are manufactured by welding the connection fitting to a half-round piece that has the same corrugated shape as the pipe on its inner surface. The part is joined to the pipe using adhesive.

The advantage of this connection is that it is available in 45° (or even other angles), as well as 87.5° connections.



Branches for SANECOR® pipe connections

3 Elastomeric clip connections. Since **SANECOR®** corrugated pipes are extremely thick, it is possible to use connection joints made of EPDM rubber, which are very competitive in price and ensure complete watertightness. They are custom-designed to connect to **SANECOR®** pipes and, due to their low production costs, these parts are manufactured for all possible combinations: 160 to 630 mm connections for 315 to 1200 mm pipes. The installation process for this solution is presented below. The "**SANECOR®** elastomeric clip catalogue" explains this procedure in detail.



Elastomeric clips with cutting template for connections

When using these elastomeric clips, to prevent the joint from encroaching on the pipe, we have stop pieces for elastomeric clips which, when installed in one of the corrugation grooves, act as a barrier, as shown in the following sequence.



Stop piece installation sequence for SANECOR® connections






SANECOR®, with over 30 years of experience, committed to delivering durable and sustainable products

2. Watertight manholes in sewage networks

2.1. SANECOR® inspection chambers and manholes





Manholes made of conventional materials (concrete and brick). On the right, prefabricated concrete rings

The purpose of manholes in a sewage network is to provide access to the pipeline so that inspections, maintenance, repairs, etc. can be carried out. Traditionally, these manholes have been manufactured *in situ* with cheap materials such as reinforced concrete or brick masonry, although for several years now it has also been very common to build them from prefabricated elements made of either concrete

or plastic.

Most of the advantages that plastic materials provide for sewage pipes can be applied to the other elements of the network and, in particular, to manholes: chemical behaviour, resistance to corrosion and abrasion, lower load losses, installation performance and costs, on-site safety, etc. Watertightness is an area that warrants special attention, as it is of critical importance in manholes, since a large amount of the problems that arise when operating a sewage network- leaks and infiltrations in the network- stem from a lack of watertightness in the manholes.

With regard to cost, although plastic materials are far more expensive than traditional materials, the cost difference between different manholes is significantly reduced when comparing the number of installed units. This is because they are installed far more efficiently due to the low weight of the material and the ease of assembly of these mostly prefabricated elements. Finally, it should be noted that, depending on the thickness of the manhole wall and the material used, the mechanical strength of plastic manholes may not be adequate to withstand external loads from the existing ground and traffic. In such an event, the manhole must be lined with concrete after installation. In this sense, the pipes in an urban sewage network are usually located under existing roads, as they collect water from the connection points from buildings.

At **Molecor**, we have extensive experience in manufacturing manholes from different materials. Over the years, this has helped us to understand the pros and cons of each material (fibre cement, concrete, FRP, HDPE and PVC).



Lack of watertightness in concrete manholes



Connection with plastic prefabricated parts





Manholes made of plastic materials (polyester and polyethylene)

This experience, combined with our innovation strategy, has enabled us to design and develop a wide range of manholes which take advantage of the beneficial properties of plastic materials while, at the same time, overcoming the drawbacks of earlier plastic solutions, mainly related to cost, strength and the on-site adaptation of the prefabricated solution.

The cost-saving **SANECOR®** design ensures optimal mechanical performance and outstanding watertightness in the network. It has also been in use for over 30 years and has hundreds of references across Spain.

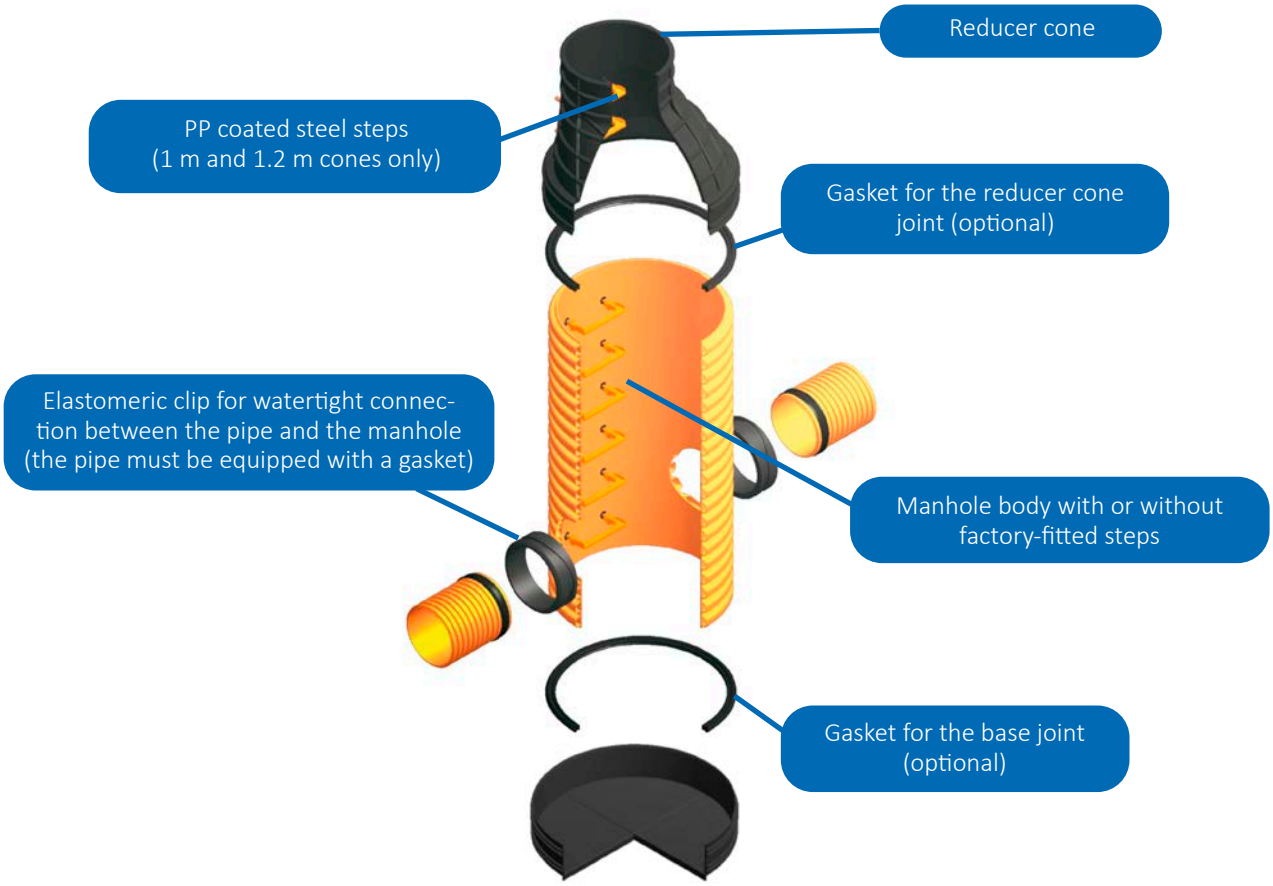




SANECOR® manholes

SANECOR manholes and inspection chambers

Details of the components of a standard **SANECOR®** manhole (pipes up to DN630):



Outline of other **SANECOR®** manhole solutions



2.2. SANECOR® manhole components and installation

We can divide the manhole into three distinct parts, which, from top to bottom, are as follows:

1 The **entrance to the manhole** via a highly rigid conical piece that reduces the diameter of the manhole to the diameter of the inspection chamber (600 mm).

