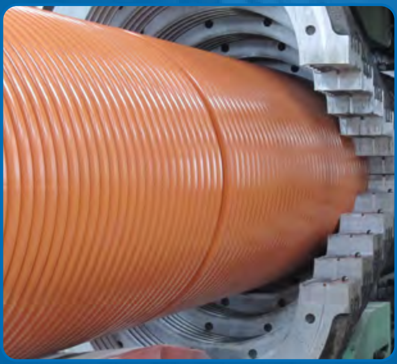
SANECOR

Corrugated PVC sewage system



Maximum efficiency and waterproof system

MOLECOR
Smart water

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SANECOR® system

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1. The sustainable solution of maximum efficiency for sewage system

1.1. Sewage piping in Spain

Hydraulic installation development in general and specifically that relating to urban water sewage must take into account certain social and environmental demands. A sewage system must be manhole designed and executed so that it provides the health indices and environmental protection our current society demands although, at the same time, it must also contribute to the preservation of available resources for future generations as much as possible.

These requirements have significantly influenced the development of our sewage piping, in which composition and morphology, as manhole as the design of the various network components, are intended to achieve better-sealed and longer-lasting installations with lower running costs. Moreover, this installation optimisation is achieved with materials that require less energy consumption and, therefore, reduced CO_2 emissions into the atmosphere throughout the component life cycle in the installation. Summing up, the choice of the materials employed in the sewage system must also contribute to sustainable development regarding future needs.

The growing importance of the previous criteria has involved very high investment levels into sewage infrastructure over the last few decades. This has lead to a wide variety of existing piping with respect to material and morphology.

SANECOR® CONCRETE COLLECTOR MANHOLES FOR WASTE WATER WITH A RAINWATER COLLECTOR

A first classification would be to distinguish between rigid and flexible materials, both with their advantages and drawbacks. The first basically refer to conventional materials, employed over a very long time, whereas the second are plastic materials, which have undergone mush more development during the last few decades. **Table 1** list those most widely used.

REINFORCED CONCRETE COLLECTOR.

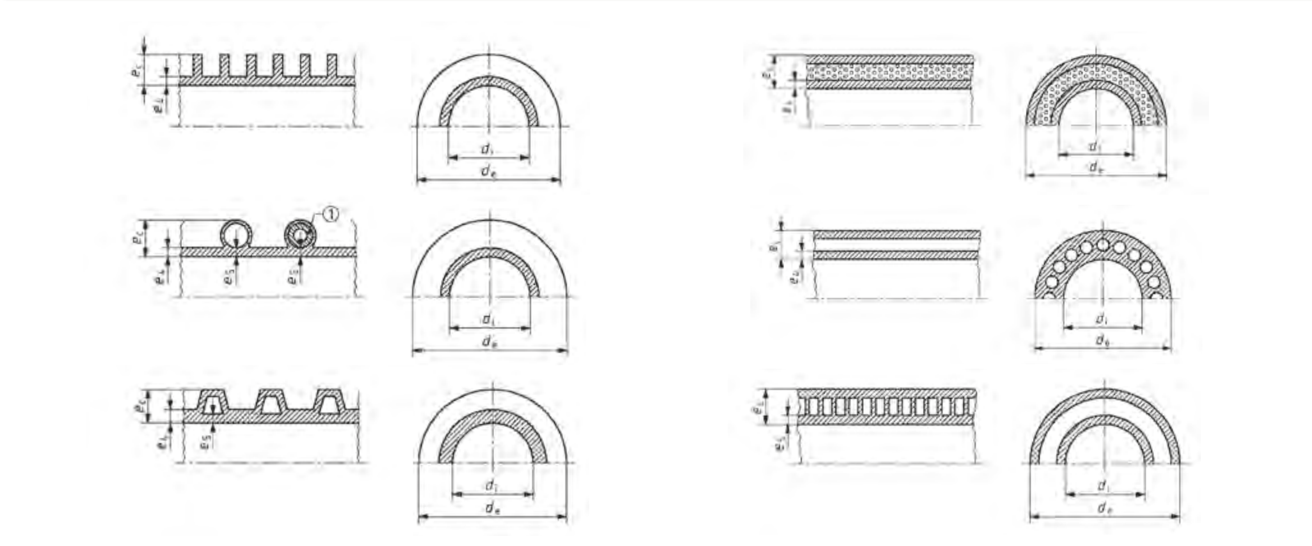
SN4 PLAIN PVC SEWAGE PIPING.

It should be mentioned that sewage piping, usually buried and supporting traffic loads, requires high rigidity, but it should also possess certain flexibility to transmit forces to the trench fill-in material and to absorb possible settling of both ground and pipe.

Sewage piping material (Table I)

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 stoneware	Corrugated PVC	PRFV filament winding
Nodular cast iron	Ribbed PVC	Centrifuged PRFV
Ductile cast iron	Spiral PVC	Polymer concrete

Within the plastic piping group are compact smooth piping manufactured from a single tubular plastic material extrusion, together with the so-called structured piping that include a more complex section designed to increase piping rigidity without increasing costs.
The following figure shows some of the most-widely employed structured sections.



PRINCIPAL PROFILES USED IN STRUCTURED PLASTIC PIPING.

Corrugated PVC.

Corrugated PE.

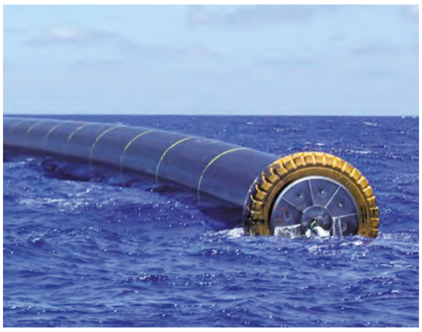
Corrugated PP.

PRFV.

MOST-WIDELY EMPLOYED SEWAGE MATERIALS.

Of all the materials listed in **Table 1**, only a few are notable on a national level as good value for money. Thus, for example, although mass concrete is very cheap, it is falling into disuse because of its low mechanical strength. Stoneware and cast iron are tending to disappear because of their high cost. Fibrecement piping is no longer manufactured because the use of asbestos is forbidden, however, it is still widely found in existing pipeline networks. Ribbed, honeycomb and multi-layer PVC are losing ground in Spain because they are not very competitive. Lastly, there is high-cost piping, such as compact polyethylene, which is normally limited to submarine outfall pipelines, or polymer concrete composed of polyester resin reinforced with aggregate that are only used for pipe jacking.

Stoneware.



Smooth PE (frequent in submarine outfall pipelines).

Polymer concrete (pipe jacking).

OCCASIONALLY EMPLOYED SEWAGE MATERIALS.

1.2. Plastic sewage piping specifications

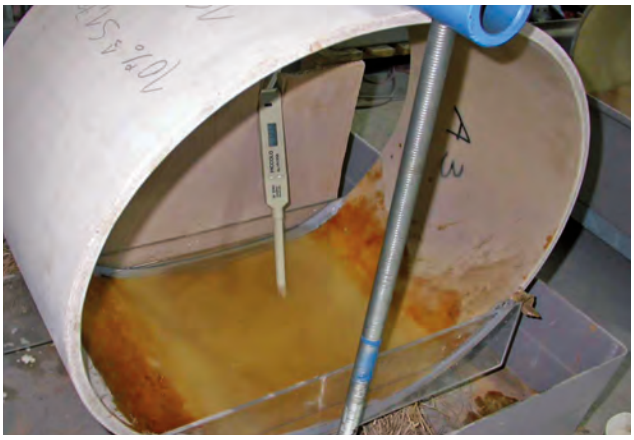
The use of plastic materials in sewage piping has any advantages that are listed below:

Chemical resistance

The specific waste-water characteristics determine the need for sewage piping to have very good performance regarding the pH of the chemical components present in circulating flows.

This is one of the most outstanding characteristics of plastic piping, no matter what material is employed, because, in general, it has very high resistance to most products present in waste water.

Although PE and especially PP perform better at high temperatures, PVC is more resistant against the effects of acids, mineral oils and fuels that are so frequent in urban run-off water.



CHEMICAL RESISTANCE TEST.

EXTERIOR AND INTERIOR CORROSION EFFECTS IN PIPING.

Lack of corrosion

In general, plastic piping is inert when referring to corrosion. This leads to a significant advantage because piping material must not oxidise due to aerobic corrosion or suffer anaerobic corrosion produced by components and microorganisms in circulating water and surrounding soil.

Piping must be resistant to electro-chemical action, in other words, against electric corrosion currents that are produced when two points on the piping surface are at a different potential, or when the surrounding soil has different oxygen or salt concentrations throughout the pipeline route, which is a normal occurrence.

Electric corrosion currents only pass through piping when its material has less electrical resistance than the soil and they corrode in the same way as stray currents that form in electrical installations. In the case of effluents and especially aggressive soils, materials must be employed that are resistant to such aggression and/or special protection systems or sufficiently thick, stable and resistant coverings.

PIPING SUFFERING FROM ELECTRO-CHEMICAL CORROSION.

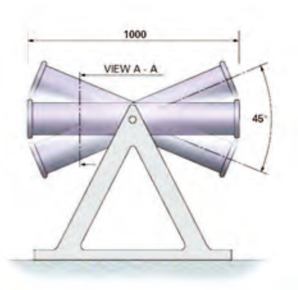
Abrasion resistance

Piping subject to solid particles dragged along by the effluent must be abrasion resistant. This is especially important in piping used in unitary sewage systems and in the rain water sewage network in separative systems.

The lower internal rugosity values of plastic piping have favourable effects on the performance against abrasion.

In fact, the internal surface abrasion of all plastic piping progresses very slowly. It can be guaranteed that abrasion wear at normal speeds is insignificant and that, because of this, piping duration is practically unlimited.

Thus, it has been proven that PVC piping, which is the plastic material with most time installed, has been shown to maintain excellent performance against such effects.



TEST METHOD AND EFFECT PRODUCED BY ABRASION.

Deposits and incrustation

The lack of internal piping surface porosity prevents in incrustation of materials contained in waste and rain water. On the other hand, this effect is very pronounced in concrete, fibre-cement and cast iron (interior mortar) piping.

Regarding deposits, the higher speeds achieved by water in plastic piping minimises this effect, which happens more in piping with high porosity as occurs in conventional material piping. However, in plastic piping, it must be taken into account that, depending on the actual material, the piping may have significant longitudinal flexibility that causes excessive sag. This effect can lead to counter-slopes and therefore unexpected deposits. With PVC piping, which has a high elastic modulus, this does not happen.

SEWAGE PIPING WITH MATERIAL DEPOSITS.

Joint sealing

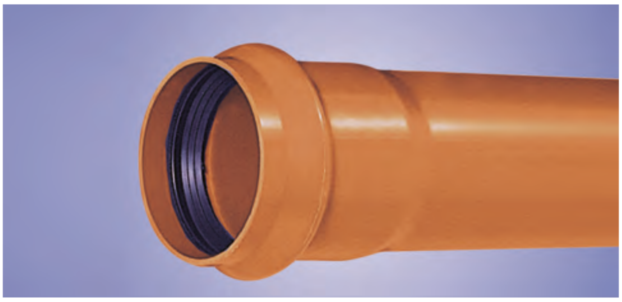
A fundamental requirement nowadays is that a sewage system does not have any leaks that could lead to environmental contamination. Furthermore, subsoil water must not be allowed to infiltrate the piping because if this is significant, it would increase energy consumption and purification costs in general and may even affect normal network and purification plant operation. All this means that excellent piping sealing is required, especially where joints, connections and manholes etc. are concerned, which are the critical aspects for compliance with this basic requirement.

MANUAL CONNECTION OF CORRUGATE PIPING.

LEAKING AT A CONCRETE PIPELINE JOINT.

In this respect, prefabricated union systems based on elastic joints, in which the sealing is guaranteed by the manufacturer's quality assurance, are especially recommended in comparison with onsite executed joints that require very strict controls making them very difficult to achieve in practice. It is essential to perform onsite hydraulic pressure tests at 0.5 atmospheres, in order to guarantee adequate system sealing.

In general, plastic piping sealing is greater than in the rigid type, with flexible piping deformation collaborating in better elastic joint sealing. Nevertheless, this will depend on the joint type design. It is often the case that, in order to save on costs, the joint is not high quality and adequate sealing is not achieved. The most important joints types employed in plastic piping will be covered later.



PLAIN PVC PIPING PRESSURE JOINTS.

SEALED CONNECTION IN SANECOR® MANHOLES.

Lastly, it is mentioned that, in addition to piping, there are other elements in the network where water infiltrations may occur, with the most obvious one being inspection manholes. These infiltrations are produced when the sewage installation is below the groundwater level.

Consequently, the sealing requirements must be extended to all network elements, especially where groundwater is concerned and even more so in inspection manholes, where collector and mains supply connections are frequent sources of leaks and water entry.

LARGE-DIAMETER PRFV PIPING SLEEVE JOINTS.

Hydraulic capacity

This is a property that is very closely related to the need to conduct waste water quickly without any stagnation. There are factors in waste water sewage networks are not present in fresh water, such as deposits on the piping bottom and walls, inspection manholes and the larger number of joints etc. For this reason, in the piping uniform rugosity equivalent **K**, (Prandtl-Colebrook), all these facts are incorporated, assigning various values to the pipeline according to the fluid type circulating through it (clean water, rainwater, sewage or industrial etc).