2 The **shaft or manhole body**, of the required height and with or without factory installed access steps. It is highly rigid so it does not need to be reinforced with concrete.

3 The **bottom of the manhole**, where the connections to the manifold are located. Depending on its diameter, these can be made in a number of ways. Up to a certain diameter, which in turn depends on the diameter of the manhole, the pipes enter directly into the manhole body through elastomeric seals which, thanks to the great thickness of the corrugated wall, ensure complete watertightness.

Above a certain diameter, the connection to the pipe can be made via manhole bases that connect the manhole to the crown of the pipe or via connecting pieces that allow you to access the full-section pipe.



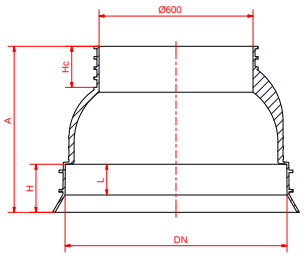


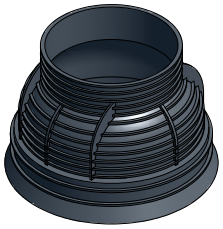


Entrance to the manhole

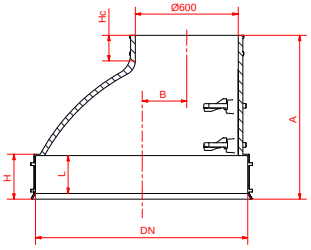
The manhole entrance reducer cone is made of high-quality HDPE, using a system that allows a large volume of plastic parts to be produced at a competitive price. This cone, which has a 600 mm opening, is asymmetrical and features two steps in the 1000 and 1200 mm manholes, while it is symmetrical and has no steps in the 800 mm manhole. It features a ribbed design to ensure high rigidity.

The cone fits into the upper end of the body, making it very easy to install. Optionally, a gasket can be installed between the reducer cone and the manhole body to ensure watertightness in the event of high groundwater levels.





Reducer cone for manhole with 800 mm diameter





Reducer cone for manhole with 1000 and 1200 mm diameters

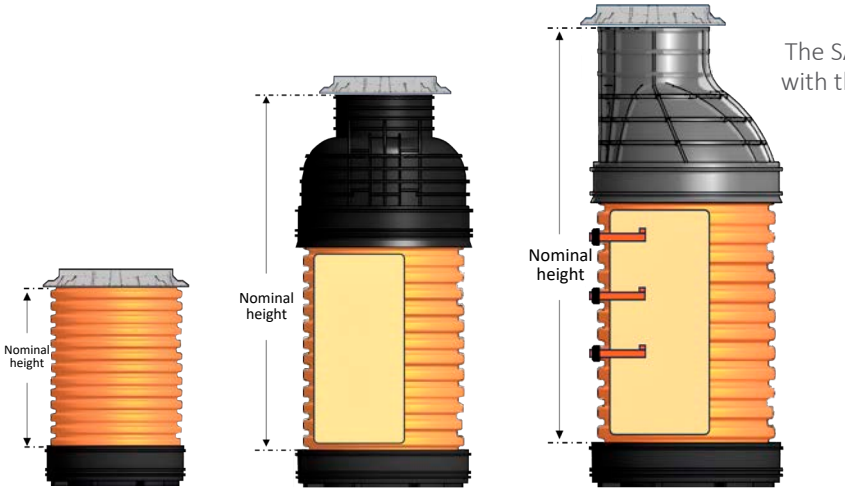
Manhole body

This is made from corrugated PVC pipe material with SN8 nominal stiffness, which ensures very high resistance to external loads throughout the life of the manhole. This material means that the manholes do not have to be reinforced with concrete to strengthen their rigidity. On the contrary, having a flexible material can be very beneficial in the event of ground settlement. **SANECOR®** manholes come in various diameters, ranging from 630 to 1200 mm. For shallow manholes, 630 mm diameter inspection chambers (without a cone or steps) can be used, which are very suitable for heights of less than 1.5 m, or 800 mm diameter manholes can be used for greater heights, with the option of adding steps.





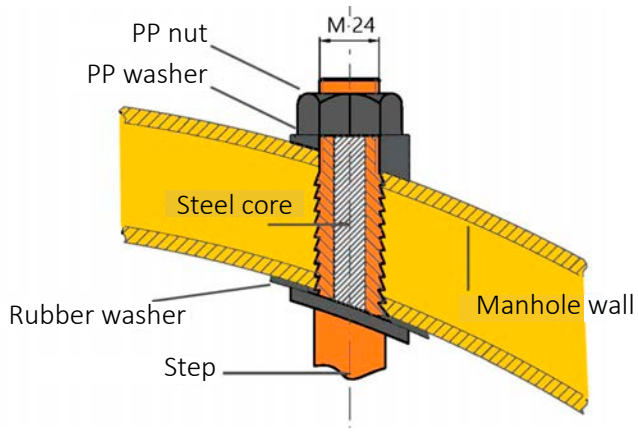
The SANECOR® manhole body is manufactured with the same material as SANECOR® SN8 pipes



DN630 mm manhole | DN800 mm manhole | DN1000 and 1200 mm manhole

Standard range of SANECOR® bodies

For the most common manholes with diameters of 1000 m and 1200 m, which, unless otherwise requested, are always fitted with steps, heights vary from between 1.5 m and 6 m. The steps installed in the manhole body are made of steel and are coated with polypropylene to seal against water from the water table. They are installed at the top of corrugations, evenly spaced at no more than 30 cm intervals.



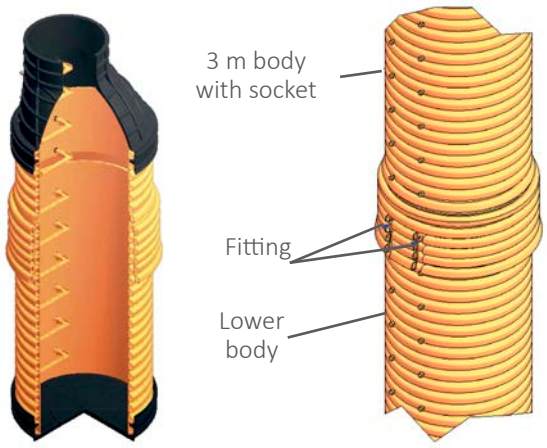
Details of the step attachment

The height of the bodies is customised according to the depths present on the site (bodies are manufactured in length increments of 0.5 m), up to a maximum of 5.5 m, for 6 m manholes.

For deeper manholes, a second unit is used with a socket end to allow it to be joined to the previous unit.

Manholes of a certain depth must be equipped with grating or safety platforms which, as well as protecting against accidents, allow users to stop safely as they climb down.

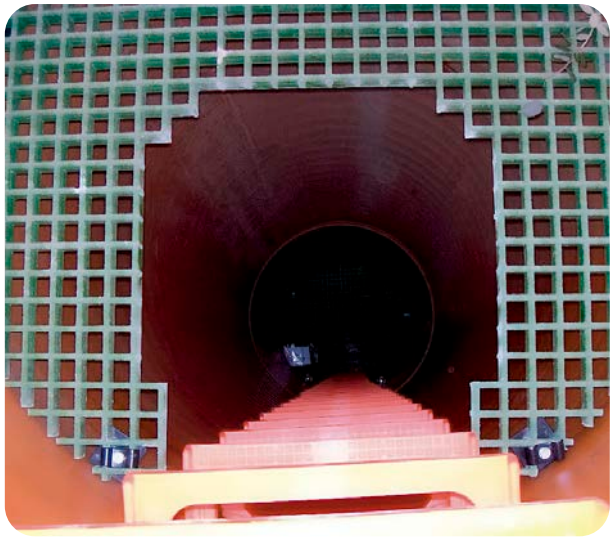
It is advisable to install these elements every 2.5 or 3 m of depth.