The effect of usage and piping conservation on the mentioned equivalent rugosity are also taken into account. The commonly used values in waste water pipelines are given below.

Coefficient K values for various materials (Table 2)

PIPING TYPE	K (mm)
Stoneware	0.10-0.25
Smooth internal wall PVC	0.10-0.25
Smooth internal wall PE-AD	0.10-0.25
Centrifuged PRV	0.10-0.25
PRV filament winding	0.20-0.50
Fibre-cement	0.25-0.40
High-quality smooth concrete	0.40-0.80
High-quality smooth concrete	0.80-1.50
Rough concrete	1.20-4.00
Onsite manufactured concrete	2.50-6.00

The lower values in **Table 2** are essentially applicable to new piping or that with a good conservation system, with long, straight sections between inspection manholes, to main collectors and outfalls. The higher values are for the opposite situations.

INTERIOR SURFACE OF SANECOR® PIPING.

THE INTERNAL FRICTION COEFFICIENT IS MINIMUM IN PLASTIC PIPING

Another determinant factor for piping hydraulic capacity is the inside diameter. In plastic piping, the diameter rating in almost all cases corresponds to the outside diameter. This means that the inside diameter and therefore the hydraulic capacity will depend on the thickness assigned by the manufacturer to its piping. In the case of structured piping, this thickness can be very considerable. Because of the importance of this factor as a differentiating element for the various piping types this will be described in detail later.

Performance and installation costs Safety during installation

In general, plastic piping is very light and, in the case of the structured type, even more so. This characteristic leads to very low handling and installation costs because significant savings are obtained in the machinery and personnel required during installation.

LEFT, SANECOR® PIPING INSTALLATION WITH DISCRETE MECHANICAL MEANS (MEDIUM AND LARGE DIAMETERS), RIGHT, MANUAL CONNECTION (SMALL DIAMETERS).

In addition to the above, the weight also significantly increases works performance, which reduces deadlinesc and therefore fixed costs that can be a determining factor for project economic feasibility.

Lastly, but no less important, another basic advantage of piping lightness is the increased safety for installation personnel. For deep piping that requires trench wall shoring, the less time spent in the trench means increased works safety.


MONTAJE DE TUBOS DE PRFV EN ZANJA ENTIBADA.


SANECOR® 1200 MM PIPING WITH ANGULAR DIVERSION.

Piping flexibility

Frequently, network piping is subject to forces and deformation produced by differential soil settling, which must not cause any fracturing or leaks. This requires piping flexibility that enables it to adapt to deformation and minimising local forces that are produced.

Plastic piping with elastic joints adapts to settling and easily absorbs the produced stresses, whereas in a rigid-element system, which is incapable of adapting to the same deformation, enormous forces appear that can cause fracture and subsequent leaks.


PLASTIC PIPING FLEXIBILITY IS IMPORTANT REGARDING SOIL DISPLACEMENT ABSORBING.

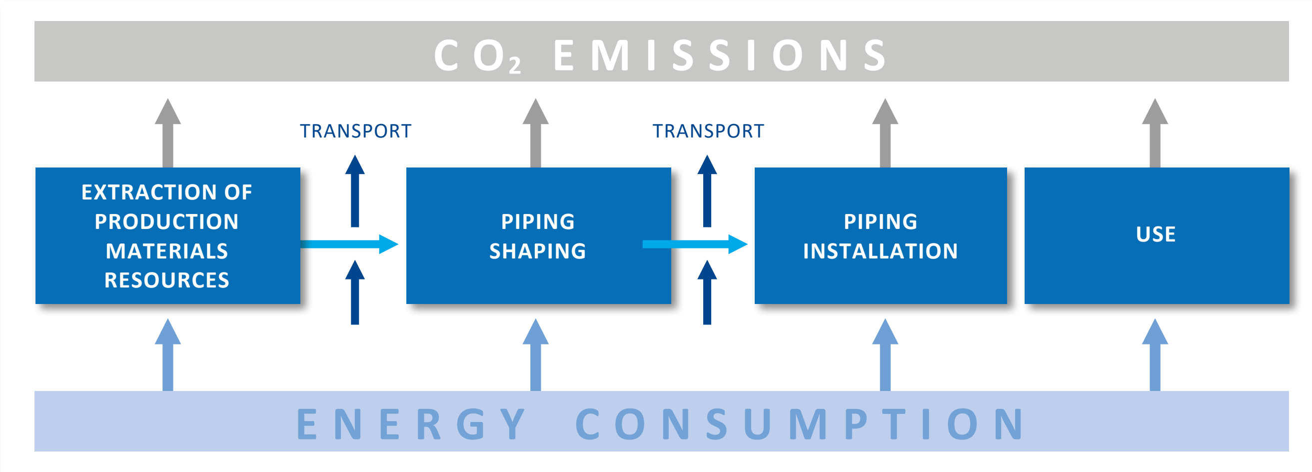
Energy consumption

According to a study (*) carried out by the Environmental Modelling Laboratory belonging to the Engineering Project Department at the Catalonian Poly-technical University, the energy consumption and CO_2 emission into the atmosphere throughout the life cycle of these products, are very low when compared to reinforced concrete piping.

(*) “Energy consumption and CO_2 emission estimates associated with the production, use and final arrangement of PVC, PEHD, PP, cast iron and concrete piping” (December.2005). Authors: Dr. José María Baldasano Recio, Dr. Pedro Jiménez Guerrero, María Gonçalves Ageitos and Dr. René Parra Narváez.

This life cycle contemplates all product stages during its useful life-time:

- Extraction of raw material for manufacturing the piping.
- Transporting the raw material to the production plant.
- Piping manufacture.
- Transporting the piping to the installation worksite.
- Piping installation.
- Piping usage: maintenance and repair jobs.



LIFE CYCLE SCHEMATIC FOR BURIED PIPING (WITHOUT RECYCLING STAGE).

Sewage piping - Energy consumption and CO_2 emission for three metres of piping

	ENERGY CONSUMPTION (KW/H)	CO_2 EMISSION (KG DE CO_2)
SN4 smooth PVC (80% recycled) DN315	69,0	22,0
SN8 corrugated PVC (80% recycled) DN315	34,7	11,5
SN8 corrugated PE (80% recycled) DN400	64,4	21,0
SN8 corrugated PP (80% recycled) DN400	60,4	21,6
SN4 PVC (0% recycled) DN315	262,2	76,9
SN8 corrugated PVC (0% recycled) DN315	121,3	36,1
SN8 corrugated PE (0% recycled) DN400	211,0	58,6
SN8 corrugated PP (0% recycled) DN400	191,0	61,5
DN400 concrete	345,0	129,4

The findings of this study are summarised in the above table. As can be seen, the plastic material values are lower than those for concrete because of the lower weight and raw material content of the former with respect to the latter. This difference is much higher if recycled plastic materials are used. It can also be seen that a 315 mm diameter is considered for the two PVC pipes, while a higher equivalent diameter of 400 mm was considered for the others. The reason for this will be discussed later.

1.3. Sewage piping optimisation: SANECOR® piping

Until the mid 70s, the gravity-fed sewage networks in Spain were usually concrete or fibre-cement, raditional materials for many years, during which Molecor was a major manufacturer in Spain. Since then, the first PVC piping started to appear, which provided a qualitative advance because of the material properties described in the previous section. However, because this smooth piping was nly produced in a certain thickness for each diameter to guarantee an initial minimum annular rigidity of 4 kN/m² (SN4 rigidity rating), which, under specific installation conditions, was insufficient to prevent excessive deformation in the medium and long terms. For this reason, Molecor and other European manufacturers commenced development of PVC piping that increased rigidity without it costing any extra. This was a significant conceptual leap forward ecause it achieved a structural improvement that optimised raw material consumption at the same time and that of energy throughout the full piping life cycle.

Employing these criteria at the end of the 80s, Molecor launched the SANECOR® piping, in hich the wall thickness was made up of two layers, he outer being corrugated and the inner smooth. Right from the beginning, this piping was designed to be a highly sustainable product intended to fully satisfy sewage network requirements, optimising energy consumption associated with production, installation and operation also minimising environmental interaction. To this end, significant advantaged were incorporated compared to most plastic piping, for which the most important are summarised below.

COLECTOR DE PVC CORRUGADO SN8.

Maximum short and long-term rigidity

As previously seen, plastic piping flexibility is a significant factor in adapting to soil settlement. However, this has to be balanced by the even more important requirement for the piping to have sufficient short and long-term rigidity and be able to withstand all external loads throughout its useful lifetime.

As previously seen, plastic piping flexibility is a significant factor in adapting to soil settlement. However, this has to be balanced by the even more important requirement for the piping to have sufficient short and long-term rigidity and be able to withstand all external loads throughout its useful lifetime.

In practice, depending on surrounding soil conditions, the capacity to withstand external loads will have greater or lesser relevance. To a large extent, these conditions will depend on how the installation was carried out, namely trench dimensions, fill-in type and compaction.

The above may be quantified using the buried piping deformation formula:

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

This deformation is a percentage of the piping diameter and is a direct function of the vertical loads, $\mathbf{Q_{vt}}$, that are opposed by two factors:

- $\mathbf{E_S}$ = surrounding soil modulus of elasticity that depends on the trench, fill-in type and compaction with is installation quality.

- **RCE** = piping specific circumferential rigidity, defined as:

$$RCE = \frac{E_C \cdot I}{D_{m^3}}$$

where:

- $\mathbf{E_C}$ = piping material modulus of elasticity.

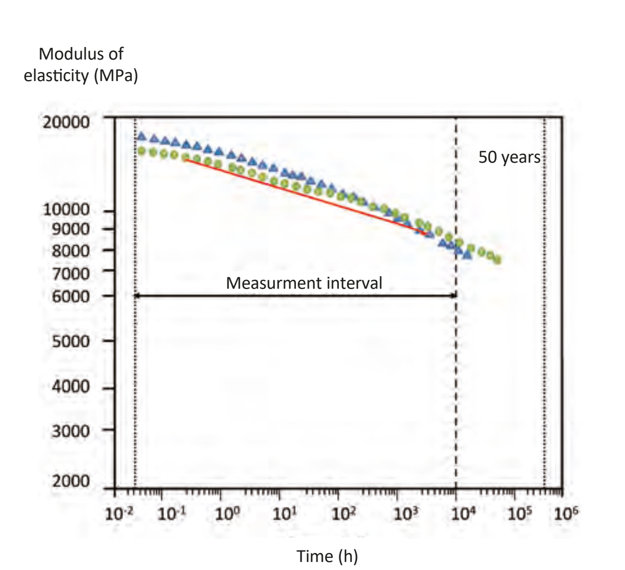
- **I** = moment of inertia per unit length, which depends on piping thickness.

- $\mathbf{D_m}$ = piping mean diameter.

The deformation formula shows that if the soil component is sufficiently high ($\mathbf{E_S}$ high value), the piping rigidity does not require high values. If, on the other hand, the soil modulus of elasticity $\mathbf{E_S}$ is not sufficiently high, piping deformation will largely depend on its own rigidity.

However, when using plastic piping, the more standard technical documentation (the MOPU or UNE 53331 specifications, among others, in Spain), limit plastic piping deformation to 5% its diameter over fifty years. This time limit is linked to the known characteristic of plastic materials and of polymers in general, to undergo modulus of elasticity losses over time when such elements are subject to mechanical stresses.

This loss is called "creep" and is due to deformation of the polymer macromolecules and is very strong at the beginning, but falls over time and is asymptotic for the fifty-year horizon. Creep is usually represented as regression curve for the materials that is shown on a logarithmic time scale, as in the figure below:

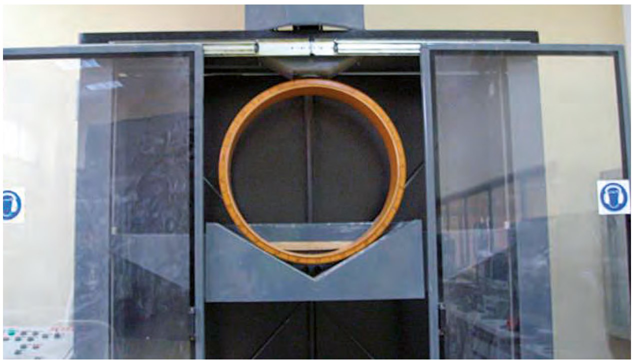


GENERAL PLASTIC MATERIAL REGRESSION CURVE SCHEME.

When piping has to withstand interior pressure, the corresponding product standards require that the piping be able to withstand the expected working pressure for fifty years after being put into operation.

The manufacturers have to design piping to initially withstand pressures that are much higher than required so that they maintain the expected pressures in the long term.

In non-pressurised buried piping, the operating loads are due to external factors only, such as the weight of the overlying soil, dynamic vehicle traffic forces and the static forces of any surface loads etc. In non-pressurised buried piping, the operating loads are



ENSAYO DE RIGIDEZ DE UN TUBO FLEXIBLE.

due to external factors only, such as the weight of the overlying soil, dynamic vehicle traffic forces and the static forces of any surface loads etc. As previously seen, the forces of such loads are opposed by the various resistant values in the soil and piping rigidity. If it is expected that soil conditions will not be sufficiently good to attain high $\mathbf{E_S}$ values, or it is not possible to guarantee correct installation, then it will be necessary to guarantee a sufficiently high initial piping rigidity $\mathbf{RCE_0}$ so that the long-term rigidity $\mathbf{RCE_{50}}$ is maintained at acceptable values.