Deep manholes using two units

SANECOR® manholes are equipped with custom-made grating, made of reinforced polyester to prevent electrochemical corrosion.





Polyester grating in SANECOR® manholes

Making connections to the manhole body

The pipe's junctions or any connections to the manhole body are made by means of rubber gaskets called elastomeric clips, which are installed after drilling the necessary holes on the site .

The extremely thick corrugated bodies make it possible to install clips of sufficient length to ensure total watertightness, even when there is some angular deflection. For this purpose, these parts are custom-designed according to the dimensions of the corrugated body. It should be noted that the watertightness of **SANECOR®** manholes can only be assured by using original elastomeric clips.

The method for carrying out the connections is very simple and does not require specially trained personnel. The following figure shows the procedure that is used. The clip is supplied with an adhesive template which, when fixed to the manhole body in the trench, allows holes to be drilled quickly and accurately.



Drilling of holes for insertion of elastomeric clips

Up to pipe diameter 250 mm, drilling can be carried out with a crown drill bit installed on a hand drill. For larger diameters a jigsaw should be used. Nonetheless, the supplied template, which includes the relevant instructions, makes cutting very easy. Any imperfections due to drilling by hand are offset by the high depth and custom fit of the inner channel of the elastomeric clip.



Elastomeric clip



Installation

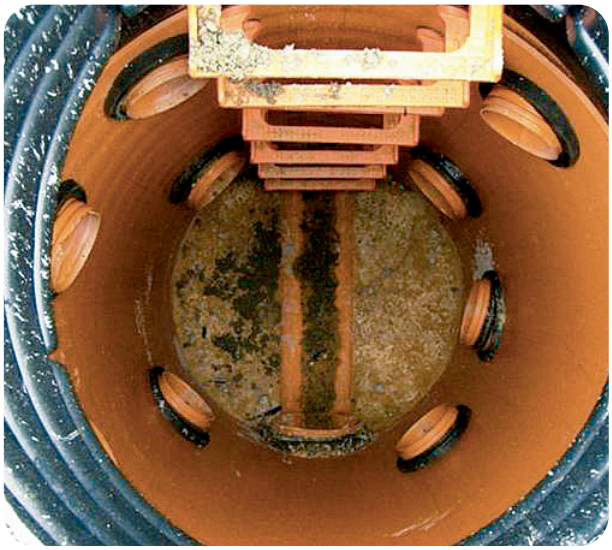




Fitting of pipes to the manhole body

This system makes it possible to connect the pipes to the manhole body *in situ* and at the exact point where they need to be connected, with no need to make adaptations, as is required with prefabricated elements.





Multiple connections made *in situ*

Bottom finish with pipe connection to manhole body

As noted above, the bottom of the manhole can be finished in various ways depending on the diameter of the pipe.

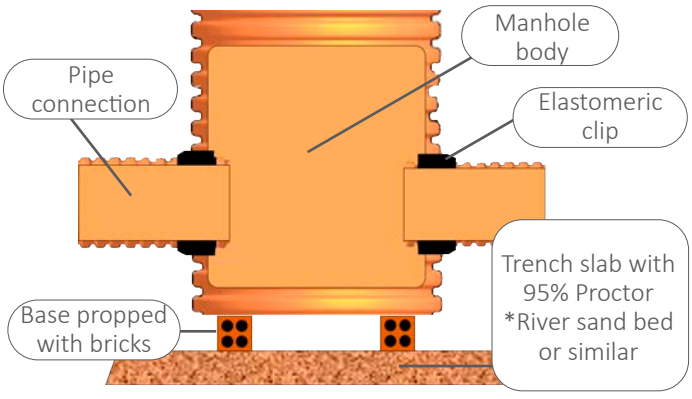
Direct connections to the manhole body via elastomeric clips are limited to the maximum pipe diameters specified in the following table:

Manhole DN	Maximum pipe DN
630	315 mm
800	400 mm
1000	630 mm
1200	630 mm

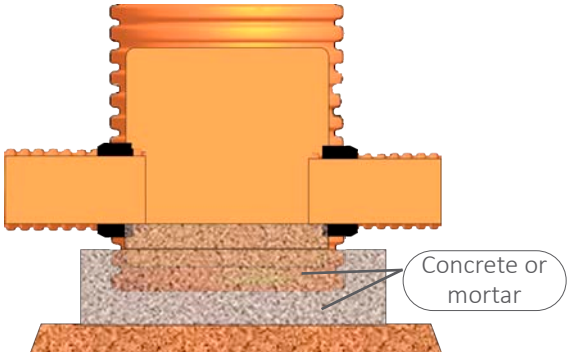
In these cases, which are most common, the bottom of the manhole is finished with concrete. If a water table is present in the trench, the lower end of the body is sealed with an HDPE plastic base, which features a gasket, to prevent the ingress of water through the bottom. We therefore have 2 scenarios:

1 Although the use of the watertight plastic base is always recommended, if there is no water table in the trench, the bottom of the manhole can be made of concrete. For this purpose, a slab is built with specific dimensions depending on the diameter of the manhole, with sufficient depth to allow the bottom 2 corrugations of the manhole body to be set in place, while also leaving a clearance of around 10 cm below it.

2 It is common practice to first fit the connections to the manhole, prop it up and then pour the concrete from below up to the required height.