Here, the creep coefficient of a determined plastic element **p** is defined for a certain time **t** as:

$$Cf = Ep_0 / Ep_t$$

In other words, as the ration of the modulus of elasticity **p** and the modulus of the same plastic **p** after time **t**. The creep coefficient for time **t** that is considered (two or fifty years etc.) will determine the initial plastic piping rigidity value. As will be seen later, the creep coefficients may vary greatly depending on the plastic type under consideration.

Taking into account the significance of these concepts because of their influence on plastic piping durability, it will be shown how to optimise piping type selection from among the usual options.

This is covered by two standards:

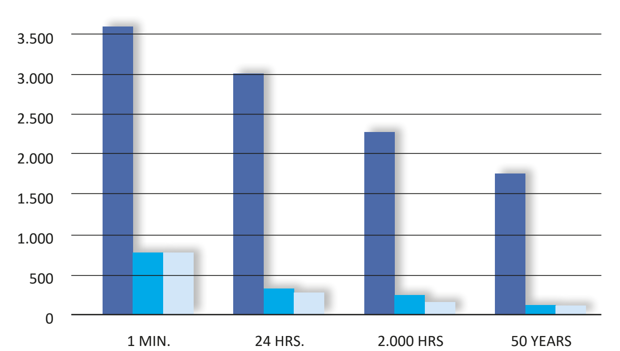
1. **The German DIN 16961-2 from 2000:**
Thermoplastic piping and accessories with profiled exterior and smooth interior surfaces.

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

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

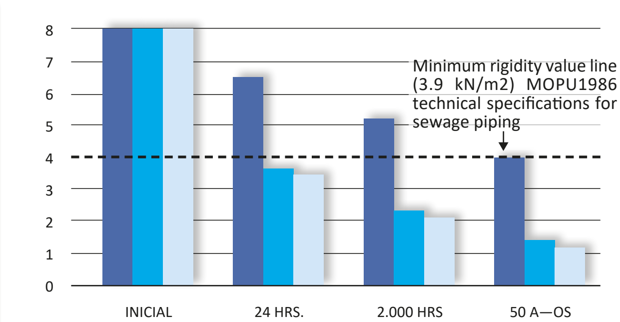
If these values are entered into the previous rigidity formula, it is clear that in order to achieve a certain initial rigidity, corrugated PE and PP piping must have their moment of inertia **I** and therefore thickness considerably increased in relation to PVC piping since the latter has a much higher $\mathbf{E_0}$ value.

Moreover, due to creep effects, the mentioned standard defines a series of decreasing modulus of elasticity values over time for each material when the piping is subject to forces, as in the case of piping buried under vehicle traffic. The first of the two graphs shows the fall in modulus $\mathbf{E_t}$ and the second, starting with SN8 piping, the corresponding fall in rigidity by the same proportion since the **I** and $\mathbf{D_m}$ values remain invariable over time in the formula for the latter.



	1 MIN.	24 HRS.	2.000 HRS	50 YEARS
PVC	3.600	3.000	2.300	1.750
PE	800	380	250	150
PP	800	360	210	120

COMPARISON OF THE MODULES OF ELASTICITY OVER TIME ACCORDING TO DIN 16961.



	INICIAL	24 HRS.	2.000 HRS	50 A—OS
PVC SN8	8,0	6,7	5,3	4,0
PE SN8	8,0	3,8	2,4	1,5
PP SN8	8,0	3,6	2,1	1,2

DEVELOPMENT OF RIGIDITY RCE = (EXL)DM3 OVER TIME ACCORDING TO DIN 16961.

The $\mathbf{E_t}$ values are employed to provide the creep coefficients for the three considered materials. So, for the $\mathbf{E_{50}}$ values at fifty years:

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

These same coefficients are those corresponding to the rigidity losses if the loads applied to the piping were of the order of magnitude contemplated in this standard.
In SN8 PVC piping, which includes SANECOR® piping, the rigidity fall at fifty years is half the initial value because the original design sought rigidity of 3.9 kN/m² at fifty years, which coincided with the initial value marked by the MOPU-1986 technical specifications for sewage piping.

Although these specifications marked this value as initial, experience from many installations that were not correctly executed caused various manufacturers, among them Molecor, to design sewage piping with this value as the fifty-year requirement. Thus, the initial required rigidity for PVC piping was **RCEmin** = 3.9 x 2.06 = 8 kN/m², in other words SN8 piping. This gave rise, among others, to the SANECOR® corrugated piping that has been so widely used in Spain since the beginning of the 90s.

With the same requirements as PE and PP piping, the designs for this piping would have included minimum initial rigidities of 21 kN/m² and 26 kN/m², respectively. It is quite clear that the SN8 rigidity is totally insufficient when the piping installation is not correctly executed, which is why the use of such piping in sewage networks produced significant general piping ovalisation. Despite this, low prices mean its use is widely extended. Low prices are due to this piping being very light with very low raw material costs.

In SN4 compact PVC piping, a situation in which trench conditions and applied loads cause a loss in modulus of elasticity as contemplated by the mentioned standard would lead to piping with residual rigidity of around 2 kN/m², which is quite insufficient to prevent serious long-term deformation.

2 The European UNE-EN 13476 from 2008:

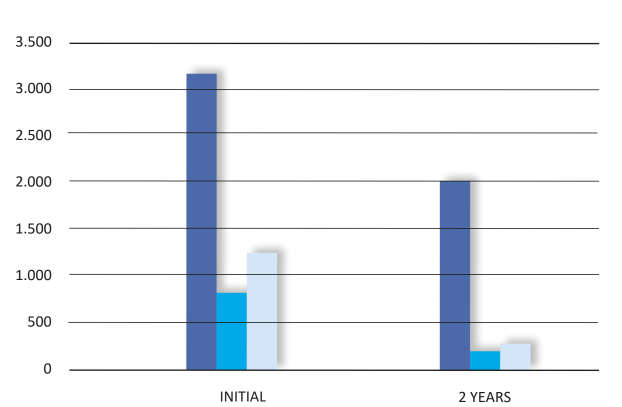
Plastic piping systems for sewage and nonpressurised underground sewage - Structured wall piping systems of non-plastified polyvinyl chloride (PVCU), polypropylene (PP) and polyethylene (PE).

This standard, the most recent, defines maximum creep coefficients at two years and initial moduli of elasticity for the three considered materials, which are:

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

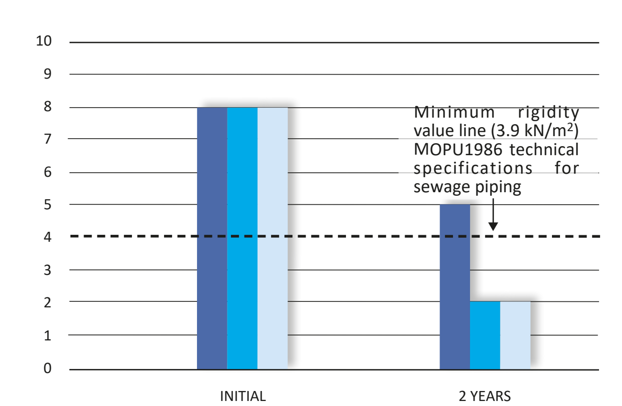
This standard only contemplates coefficients at two years because, after this period, rigidity falls are now small and this facilitates the creep test which, for two years, requires an accelerated test of only two months (the fifty-year test requires fourteen months). Furthermore, some of the initial moduli of elasticity defined by this standard varied because certain additives were employed to guarantee higher quality of the materials used in these piping types.

Since the $\mathbf{Cf_{PE}}$ and $\mathbf{Cf_{PP}}$ values are always close to 4.0, and given its high demand and that $\mathbf{Cf_{PVC}}$ has a value of around 1.6 for SANECOR® piping, the graphs for this standard are as shown in the following table.



	INITIAL	2 YEARS
PVC SANECOR	3.200	2.000
PE	800	200
PP	1.250	312

MODULES OF ELASTICITY OVER TIME ACCORDING TO UNE-EN 13476.



	INITIAL	2 YEARS
PVC SN8 SANECOR	8,0	5,0
PE SN8	8,0	2,0
PP SN8	8,0	2,0

RIGIDITY DEVELOPMENT OVER TIME ACCORDING TO UNE-EN 13476.

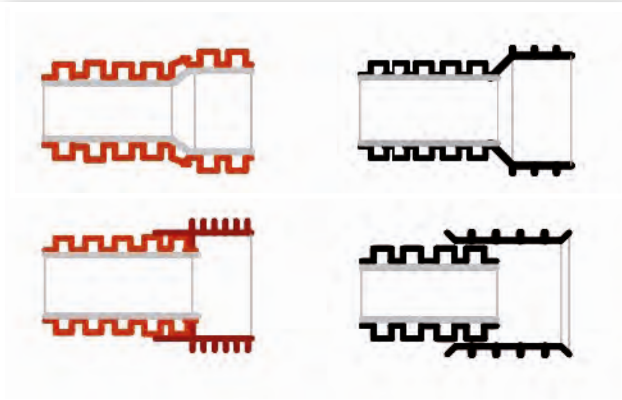
In this case it can be seen that after two years of being buried, piping under loads that produce modulus of elasticity losses of the considered magnitudes, the SANECOR® piping still has a rigidity of some 5kN/m^2, while the PE and PP corrugated piping maintains a value of only 2 kN/m^2, which is insufficient to prevent significant deformation in this time period.

The above allows the conclusion that SANECOR® SN8 PVC piping is among the habitual, costcompetitive piping types that has the best short and long-term performance regarding external loads.

Optimum sealing

Current standards accept various plastic piping joint types; although in the most often employed, elastic joints are always used. In the case of SN4 compact PVC piping, the joint is standardised as the pressure-fitting type (bell end), but in structured piping, UNE-EN 13476, contemplates widely varying types, limiting instructions only to that the jointing system must maintain adequate sealing. This standard specifies pressure bell-end fitting joints, such as employing sleeves. In any case, the sealing tests are made according to UNE-EN ISO 13259.

In PRFV piping standards, the jointing types are also very varied, with not only elastic joints (pressure bell-end fitting and with sleeves) acceptable, but also welded, flanged joints and by employing metal accessories.



VARIOUS JOINT SYSTEMS FOR STRUCTURED PLASTIC PIPING.

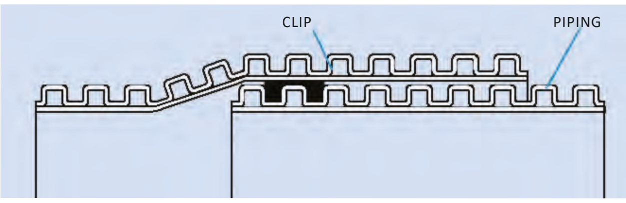
Of the solutions given in the previous figure, the two at the top are made by fitting the piping into one of its ends. They are typical for PVC and PP. The bottoms two are employed for PE piping that does not accept correct bell-end fitting. The left model is a welded cup joint and the other is a sleeve joint.

The SANECOR® piping joint is made employing the first system, called integrated mouth cup, which maintains the characteristics of the rest of the pipe (corrugated and thicknesses), something that makes it the most reliable of existing solutions.

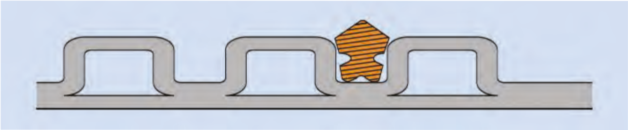
Another significant aspect affecting joint sealing is the elastomer joint. Whereas in plain piping the joint is within a manufactured housing inside the cup, in corrugated piping, the corrugation valleys are employed to house the joint.

CORRUGATED PVC PIPING (ORANGE) AND CORRUGATED PE (BLACK).

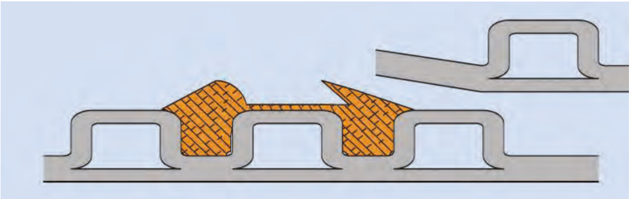
In the SANECOR® piping, this joint is bi-lobed up to diameter DN500, with a profile that, on the one hand, prevents joint movement during piping installation and, on the other ensures greater sealing. In piping with larger diameters (DN630 – DN1200), the joint is a single lip because the deeper depth of the corrugations prevents the joint from easily moving out of the housing.



SANECOR® PIPING PRESSURE FITTING JOINT.



SANECOR® SINGLE ANCHOR JOINT, DN630-1200.



SANECOR® DOUBLE ANCHOR JOINT, DN160-500.

SANECOR® PIPING (RIGHT) IS THE ONLY ONE WITH A BI-LOBED JOINT TO OPTIMISE JOINT SEALING.

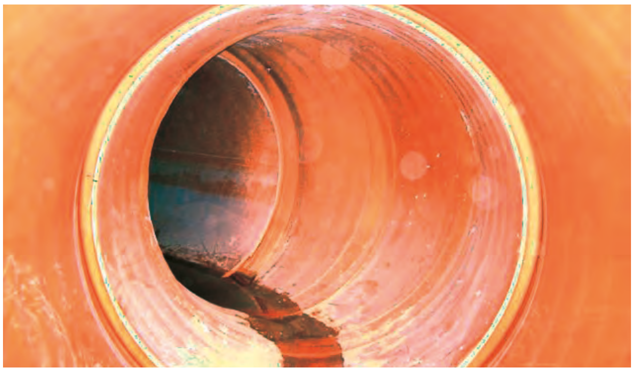
The joint must be able to easily comply with the UNE-EN ISO 13259 sealing tests that require sealing to be maintained under internal pressure conditions of 0.5 Atm and internal depression of -0.3 Atm, with differential piping deflection with respect to the cup or sleeve (greater deflection in the former), or with a determined angular deviation according to diameter. SANECOR® piping profiles enable angular deviations to be achieved that are manhole-above those established in the standards.

DN	Ángulo máximo normalizado	Ángulo máximo en tubo SANECOR®
160	6º	9º
200	5º	7º
250	4º	6º
315	3º	5º
400	1º	3º
500	1º	3º
600	1º	3º
800	1º	3º
1000	1º	2º
1200	1º	2º

DESVIACIÓN ANGULAR MÁXIMA DE LA UNIÓN ENTRE TUBOS.

Maximum hydraulic capacity

The hydraulic capacity of a gravity-red sewage pipeline is determined by two factors, the friction coefficient between the water and the piping and the piping inside diameter. As already stated, the friction coefficient in plastic piping is K = 0.10 in the Prandtl-Colebrook formula for waste water, which is ten times lower than that for concrete piping.



INTERIOR VIEW OF AN SANECOR® COLLECTOR WITH ANGULAR DEVIATION.

Regarding the inside diameter, most plastic piping follows the criterion DN = Dexterior, so that the inside diameter depends on piping thickness and the manufacturer. This provides different flow rates, given the same slope and internal rugosity for the same diameter rating.

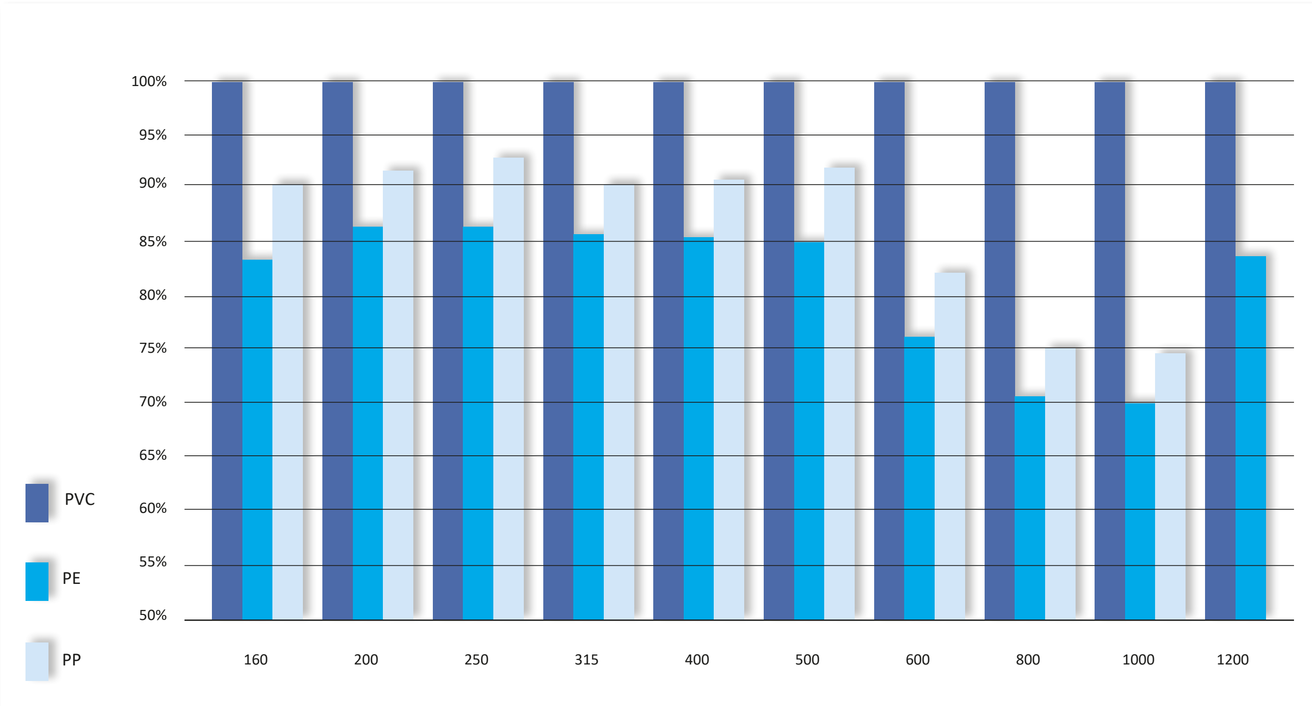
SANECOR® piping follows this criterion only to diameter DN 500 for the necessity that all piping must be compatible with the standard fittings and accessories on the market. However, from DN630, SANECOR® optimises diameters to ($D_{exterior}$ > DN).

Furthermore, for a specific piping (RCE) rigidity, the thickness depends on the corresponding material type which, on having a determined modulus of elasticity $\mathbf{E_c}$ requires a moment of inertia value of **I** in the formula:

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

Since I is a function of thickness (in plain piping $I = \frac{1}{12} e^3$), in PE and PP corrugated piping (small $\mathbf{E_c}$ value), the thickness will have to be higher than for corrugated PVC (high $\mathbf{E_c}$) in order to achieve the same rigidity. Therefore, in SANECOR® piping, the hydraulic capacity is always greater than in other thermoplastic materials and even more so in diameters greater than DN500.

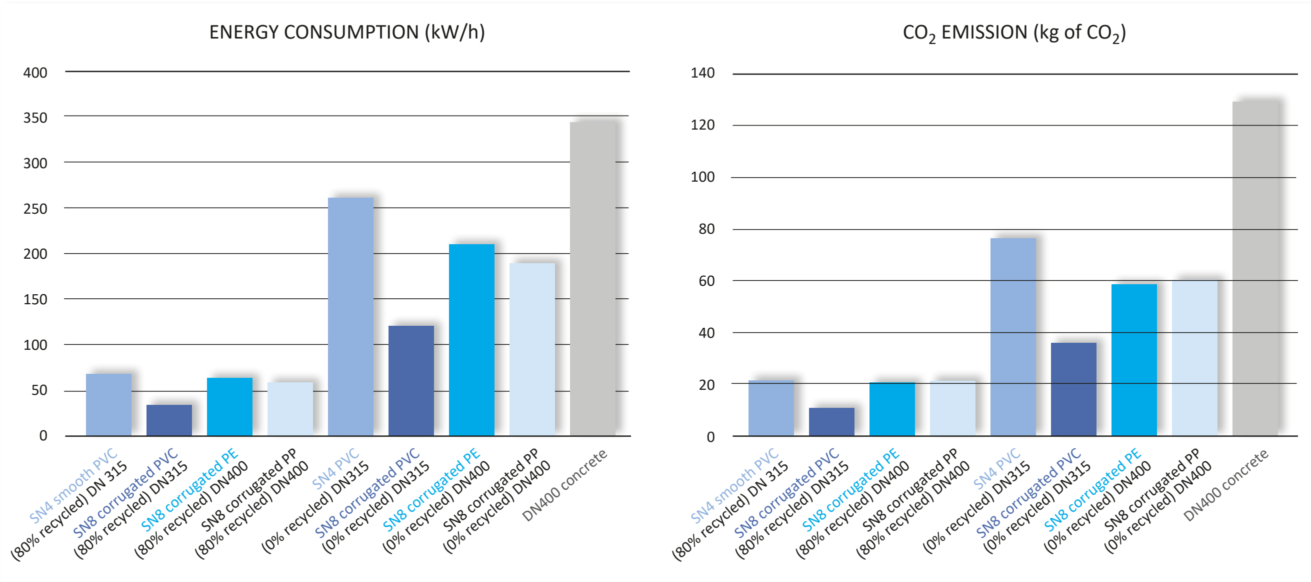
The following graph shows percentages of means flow rates at full section corresponding to the various materials employed in corrugated piping for the same slope values (1.5%) and internal rugosity (k=0.10).



DIFFERENCES IN MEAN FLOW RATE AS PERCENTAGE OF SN8 CORRUGATED PIPING (BASE 100% FOR SANECOR® PIPING).

Minimum energy consumption

As seen on page 7 and according to the mentioned study, plastic piping produce energy consumption throughout its useful lifetime and this can be very much lower than that of concrete piping. Similarly, within the examined plastic piping, which are the most widely employed, PVC piping reduces the diameter rating with respect to corrugated PE and PP piping because of the previous point and with respect to concrete piping because of the lower friction coefficient. Even so, the compact SN4 PVC piping is the one with greatest energy consumption because it is the heaviest. Regarding corrugated piping, the highest energy saving is that of SANECOR® SN8 corrugated piping because despite its weight is greater than PE and PP piping, it optimises the diameter required in relation to the latter two and it has lower manufacturing consumption both in raw materials and the piping. Foe the same reason, it is the most ecological piping from the CO_2 atmospheric emission point of view. The values in the mentioned study are given in the table on page 8 and are shown on the following graphs.



GRAPHS OF ENERGY CONSUMPTION AND ATMOSPHERIC CO_2 EMISSION FOR THE MOST COMMONLY USED MATERIALS IN GRAVITY-FED SEWAGE PIPING

SANECOR®, the most sustainable solution

A product is sustainable when it satisfies the requirements of current generations without compromising the possibilities of future ones to take care of their own needs. Along these lines, it is important for the product to have a long life cycle, to be longlasting, but, at the same time, resource consumption during this lifetime must be a minimum, as should be its social and environmental impacts.

In the case of SANECOR® sewage piping, the previous points contain a series of characteristics that contribute to product sustainability.

SANECOR® PIPING STOCKPILE.

The following table summarises the repercussions of the properties of this product on the factors contributing to greater sustainability.

CHARACTERISTIC	DURABILITY	ENERGY SAVING	ENVIRONMENTAL RESPECT
Raw material	-	↑	↑
Piping weight	-	↑	-
Material recyclability	-	↑	↑
Chemical resistance	↑	-	↑
Lack of corrosion	↑	-	↑
Abrasion resistance	↑	-	-
Deposits/Incrustation	↑	-	↑
Long-term rigidity	↑	-	-
Long-term rigidity	↑	-	-
Hydraulic capacity	-	↑	-
Installation costs	-	↑	-
Workplace safety	-	-	↑
Sealing	-	↑	↑
Maintenance costs	-	↑	-

PROPERTIES OF SANECOR® PIPING THAT INCREASE PRODUCT SUSTAINABILITY.

VIEW OF SANECOR® PIPING INSTALLED IN A TRENCH.

ONSITE HANDLING OF SANECOR® PIPING.

Maximum versatility in the SANECOR® system

SANECOR® piping possesses one of the widest ranges in plastic sewage piping. The table below contains the main dimensions of the various diameters.

SANECOR® piping range dimensions

DN	PIPING INSIDE DIAMETER	PIPING OUTSIDE DIAMETER	MAXIMUM OUTSIDE CUP DIAMETER	MEAN MOUTH 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
1.000	970	1.072	1.222	495
1.200	1.103	1.220	1.379	547

Thus, special fittings are manufactured in all diameters with the same material, being plain fittings of SN4.

rigidity rating in diameters of DN160 to DN500, having corrugated outer surfaces and smooth inner ones and corrugated outer surfaces and SN8 rigidity rating in diameters DN500 to DN1200.

In relation to accessories for main connections, the SANECOR® system has various models available for specific circumstances with respect to diameters, installation and regulations etc.

Lastly, SANECOR® piping has the most versatile range of inspection manholes manufactured of plastic materials. These elements, which are usually critical regarding sewage network sealing and maintenance costs, conserve the same optimum characteristics as the piping.

Pages 20 to 22 list the SANECOR® range of special fittings and accessories.

Similarly, page 24 onwards provides details of the SANECOR® manhole and its components.

THE COMPREHENSIVE SANECOR® SYSTEM POSSESSES HIGHLY VERSATILE SEALED ACCESSORIES AND ELEMENTS.

1.4. SANECOR® piping technical sheet

The following table summarises the technical specifications for SANECOR® piping.