Manhole bottom with a concrete finish. 1st phase



Manhole bottom with a concrete finish. 2nd phase



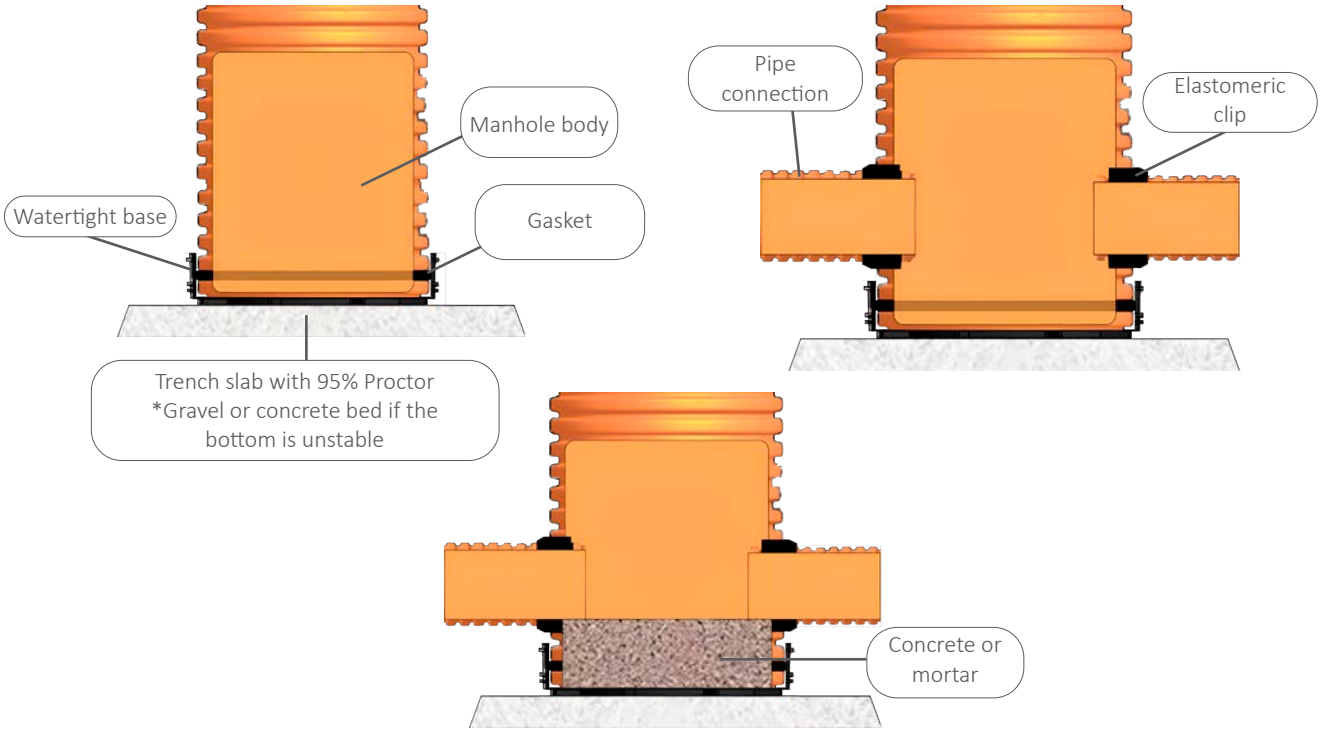
Concreting of the bottom of the SANECOR® manhole. 1st phase



Concreting of the bottom of the SANECOR® manhole. 2nd phase

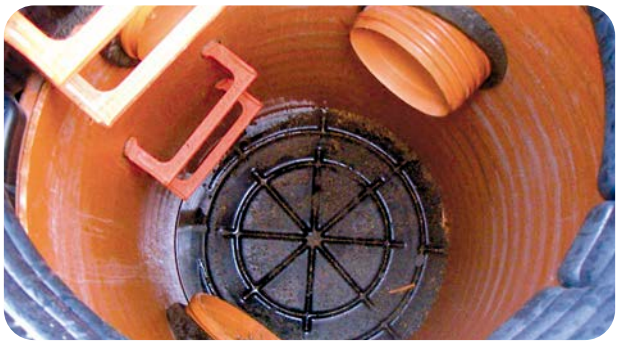
3 If fitting a manhole with its plastic base, install a base made of granular material, preferably gravel, or instead a concrete base if the bottom of the hole shows signs of instability with the presence of a water table, to provide solid and durable support. Watertightness is guaranteed by using this plastic base with the **SANECOR®** system's rubber gasket. In this case, the manhole must always be concreted on the inside up to the lower generatrix of the pipe, to stabilise the manhole against the vertical forces of the water table.

Finally, ensuring a high-quality internal finish at the bottom of the manhole is recommended to minimise the head loss in the manhole.



Manhole bottom finished with watertight base

***Note 1**: for manholes where the connections are made with elastomeric clips, the nominal height of the manhole is approximately the total height of the manhole minus the height of the base (for manholes with bases), or the total height of the manhole minus the concrete slab (for manholes without bases). In the latter case, the concrete slab must cover the bottom two corrugations, except in the case of short manholes measuring 630 mm, where it must cover the bottom three corrugations. In any event, in this type of manhole, the nominal height is not the same as the water flow depth, as this will depend on where the pipe connections are located. This depth will always be lower than the manhole's nominal height.*





Inside manhole with watertight base

2.3. SANECOR® manholes for large-diameter pipes

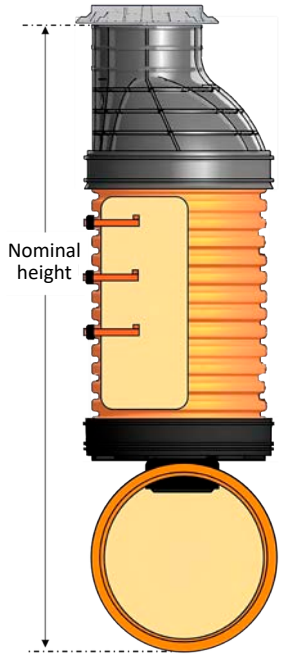
The **SANECOR®** range of manholes is not only available for pipe diameters up to 630 mm with an elastomeric clip, **Molecor** has also expanded the range to provide an efficient, lasting solution for installations that require the use of large-diameter pipes (up to 1200 mm).

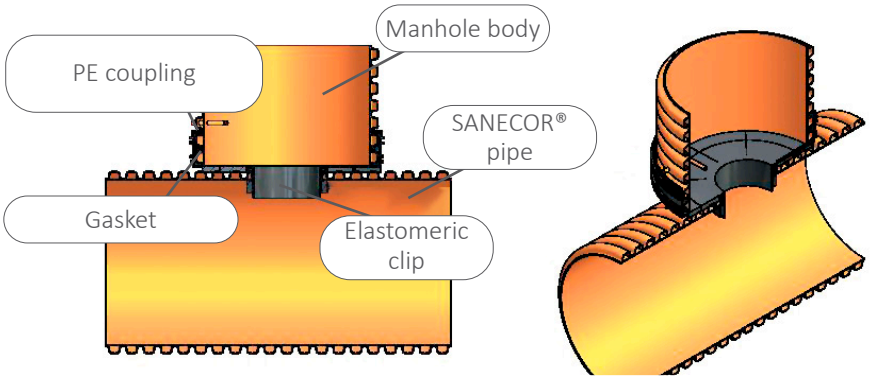
This type of manhole also comes in versions with or without steps, to meet the technical safety requirements and facilitate inspections.

2.3.1. SANECOR® manholes with inspection bases

This type of solution allows the manhole to be connected to the pipe via a base with an inspection chamber at the bottom. The lower end of the body is sealed with a base and gasket and has an opening in the middle, thus providing a concentric access point to inspect the pipe from its uppermost point.

This opening ends in a vertical collar where the pipe can be connected via an elastomeric clip to ensure complete watertightness of the assembly.





***Note**: for manholes with inspection bases, the nominal height of the manhole is approximately the sum of the height of the manhole above the pipe plus the diameter of the pipe up to a maximum nominal height of 5 metres.*

This type of manhole does not require interior finishing as the continuity of the pipe is maintained at all times. Manholes with inspection bases are accessible down to the base at the bottom, where maintenance, cleaning and any other necessary work can be performed. Workers should never enter pipes via a manhole when the network is being installed/in operation.