PHYSICAL AND CHEMICAL FEATURES	
Density	1,350 ÷ 1,520 kg/m^3
Linear dilation coefficient	8 x 10^{-5} m/m. ºC
Thermal conductivity	0.13 kcal/m.h. ºC
Specific heat	0.2 ÷ 0.3 cal/g.ºC
Vicat softening temperature	≥ 79 ºC, according to UNE-EN 727:1997
pH limits	Between 3 and 9 at 20 ºC
Dichloromethane resistance	At 15 ºC, during 30 min, according to UNE-EN 580:2003
Oven test	According to ISO 12091:1995

MECHANICAL FEATURES	
Annular Rigidity (also called SCR = Specific Circumferential Rigidity)	RCE ≥ 8 kN/m^2 according to UNE-EN ISO 9969:2008
Creep coefficient at 2 years	≤ 2.5, according to UNE-EN ISO 9967:2008 The actual value varies between 1.6 and 1.8
Impact strength According to UNE-EN 744:1996	(Clock sphere method)
Annular flexibility	30% deformation in DN160 to D315 and 20% in DN400 à DN1200, according to UNE-EN ISO 13968:2009

MECHANICAL FEATURES	
Sealing with internally pressurised elastomer joint	Tests at 0.05 MPa with angular deviation and diametral deflection, according to UNE-EN ISO 13259:2004
Sealing with joint in internal depression	Tests at -0.03 MPa with angular deviation and diametral deflection, according to UNE-EN ISO 13259:2004
Equivalent rugosity (Prandtl-Colebrook)	K= 0.01 mm (for clean water) K= 0.10 ÷ 0,25 mm (for waste water)

SANECOR® PIPING INSTALLATION IN GALLERY AND TRENCH.

1.5. Note on buried piping installation

Piping installation shall follow current standards and good practice codes, among which mention should be made of the MOPU City Sewage Piping Specifications, the CEDEX Technical Guide for Water Transport Piping and UNE-EN 1610, UNE-EN 1452- 6 and UNE-ENV 1046.

The more basic aspects of each are summarised below.

1. Trenches for housing piping must be executed so that the separation between the piping and trench wall enables the workers to lay the piping and adequate fill-in compaction. Trench width must allow the height of the upper piping generatrix to be $A = D_{ext} + X$, where D_{ext} is the piping outside diameter and X varies between 0.4 and 1.0 metre in function of the diameter.

2. A bed of granular material (sand or pea gravel of approximately 5 – 10 mm) of sufficient height, H (cm) = 10 + D/10 is essential to prevent inequality in the trench base slope producing isolated support points on stones or soil clods. Direct support on a rigid concrete base is counter-productive in the case of plastic piping because, on the one hand, all the loads on the piping from fill-in or traffic, will produce a reaction in the support that could cause piping fracture and, on the other, any deformation or differential settlement would cause concrete base fracture and act as shear on the piping producing fracture or leaks. If, for special reasons, the piping has to be concreted, it must be done completely in the form of lost formwork. Otherwise, significant stresses would be produced in the piping generatrices which would pass from concrete to the granular fill-in. If the slopes are very small and a concrete floor is required, then a fill-in bed as described above must be employed.

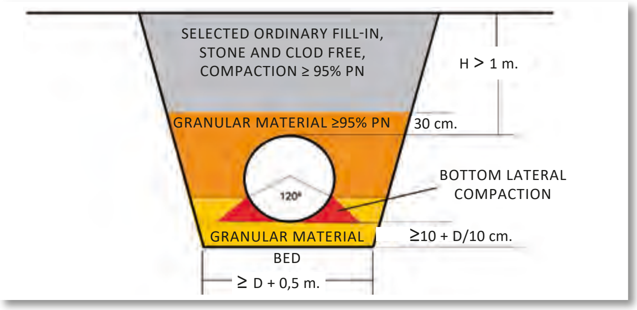
3. Lateral fill-in must be executed on the support bed in 25-30-cm layers, ensuring that the fill-in materials penetrates into areas of difficult access (lower piping section) and is well compacted, thus providing the piping with the required support angle (minimum 120º) along its full length. The lateral fill-in material must attain a height of 30 cm over the piping crown.

   It may be natural excavation soil, provided the design characteristics can be obtained. It is recommended that the grain size be 5-15 mm, ideally pea gravel or gravel that guarantees a minimum 95% natural compaction in the Proctor normal test without external means.

4. The rest of the trench fill-in up to the wear layer may be natural excavation soil, free from stones and clods, provided it has adequate characteristics according to current standards. It must have at least 95% compaction, although it must be 100% if there is heavy traffic so that no ruts or deformation affect the wear layer. However, the final layers must never be compacted below 90% in the normal Proctor test.

For further information on buried piping installation conditions, our handbook "*Installation of supply, irrigation and sewage piping according to current legislation is recommended*".

The following figure shows a typical trench indicating the most important aspects to take into account during piping installation.



TYPICAL STANDARD SECTION FOR BURIED PIPING TRENCHES.

Lastly, it must be remembered that in order to verify piping validity under the specific conditions for each installation, mechanical calculation is required based on current calculation standards. Molecor has a suitable calculation application, designed for SANECOR® corrugated piping and based on the German directive ATV A-127. This directive is recommended as being most suitable for simulating buried plastic piping short and long-term performance.

1.6. SANECOR® system accesories

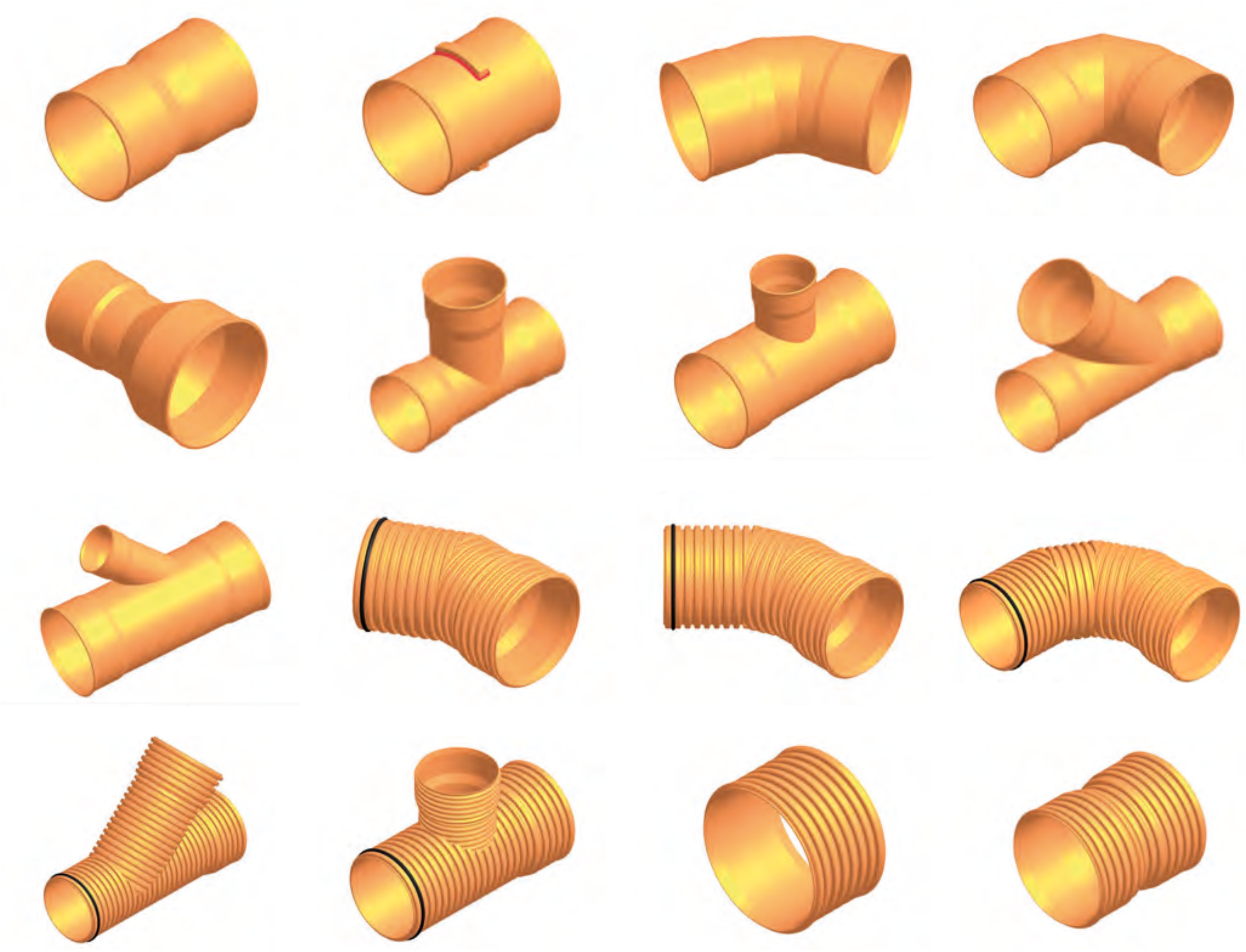
It is desirable in any sewage network for all components to have similar characteristics so that system mechanical stability is maintained, guaranteeing optimum sealing and to facilitate network maintenance.

SANECOR® system: The optimum sustainable solution for sewage networks SANECOR® piping includes a very wide range of special fittings and accessory manufactured in the same material. The Price List specifies the dimensions and includes detailed diagrams of all these elements.

Special fittings

The special fittings range for SANECOR® piping is produced in all diameters up to DN1200 and in two series ; SN4 plain series for fittings up to DN500 and SN8 corrugated series up to DN1200. The standard fittings type are the usual ones, with joint socket for non bell ends, single socket for assembling repairing reels, 30º, 45º and 90º elbows, expansion cones, 45º and 90º branches for equal or different diameter and end caps.

Furthermore, it is possible to order a wide range of specially made fittings.



STANDARD SPECIAL FITTINGS FOR SANECOR® PIPING WITH SN4 SMOOTH OUTER SURFACE AND SN8 CORRUGATED OUTER SURFACE.

SANECOR® HAS A VERY WIDE RANGE OF SPECIAL FITTINGS UP TO DN1200 (LEFT, REPAIRS WITH SINGLE SOCKET).

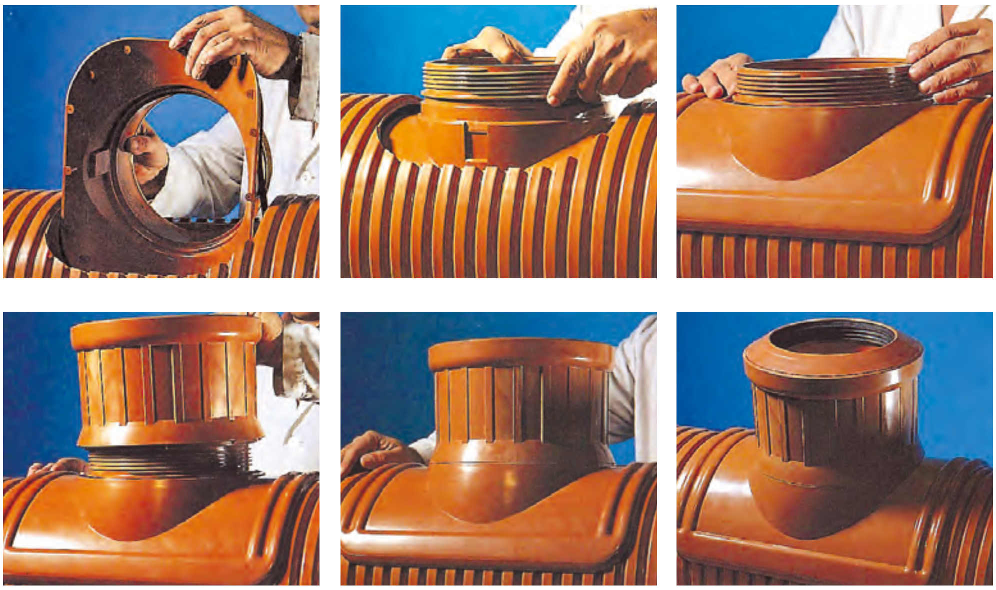
Main connection elements

There are various solutions, but those having simple installation, guarantee good sealing and involve reasonable costs should be selected.

The SANECOR® system includes the following connection types:

1. **Connections using mechanical clips.** The lower photos show the various installation stages of these accessory types. They make a very high quality PVC solution available on 160 and 200-mm diameters to 315-mm collectors. This is a reduced range because of the high investment cost required for their manufacture. These connections are fully sealed, easy to install and do not penetrate inside the collector.

2. **Connections using branch connection.** These are produced by welding the connection to a half round part that interiorly reproduces the exterior



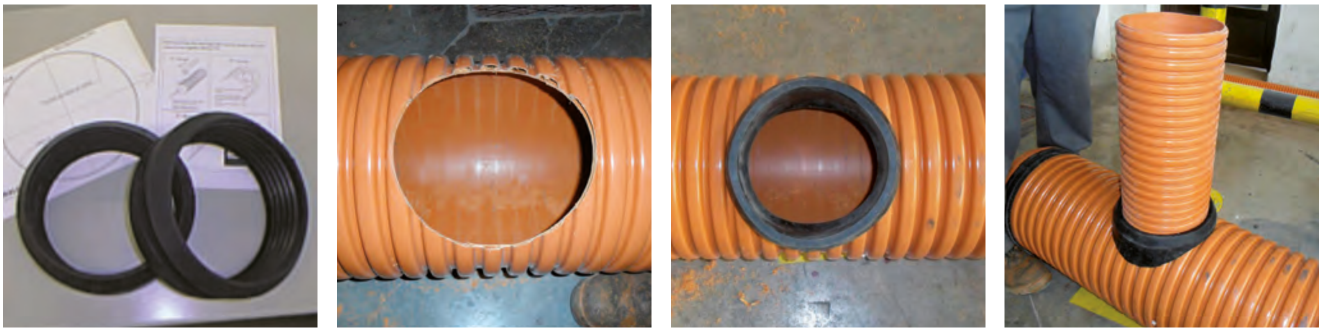
INSTALLING MECHANICAL CLIPS FOR SANECOR® PIPING.

corrugated from of the collector. The part is joined to the latter using adhesive. It has the advantage of having 45º connections (or even other angles) in addition to 90º (87,5º).

3. **Connections using elastomer clips.** Taking advantage of the large SANECOR®, corrugated piping thicknesses, it is feasible to use connection joints manufactured in EPDM rubber with are highly competitive in price and guarantee full sealing.

BRANCH CONNECTION FOR SANECOR® PIPING.

They are designed to fit the connections to SANECOR® collectors and, given the reasonable investment costs, these fittings are manufactured for all possible combinations; 160 to 630 mm connections for 315 to 1,200-mm collectors. The installation process for this solution is provided below. The document “Instructions for SANECOR® inspection manhole installation” fully described this procedure.



CONNECTION ELASTOMER CLIPS WITH CUTTING TEMPLATE.

If elastomer clips are used and, in order to prevent the connection from invading the collector, “stoped pieces” are available that form stops when installed in a corrugation valley, as shown in the following sequence.

Lastly, the following section is a detailed description of the SANECOR®, inspection manhole characteristics and components, as well as advantageous installation conditions.

“STOPED PIECES” INSTALLATION SEQUENCE FOR SANECOR® CONNECTION STOPS.

SANECOR®, WITH OVER TWENTY YEARS EXPERIENCE DIRECTED TOWARDS PRODUCT DURABILITY AND SUSTAINABILITY.

2. SANECOR® manholes for sewerage systems

2.1. SANECOR® manholes and inspection manholes

INSPECTION MANHOLES IN 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 for inspection, maintenance and repair work etc. These manholes used to be manufactured onsite with cheap materials, such as reinforced concrete or brickwork, although in recent years it has become quite usual to construct them using prefabricated concrete or plastic elements.

The advantages of employing plastic materials for sewage piping were described in the second section of this document. The majority of such advantages are extrapolatable to the other network elements, particularly inspection manholes ; chemical performance, corrosion and abrasion resistance, lower load losses, performance and installation costs, works safety etc. Sealing requires separate mention because it takes on critical relevance in inspection manholes because a large number of network operational problems, such as leaks and infiltrations, derive from lack of sealing in these elements.

Regarding costs, although plastic materials are much more expensive than conventional materials, the difference in costs between inspection manholes becomes significantly reduced when the comparison is made for installed units. This is because the installation performance is much higher due to low material weight and installation simplicity of such plastic elements that are mainly prefabricated.

Finally, it should be stated that, depending on manhole wall thickness and the employed material, the mechanical strength of the plastic manhole may not be enough to withstand the external soil loads and existing traffic. In this situation, the manhole must be lined with concrete after installation. Here, it must be pointed out that urban sewage network collectors are usually installed underneath existing roadways and collect water from the connections that leave the buildings.

At Molecor, we have great experience in manufacturing inspection manholes using various materials that, over the years, have enabled us to establish the advantages and drawbacks of each one (fibre-cement, concrete, PRFV, PEAD and PVC).

This experience, combined with Molecor innovating strategy, have enabled us to design and develop a significant range of inspection manholes using plastic materials that, on the one hand, make use of the advantageous characteristics of plastic materials and, on the other, resolve problems arising with other previous plastic solutions, mainly referring to costs, mechanical strength and in situ adaptation of the prefabricated solution.

SEALING FAILURE IN CONCRETE MANHOLES.

CONNECTION WITH PREFABRICATED PLASTIC ELEMENTS.

INSPECTION MANHOLES USING PLASTIC MATERIALS (POLYESTER AND POLYETHYLENE)

The SANECOR® design, which greatly reduced costs, guarantees optimum mechanical performance and excellent network sealing. It also has over twelve years of experience and hundreds of references throughout Spain.

SANECOR® MANHOLES.

2.2. Components and installation of SANECOR® inspection manholes

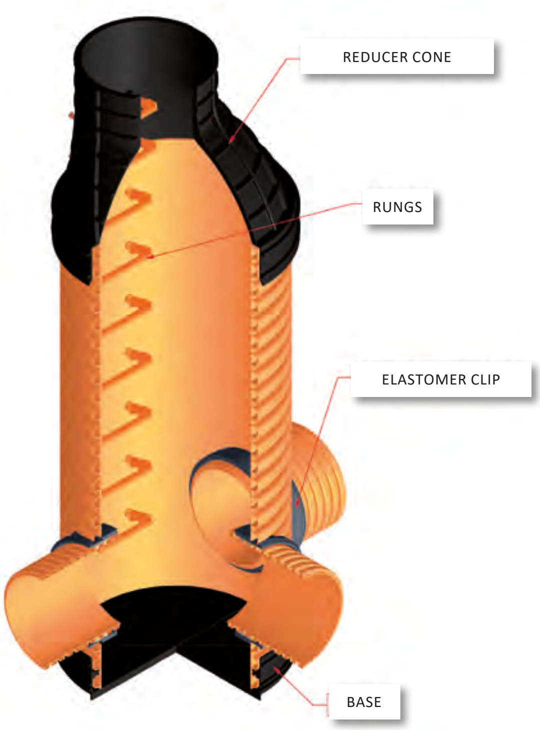
A manhole can be divided into three sections which, from top to bottom, are:

1. Manhole access via a very rigid conical part that reduces the manhole diameter to the inspection diameter (600 mm).

2. The manhole body, of the required height, with factory-installed access rungs. Its high rigidity does not require concrete reinforcement.

3. The manhole bottom with the collector connections. In function of its diameter, it can be executed in various ways. Up to a certain diameter which, in turn, depends on the manhole diameter, the piping are directly connect in the manhole body via elastomer joints, taking advantage of the large corrugated wall thickness and guaranteeing complete sealing. After a certain diameter, the collector connection may be executed either by bases with inspection that connect the manhole to the collector crown or by connection parts that allow access to the full collector section.

The following diagrams show the described configuration.



GENERAL SANECOR® MANHOLE DIAGRAM.

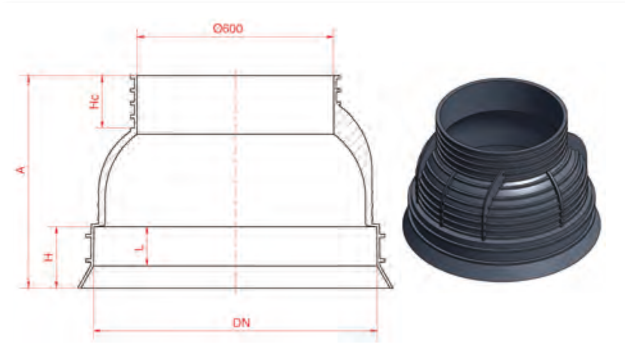
GENERAL DIAGRAM OF SANECOR® MANHOLE COMPONENTS WITH THE VARIOUS ALTERNATIVE CONNECTIONS TO THE COLLECTOR.

Each component is described in detail below.

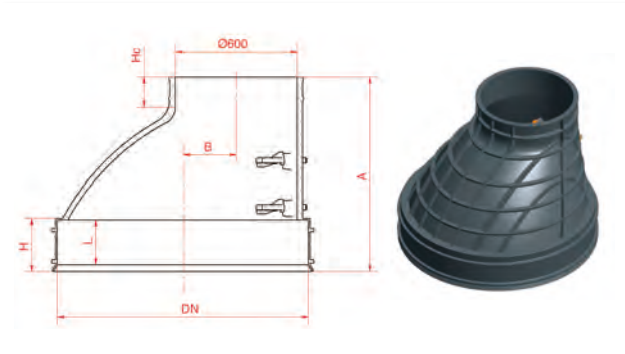
Inspection mahole access

The access reducer cone to the manhole is manufactured of high quality PEAD employing a system that produces high-volume plastic parts at a competitive price. This cone has a 600 mm entrance and is asymmetrical with two rungs in 1,000 and 1,200 mm manholes, whereas it is symmetrical without rungs in the 800 mm version. The design incorporates ribbing to ensure high rigidity.

The cone fits into the upper end of the body with installation being very simple. A sealing joint may be optionally installed between the reducer cone and the manhole body to guarantee sealing in high groundwater level situations.



800 MM DIAMETER MANHOLE REDUCER CONE.



1,000 AND 1,200 MM DIAMETER MANHOLE REDUCER CONE.

Manhole body

This is manufactured in corrugated SN8 (SANECOR®) rigidity rated PVC to ensure very high resistance to external loads throughout the manhole useful lifetime.

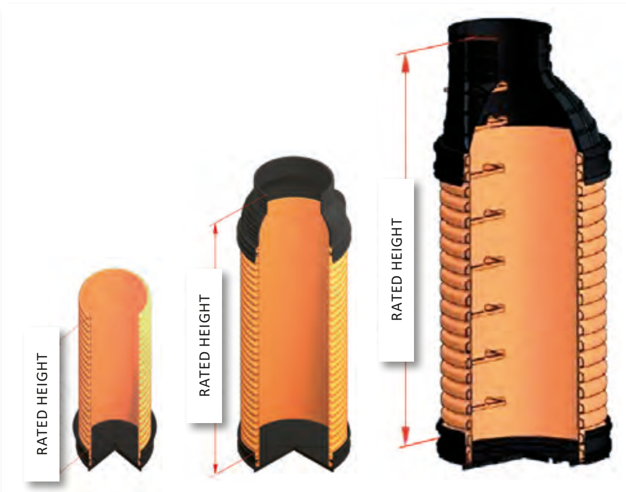
This material ensures that the manholes do not require concreting to reinforce rigidity. Quite the opposite, having a flexible material may be highly advantageous against soil settling. The SANECOR® manholes are available in a range of diameters between 600 and 1,200 mm.

For shallow manholes 600 mm diameter versions may be used, without rungs or cone, which are very suitable for heights of less than 1.5 metres, or 800 mm manholes for greater heights that include the option for rungs.

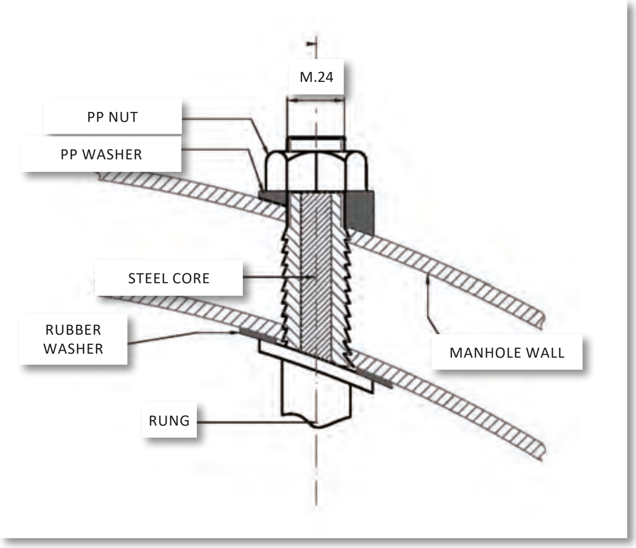
THE SANECOR® MANHOLE BODY IS MANUFACTURED FROM SANECOR® SN8 PIPING

For the more habitual manholes with diameters of 1,000 and 1,200 mm which, unless indicated otherwise, always include rungs, the height range varies between 1.5 and 9 metres.

The rungs installed in the manhole body are of steel and covered in polypropylene to guarantee sealing against groundwater entry. They are installed on the corrugationcrests with a constant maximum 30 cm separation.



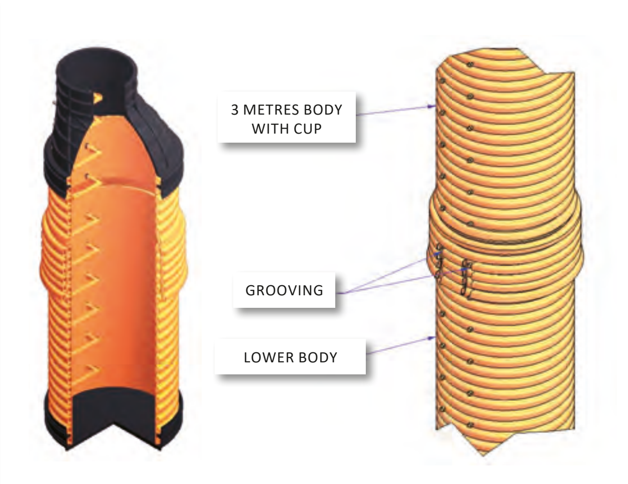
SANECOR® STANDARD BODY RANGE.



RUNG ANCHORAGE DETAILS.