The dimensions of the manholes and pipes available in this range are shown below:





Installation of the body with inspection base

Dimensions of manholes and connections	
Manhole DN	**For pipe**
1000	800, 1000 and 1200 mm
1200	800, 1000 and 1200 mm

Installation instructions Manholes with inspection bases (for DN800, 1000 and 1200 pipes)

2.3.2. SANECOR® prefabricated welded manholes with solid base

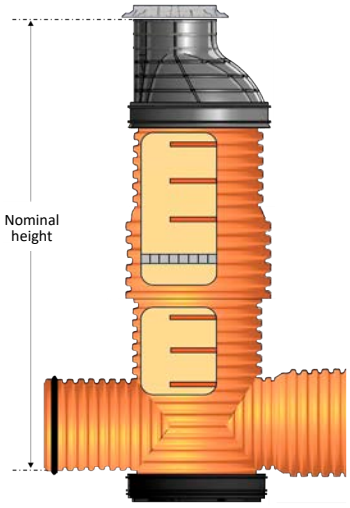
As technology has evolved and our knowledge and experience of working with PVC-U pipes has increased, we have developed a whole range of manholes by using chemical welding to join pipe segments together, thus providing a solution for large-diameter pipes.

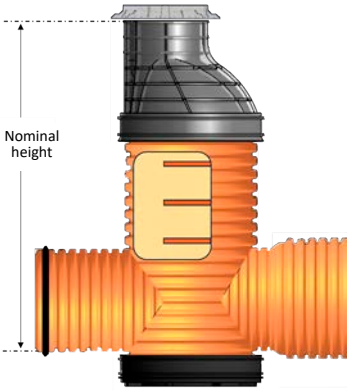
This solution is based on a **SANECOR®** manhole with a 1000 or 1200 mm solid base to which an inlet and/or outlet of the corrugated PVC pipe is welded at 180° so that it can be connected directly to the pipeline during the installation phase.

For connections at angles other than 180°, contact our technical office.

Each joint is welded on both the inside and outside to guarantee the watertightness and mechanical strength of the system.

This type of solution with a welded inlet and outlet is possible when the diameter of the manhole is larger than the diameter of the pipe.





Welded manhole with solid base (manhole DN > pipe DN)	
Manhole DN	**For pipe**
1000	800 mm
1200	1000 and 1200 mm

Generally speaking, the manholes in this type range have a single body for all nominal heights except for 1200 mm manholes with a 1000 mm pipe, which are higher than 3 m. These are composed of two bodies joined together using the flare end/male system and an elastic joint.

In solutions that have steps, when the manhole is composed of two bodies, grating will be installed in the area where the bodies are connected together.

The male outlet will be fitted with a rubber gasket so it can be connected to the **SANECOR®** pipe on site.



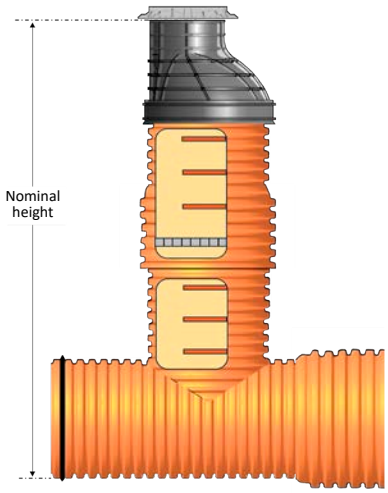
Installation of prefabricated welded manhole with solid base

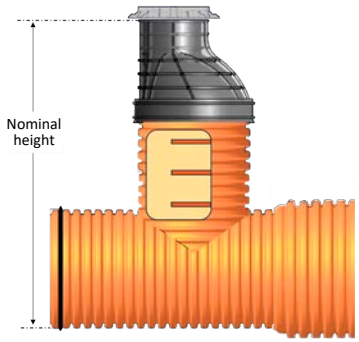
Once installed, in order to finish the inside of the manhole, a layer of concrete will be laid to make it flush with the water level in the pipe, in the same way as for conventional manholes, as detailed on page 32 of this document.

The following table summarises the nominal heights of the welded manholes in this range and their codes.

Installation instructions
Prefabricated welded manholes with inspection bases (for DN800, 1000 and 1200 pipes)

1000 manhole to 800 pipe		1200 manhole to 1000 pipe		1200 manhole to 800 pipe	
Code	Nominal height	Code	Nominal height	Code	Nominal height
PSA100020	2	PSB120022	2.2	PSA120020	2
PSA100023	2.3	PSB120025	2.5	PSA120023	2.3
PSA100026	2.6	PSB120028	2.8	PSA120025	2.5
PSA100029	2.9	PSB120031	3.1	PSA120028	2.8
PSA100032	3.2	PSB120033	3.3	PSA120031	3.1
PSA100035	3.5	PSB120036	3.6	PSA120033	3.3
PSA100038	3.8	PSB120039	3.9	PSA120036	3.6
PSA100041	4.1	PSB120042	4.2	PSA120039	3.9
PSA100044	4.4	PSB120044	4.4	PSA120042	4.2
PSA100047	4.7	PSB120047	4.7	PSA120044	4.4
PSA100050	5	PSB120050	5	PSA120047	4.7
PSA100053	5.3	PSB120052	5.2	PSA120050	5
PSA100056	5.6	PSB120055	5.5	PSA120052	5.2
				PSA120055	5.5





2.3.3. SANECOR® prefabricated welded manholes with built-in junction

This second type of welded manhole has allowed us to simplify the manhole's design with a single weld, enabling us to create a new range that makes on-site installation even easier. It consists of a 1000 or 1200 mm pipe section welded directly to the manhole body. The end result is a T-assembly that can be installed directly on the pipe using a **SANECOR®** male-female joint. This solution can be manufactured when the diameter of the manhole is equal to or smaller than the diameter of the pipe.

T-welded manhole (manhole DN ≤ pipe DN)	
Manhole DN	For pipe
1000	1000, 1200 mm
1200	1200 mm

Generally, this range of manholes will only have a lower T-assembly for heights below 3 metres. For heights above 3 metres a **SANECOR®** pipe section with a socket will be fitted to reach the desired height.

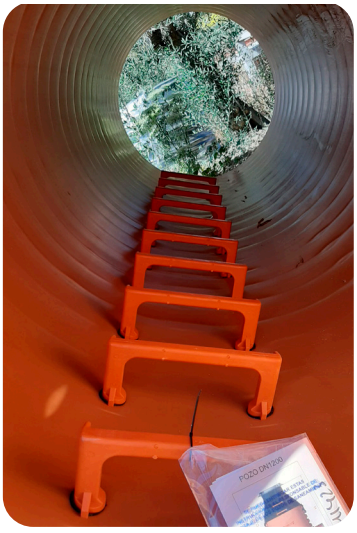
In solutions that have steps, two-body manholes will be equipped with grating in the area where the bodies are connected together. The male outlet will be fitted with a rubber gasket so it can be connected to the **SANECOR®** pipe on site.

Once the manhole is installed, no internal finishing will be necessary as its geometry ensures an extremely level

Installation instructions Prefabricated welded manholes in T-assembly (for DN1000 and 1200 pipes)

flow of water and outstanding continuity in the pipeline. The following table summarises the nominal heights of the welded manholes in this range and their codes.