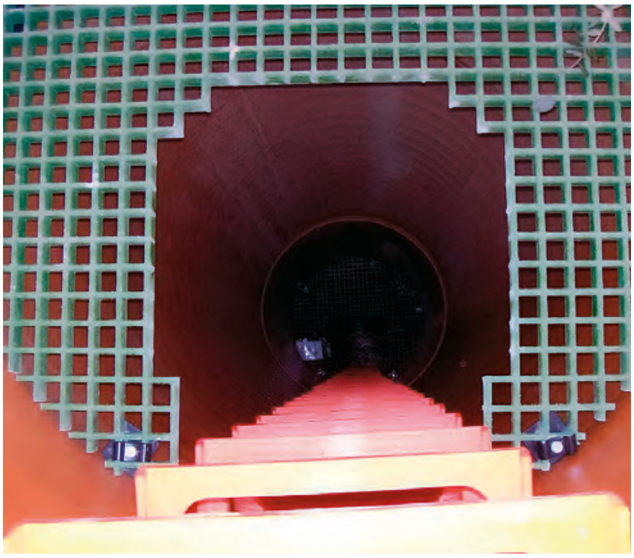
Body height adapts to the depths at the worksite (bodies are manufactured in lengths that vary 0.5 m) attaining a maximum 5.5 metres corresponding to 6-metre manholes. A second module is used for deeper bodies with a bell end to permit connection with the previous module.

In manholes of a certain depth, tramex or safety platforms are required that, in addition to protection against possible accidents, provide the option of making safe stops during descent. It is recommended that these elements be installed every 2.5 or 3 metres depth.



DEEP MANHOLES USING TWO MODULES.

SANECOR® manholes include fitted tramex in reinforced polyester to prevent electro-chemical corrosion.



POLYESTER TRAMEX IN SANECOR® MANHOLES.

Mains connections to the manhole body

Collector connections or those to the manhole body are executed using rubber gaskets called elastomer clips that are installed after drilling the corresponding holes in situ. The great thickness of corrugated bodies enables clips of sufficient length to be installed and ensure complete sealing, even when there is a certain angular deviation. For this reason, these parts are design to the corrugated body dimensions.

The connection execution method is very simple and does not require skilled labour. The following illustration shows the employed procedure. The clip is supplied with an adhesive template that is stuck to the manhole body in the trench so that the hole can be made quickly and reliably.

HOLE DRILLING PROCEDURE FOR ELASTOMER CLIP INSERTION.

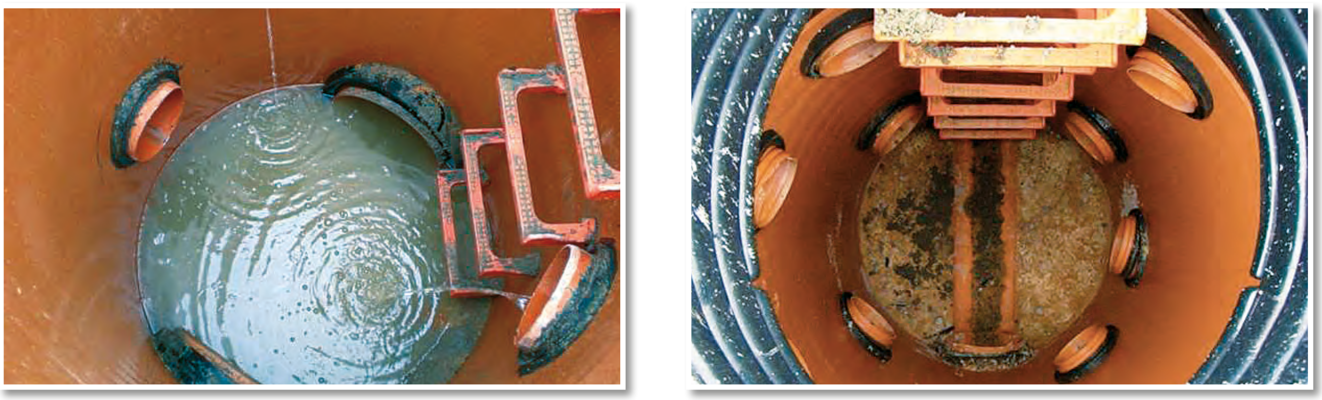
A cutting crown fitted to a hand drill can be used to make holes for up to 250 mm diameter piping. Larger diameters can be prepared using a jig-saw. Even so, the supplied template, which includes the necessary instructions, enables the hole to be easily made. Any imperfections of handmade hole are absorbed by the large depth and the close fitting of the elastomer clip interior channel.

ELASTOMER CLIP.

INSTALLATION.

PIPING INSTALLATION TO THE MANHOLE BODY.

This system enables the piping connections to be made to the manhole body in situ at the exact connection location without any adaptations as required for prefabricated elements.



EXECUTING MULTIPLE CONNECTIONS IN SITU.

Bottom finish with the piping connections to the manhole body

As previously stated, the manhole bottom finish can be accomplished in various ways depending on collector diameter.

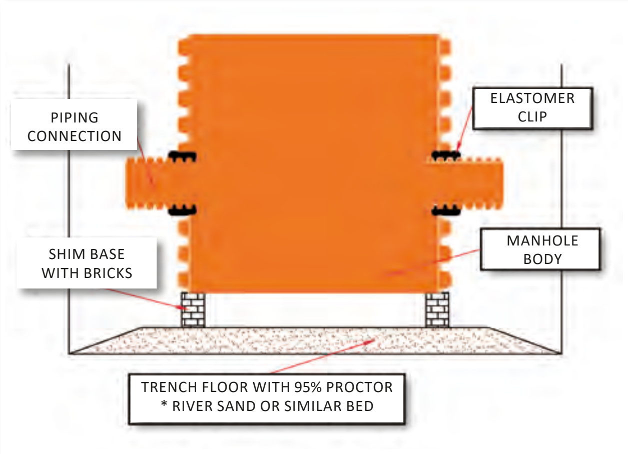
The direct connection to the manhole body using elastomer clips is limited to a maximum collector diameter according to the following table:

Manhole diameter	Maximum colector diameter
600	315
800	400
1.000	500
1.200	600

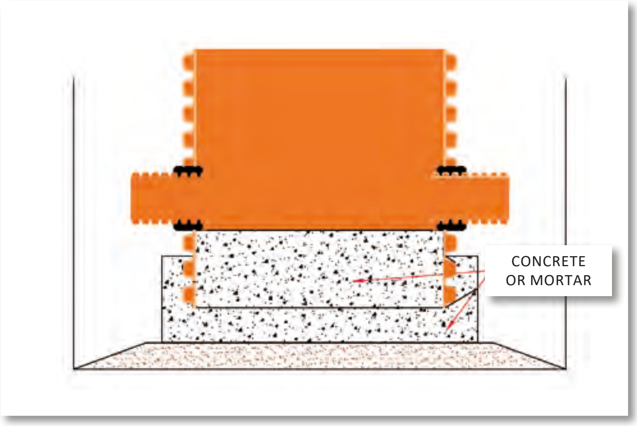
In such cases, which are the most frequent, the manhole bottom is finished using concrete. If there is groundwater presence in the trench, the lower end of the body will be closed off with a PEAD plastic base that incorporates a sealing gasket to prevent water entering at the bottom. There are, therefore, two cases.

1. Although the use of a sealed plastic base is always recommended, if there is no groundwater presence in the trench, the manhole bottom can be constructed using concrete. This requires a floor of dimensions according to the manhole diameter with a depth that permits embedding of the two lower manhole body corrugations and which also leaves a free bottom below this of about 10 cm.

In practice, a frequent procedure is to first execute the manhole connections, leaving it shimmed and then concrete underneath to the required height.



MANHOLE BOTTOM FINISH WITH CONCRETE, FIRST PHASE.



MANHOLE BOTTOM FINISH WITH CONCRETE, SECOND PHASE.

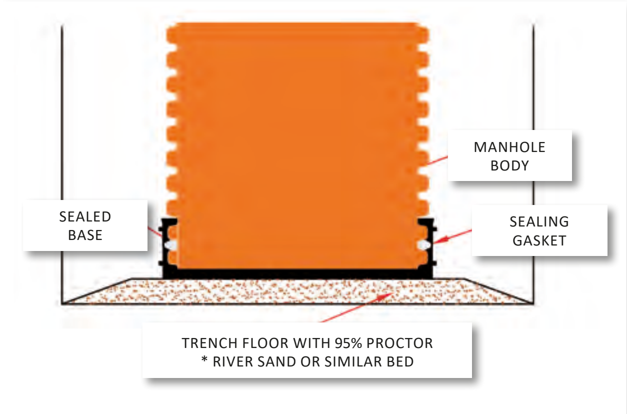
MANHOLE BOTTOM CONCRETING, FIRST PHASE.

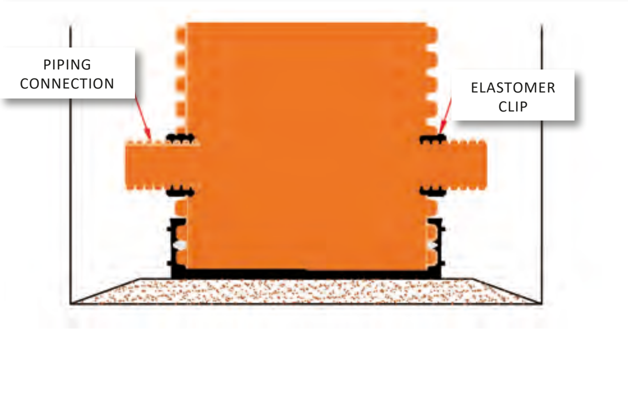
MANHOLE BOTTOM CONCRETING, SECOND PHASE.

2 If the manhole is installed with its plastic base, a lean concrete floor will also be prepared, but this time, only to fix the manhole bottom because sealing is guaranteed by the plastic base that includes a sealing gasket. In this case, the manhole must always be concreted inside up to the lower collector generatrix in order to ballast the manhole against vertical groundwater thrust.

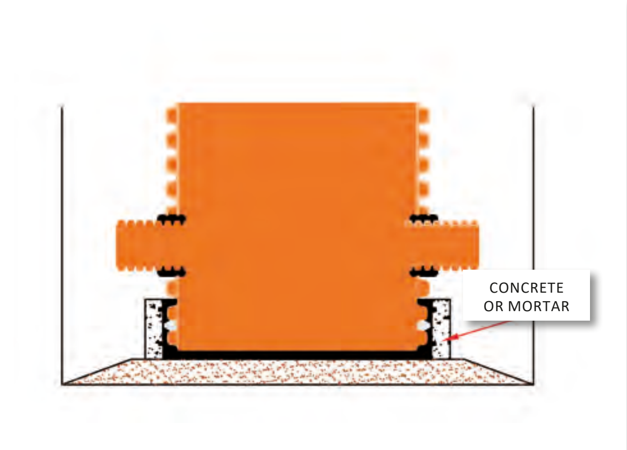
Finally, it is recommended that the interior bottom finish is adequately executed so that there is minimum load loss inside the manhole.

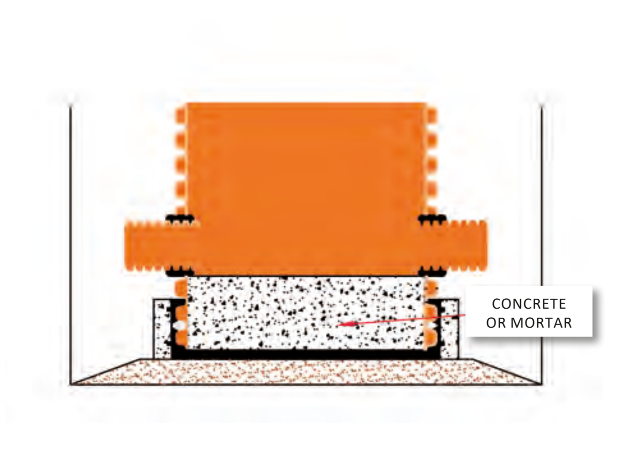
Note No. 1: In manholes where connections are made using elastomeric clips, the nominal height of the manhole roughly corresponds to the total height of the manhole minus the base height in manholes with bases, or to the total height of the manhole minus the concrete slab in baseless manholes. In the latter case, the concrete slab must cover the bottom 2 corrugations, except for the short 600 manholes, where it must cover the bottom 3 corrugations. In any case, in these types of manholes, the nominal height does not align with the water level depth, as this will depend on the positioning of the collector connections. This depth will always be less than the nominal height of the manhole.

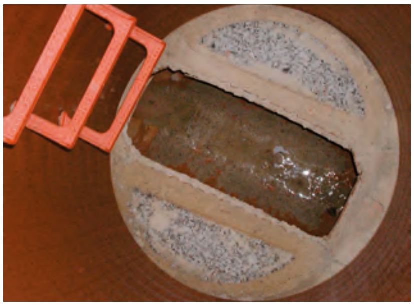




MANHOLE BOTTOM FINISH WITH SEALED BASE.



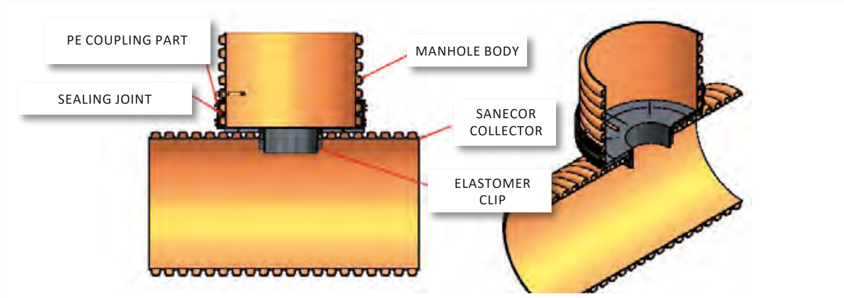


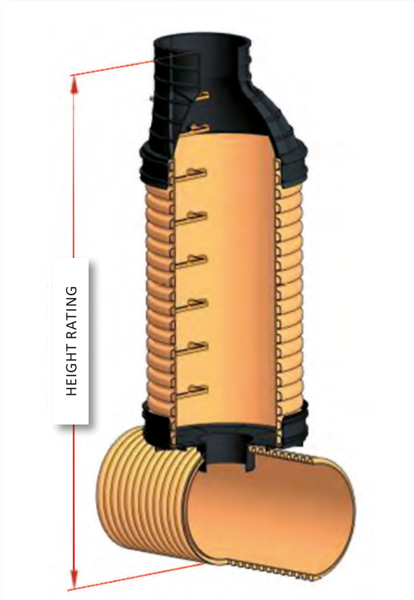


MANHOLE INTERIOR WITH SEALED BASE.