1000 manhole to 1000 pipe		1000 manhole to 1200 pipe		1200 manhole to 1200 pipe	
Code	Nominal height	Code	Nominal height	Code	Nominal height
PSB100023	2.3	PSC100023	2.3	PSC120024	2.4
PSB100026	2.6	PSC100026	2.6	PSC120027	2.7
PSB100029	2.9	PSC100029	2.9	PSC120030	3
PSB100033	3.3	PSC100033	3.3	PSC120033	3.3
PSB100036	3.6	PSC100036	3.6	PSC120035	3.5
PSB100039	3.9	PSC100039	3.9	PSC120038	3.8
PSB100042	4.2	PSC100043	4.3	PSC120041	4.1
PSB100045	4.5	PSC100046	4.6	PSC120043	4.3
PSB100048	4.8	PSC100049	4.9	PSC120046	4.6
PSB100051	5.1	PSC100052	5.2	PSC120049	4.9
PSB100054	5.4	PSC100055	5.5	PSC120051	5.1
PSB100057	5.7	PSC100058	5.8	PSC120054	5.4
PSB100061	6.1	PSC100061	6.1	PSC120057	5.7
				PSC120060	6



Inside view of prefabricated welded manhole in T-assembly

2.3.4. Manholes in pipes with direction change

Where there are changes in the direction of the pipe network, a manhole is usually installed at the point where the direction changes.

When the diameter of the pipe allows it to be connected directly to the manhole body these manholes feature an installation system that makes it possible to connect them at the required angle.

When the manhole is installed with an inspection base, the **SANECOR®** system is able to accommodate large-diameter bends for placement of the manhole at the point where the direction changes.



Manhole installation for pipes with direction change

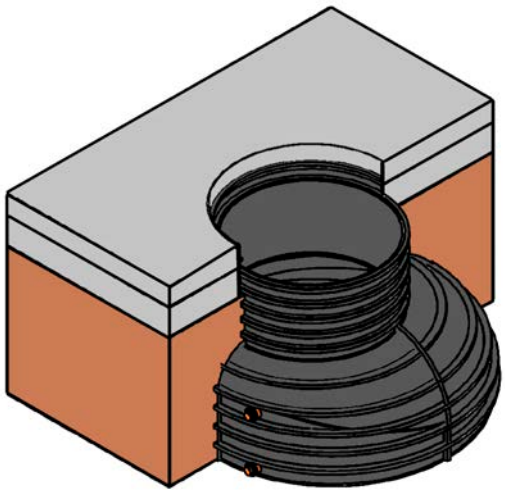
2.4. Upper finish of SANECOR® manholes



As regards backfilling and compaction around the manhole, this should be handled in the same way as pipes, although the requirements due to loads are less demanding in this case. However, it must be ensured that there are no pebbles or stones in the backfill to avoid damaging the manhole's body or cone.

Furthermore, if the watertight plastic base is used, the bottom of the trench must be cleaned in the same way as the pipes.

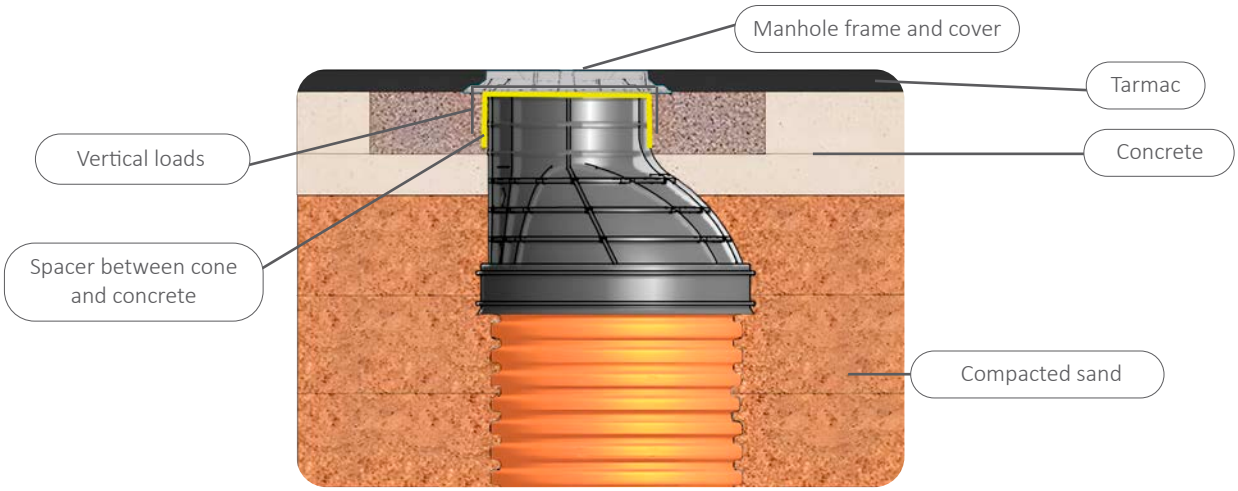
Regarding the top of the manhole, bear in mind that the plastic cone should not bear any vertical loads directly. If not included in the final surface type, a small concrete slab must be placed around the opening of the cone, through the manhole cover frame, to distribute the traffic loads that would otherwise exert force on the vertical surface of the manhole.



Top of the manhole

Obviously, the frame should not rest on the edge of the plastic cone either. Bear in mind that, if there is heavy traffic, the surface of the cone would bear the heaviest loads due to the shallow depth of the cone. The drawback of these loads being transmitted through a plastic column is that the column would be subject to vertical displacements which, however small, may crack the binder course.

If necessary, the height of the cone can be adjusted by cutting away part of its upper neck or, if the difference in size is too great, by cutting away corrugated sections of the manhole body (each corrugation measures approx. 10 cm).



Finish at the top of the manhole

2.5. Drop manholes

Watertight drop manholes can also be installed in the **SANECOR® manhole system**. These elements are used when the pipeline follows a very steep slope. As the slope of a pipeline should not generally exceed 3°, drop manholes are used to reduce such slopes.

The following figures highlight the flexibility of the **SANECOR®** system. In a drop manhole, which is used when the difference in elevation between the inlet and outlet of the pipeline is greater than 1 m, the water flowing into the manhole is diverted towards the base to prevent the water from dropping vertically.

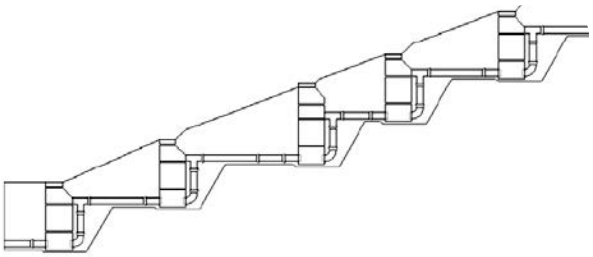
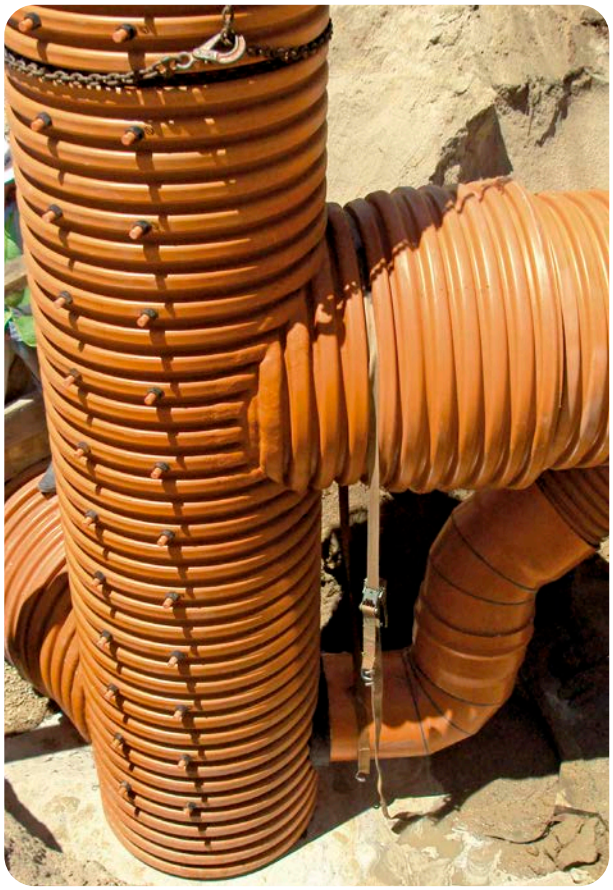
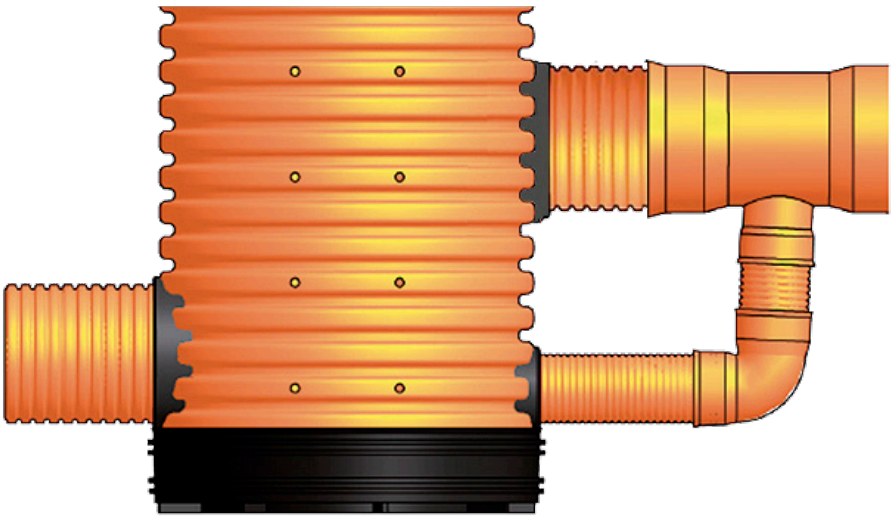


Diagram of a drop manhole arrangement



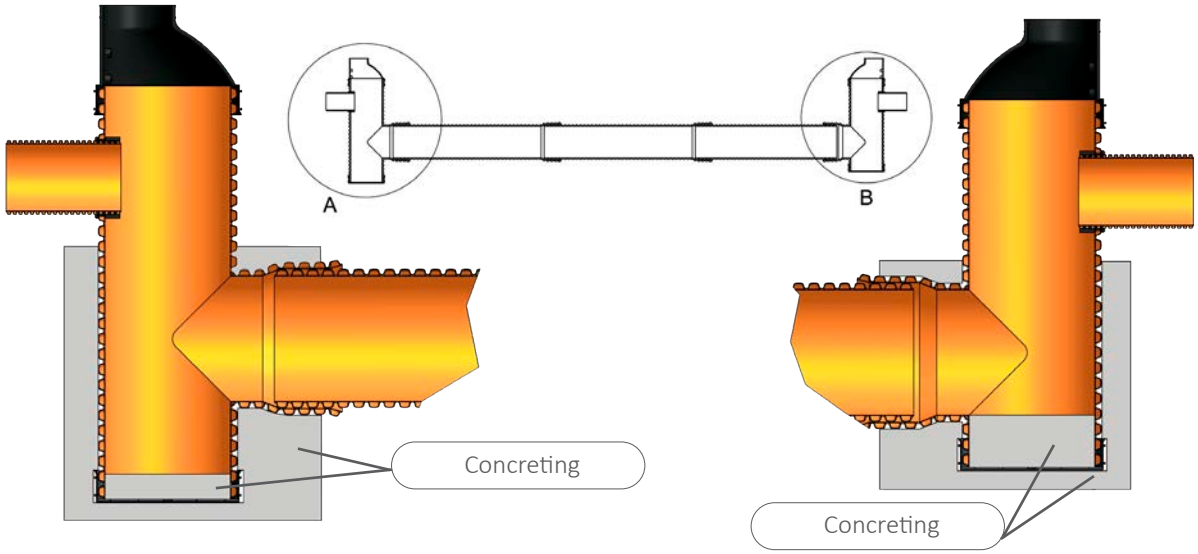


Drop manhole with SANECOR® manhole system



SANECOR® drop manhole

Drop manholes are also employed when siphons are used to bypass obstacles that obstruct the route. These manholes allow the siphon to be inspected.



SANECOR® drop manholes in siphon

2.6. Special inspection chambers and manholes

Flow-through inspection chamber

SANECOR® pipes have flow-through inspection chambers for outlets in diameters DN160 and D200. Made of high-quality polypropylene, these chambers, with their high mechanical strength due to the prismatic design of their central body, offer a very reliable alternative to conventional solutions for these elements.

Watertightness is ensured by means of elastic joints that can absorb certain angular deflections and ground settlements, meeting the requirements of the current regulations. The joints are made of EPDM with PP reinforcement rings, in accordance with the UNE-EN 681 standard, ensuring that the system is fully sealed. These joints are also removable. The hydraulic capacity is also optimised by the slope (3.5%) and inner smoothness of the main channel, preventing any build-up of sediments. On-site installation is enhanced by:

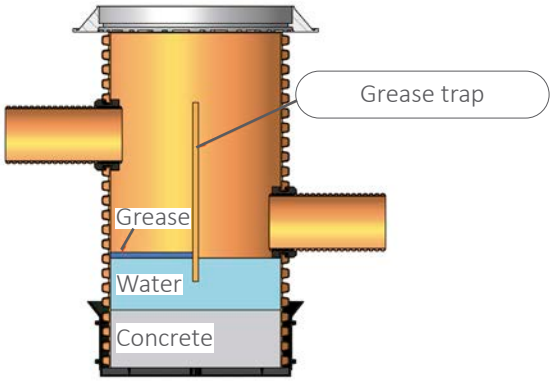
- Having an open bottom base to facilitate concrete settlement, levelling and penetration during installation.
- Avoiding displacements thanks to grooves in the body section of the chamber, to be filled and compacted with concrete or sand.
- Being equipped with flow direction arrow symbols to prevent incorrect installation.



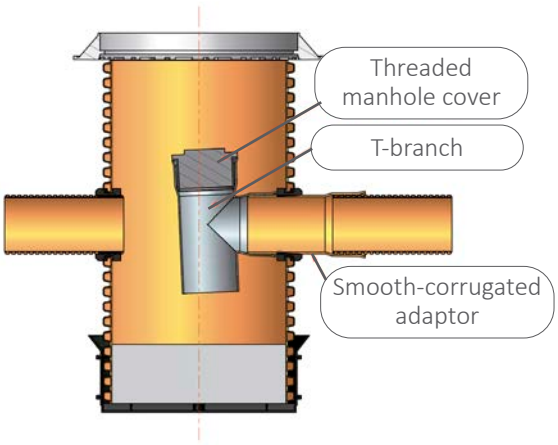
Flow-through inspection chamber

Other applications with SANECOR® inspection chambers and manholes

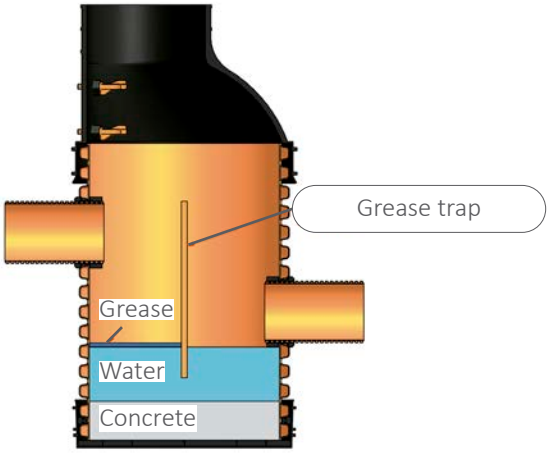
With the **SANECOR®** system a wide range of inspection chamber and manhole solutions can be installed for a variety of applications. The following figures show some examples, which are self-explanatory.

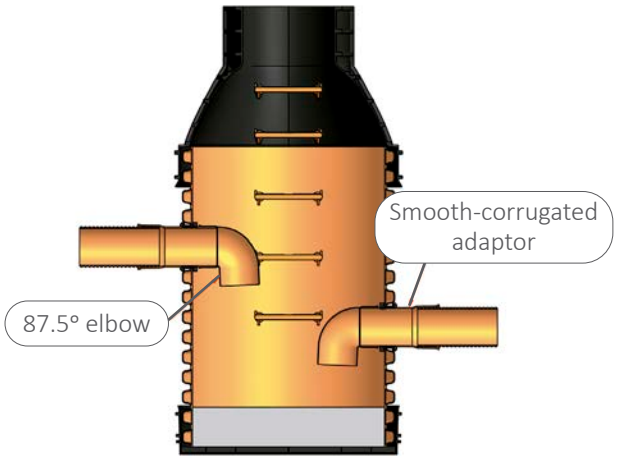


Grease trap chamber

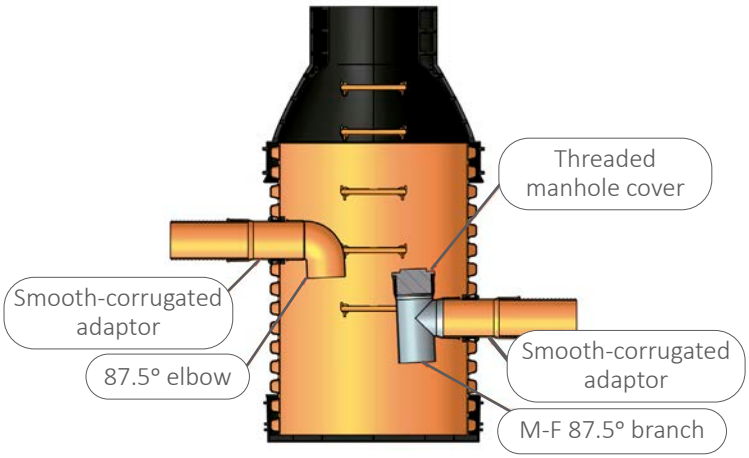


Siphon chamber

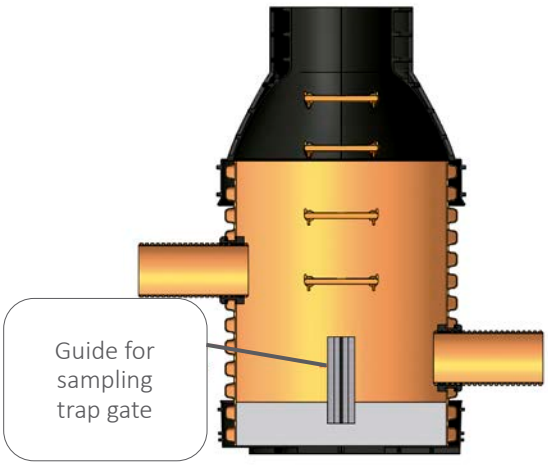




Grease trap manholes



Siphon manhole with grease trap



Sampling manhole

3. SANECOR® pipe references

SANECOR® corrugated pipes have been manufactured since 1992. Since then, they have been installed in thousands of sites across the whole of Spain, as well as in France, Portugal and around the world.

The vast majority have been gravity sewage and drainage systems, both for wastewater and rainwater, although this solution has also been used for non-pressure agricultural irrigation pipes, mainly when converting irrigation ditches into underground pipelines.

The total length of installed pipelines is estimated at around 58,000 km, 92% of which are installed in Spain. The kilometres of pipes installed in each region are listed below, broken down by province.

SANECOR® corrugated PVC pipe references (in km)			
Andalusia	**11,059**	Burgos	420
Almería	481	León	1,186
Cádiz	2,876	Palencia	439
Córdoba	1,607	Salamanca	1,055
Granada	373	Segovia	538
Huelva	1,303	Soria	261
Jaén	1,288	Valladolid	1,416
Malaga	1,452	Zamora	197
Seville	1,680	**Catalonia**	**2,586**
Aragón	**2,427**	Barcelona	1,064
Huesca	822	Girona	680
Teruel	632	Lleida	377
Zaragoza	973	Tarragona	466
Asturias	**725**	**Ceuta**	**223**
Balearic Islands	**1,178**	**Extremadura**	**1,803**
Valencian AC	**4,015**	Badajoz	1,115
Alicante	1,408	Cáceres	688
Castellón	555	**Galicia**	**3,098**
Valencia	2,052	A Coruña	1,181
Canary Islands	**3,036**	Lugo	297
Las Palmas	2,851	Ourense	79
Tenerife	186	Pontevedra	1,542
Cantabria	**737**	**Rioja**	**119**
Castilla-La Mancha	**8,094**	**Madrid**	**6,657**
Albacete	973	**Melilla**	**67**
Ciudad Real	1,110	**Murcia**	**1,331**
Cuenca	705	**Navarra**	**181**
Guadalajara	1,599	**Basque Country**	**182**
Toledo	3,708	Álava	35
Castilla-León	**5,799**	Guipúzcoa	33
Ávila	288	Vizcaya	113
National total 53,317			
Portugal		2,983	
France		1,527	
Other exports		92	
SANECOR® TOTAL 57,919			

4. Regulations and certifications

The product standard applicable to **SANECOR®** corrugated PVC pipes is UNE-EN 13476: "Plastics piping systems for non-pressure underground drainage and sewerage". **SANECOR®** pipes have the AENOR and CERTIF marks in accordance with this standard, with certificate nos. 001/007322 and TMP-004/2023 respectively.

AENOR product certificate





CERTIF product certificate



Quality management system certificates



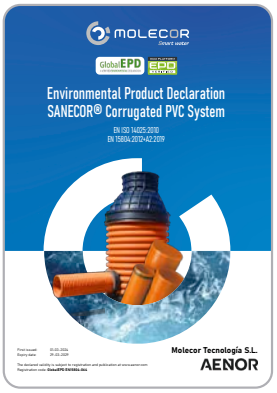


Environmental management system certificates





SANECOR® Environmental Product Declaration



Operation Clean Sweep® (OCS) certificate of conformity



Notes



















SANECOR

The optimal sustainable solution for sewage networks

AENOR GESTIÓN DE LA CALIDAD ISO 9001 ER-1644/2008 ER-0440/1996

AENOR GESTIÓN AMBIENTAL ISO 14001 GA-2014/0250 GA-2001/0255

IQNET RECOGNIZED CERTIFICATION

AENOR TUBOS PLÁSTICOS 001/007322 UNE-EN 13476-1 UNE-EN 13476-3

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