Manhole bottom finish with inspection base

In 1,000 and 1,200 mm diameter manholes, when the collector diameter exceeds 500 and 600 mm respectively, the manhole joint to the collector can be executed using an inspection bottom. The lower manhole end is closed with a base with sealing gasket that is open at the centre, so that there is a concentric aperture that allows the collector to be inspected by its crown. This aperture is finished with a vertical neck that allows connection to the collector via an elastomer clip to ensure full assembly sealing.





Note No. 2: In manholes with a base, the nominal height of the manhole roughly corresponds to the sum of the manhole height above the collector plus the diameter of the collector.

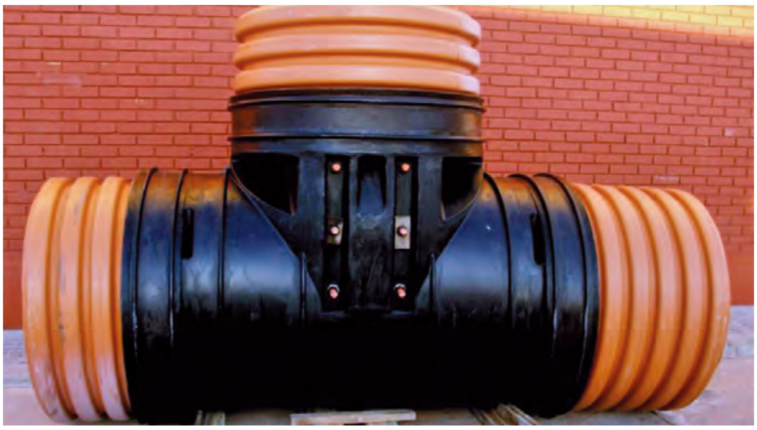
The maximum inspection diameter depends on collector diameter:

Collector diameter	Maximum inspection diameter
600	315
800	400
1.000	500
1.200	600

MANHOLE BODY INSTALLATION WITH INSPECTION BASE.

Manhole bottom finish using a full pass-through connection part

In 1,000 and 1,200 mm diameter manholes, when the collector diameter exceeds 500 and 600 mm respectively, the manhole joint to the collector can be optionally executed with a PEAD “T” part. This has very high rigidity and maintains full-section collector access, which can be inspected via the three plates in the tangential section of the part body.



FULL PASS-THROUGH CONNECTION PARTS.

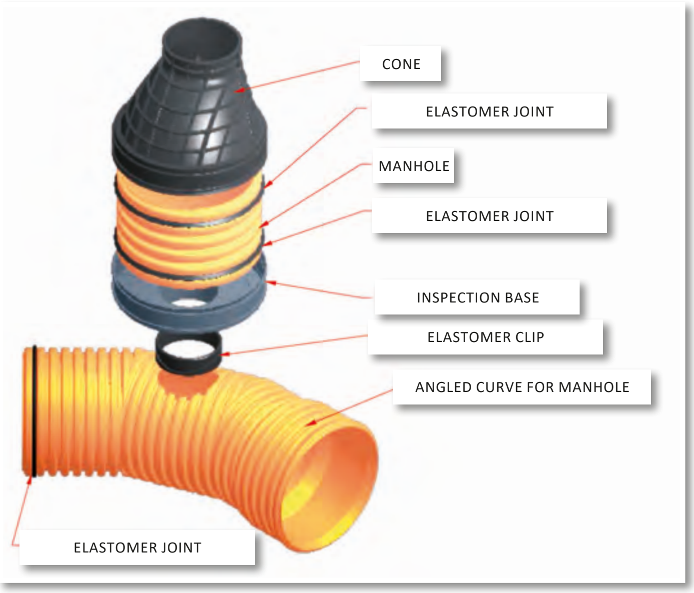
In order to maintain sealing, the connection to the manhole and the two collector ends must be executed using the same gaskets when the pipelines are joined together.

Note No. 3: In manholes with junction pieces, the nominal height of the manhole roughly corresponds to the total height of the manhole.

FULL PASS-THROUGH CONNECTION PART INSTALLATION.

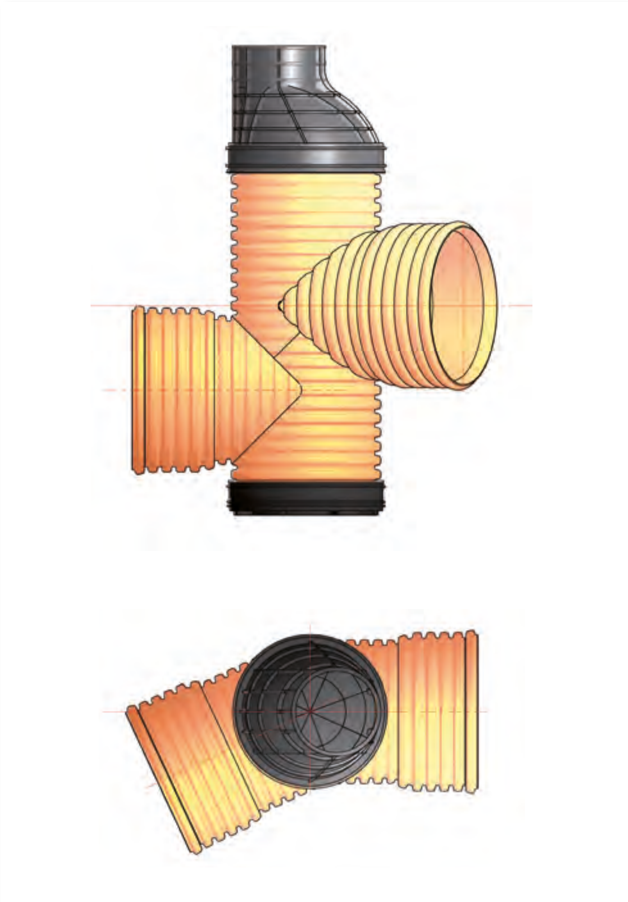
Manholes in collectors with direction change

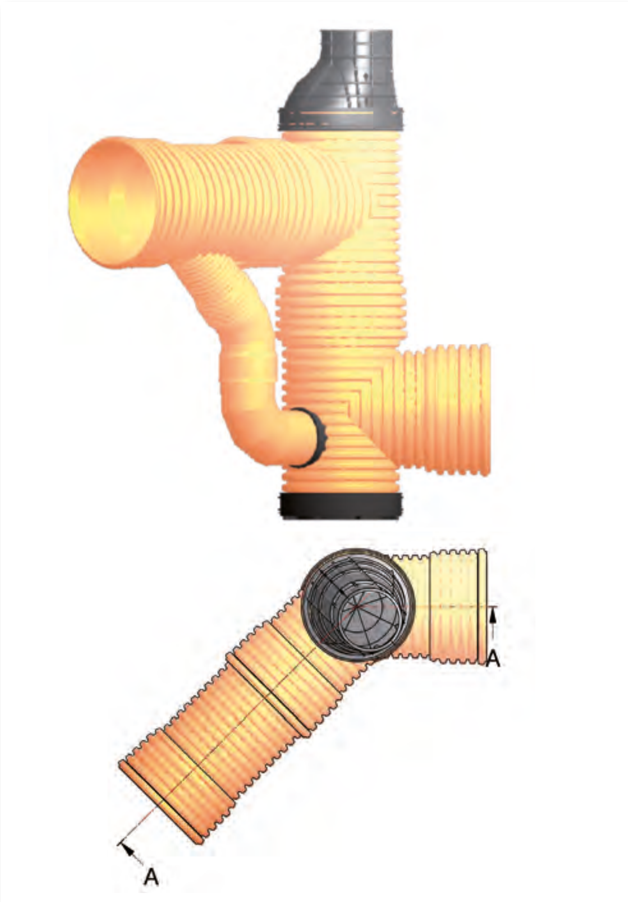
When the collector network route contains direction changes, it is habitual to install inspection manholes at the direction change point. When collector diameter allows direct connection to the manhole body, the installation system for these manholes enables connection execution with necessary angle. When the manhole is installed using an inspection base, the SANECOR® system contemplates large diameter curves in order to position the manhole at the direction change.



MANHOLE INSTALLATION IN COLLECTORS WITH DIRECTION CHANGE.

Lastly, when full pass-through connection parts are required for large diameter collectors, short elbows may be employed at the PEAD connection part ends or welded exits to the manhole body.





MANHOLES IN LARGE DIAMETER COLLECTORS WITH DIRECTION CHANGE.

2.3. SANECOR® manhole finish

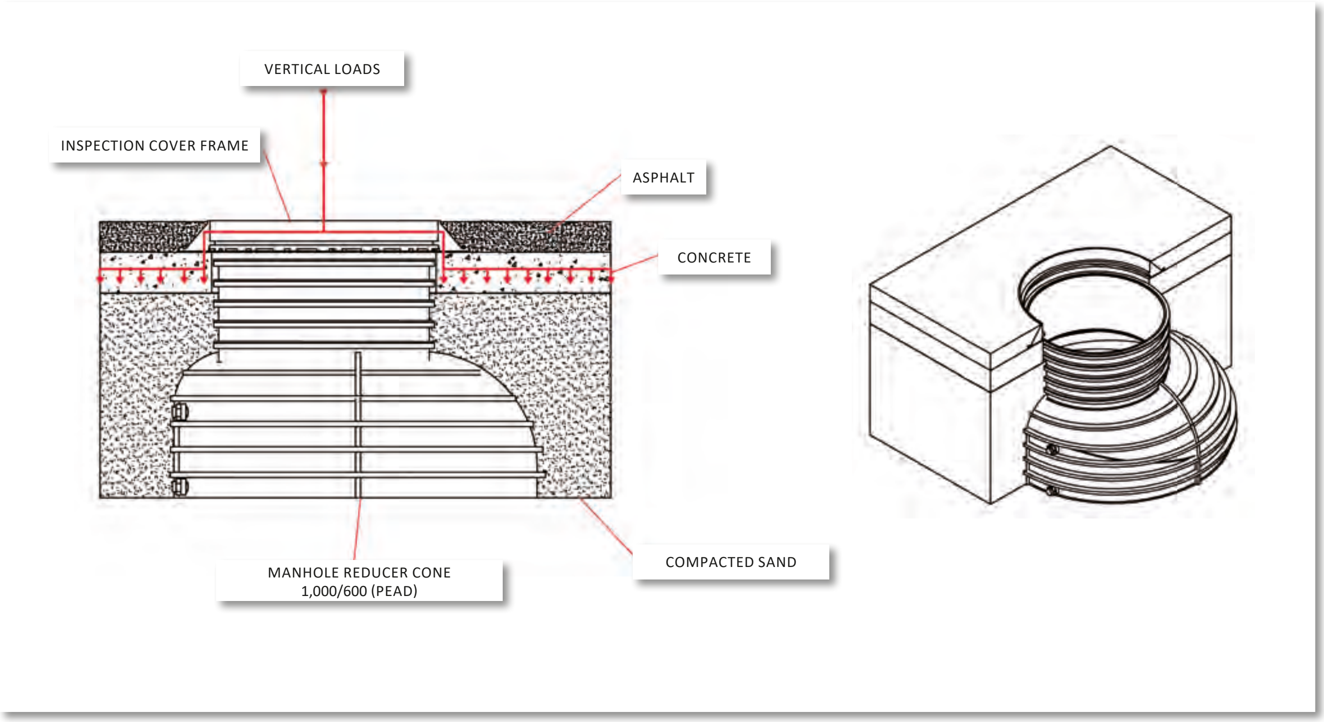
Regarding fill-in and compaction around the manhole, the best idea is to treat it in the same way as the piping, although it is certain that the requirement here is less for the load component, but is still necessary for the fill-in not to contain rocks or stones that could damage the manhole body or cone.

Similarly, in the case of using the sealed plastic base, the trench bottom must be prepared as in the piping case.

With respect to the manhole crown, it has to be considered that the plastic cone must not be directly subjected to vertical loads. If the final surface type remains undecided, a small concrete slab must be executed around the cone mouth, so that it distributes the traffic loads via the inspection cover frame, which would otherwise fall on the manhole vertical. Logically, the frame must not rest on the edge of the plastic cone either. In a heavy traffic situation, it must be taken into account that the cone waste would receive the greatest loads because of its shallow depth. The drawback of these loads being transmitted via a plastic material column is that this same column would suffer vertical displacements that could fracture the agglomerate layer no matter how small they are.

MANHOLE CROWN.

If necessary, the cone height can be adjusted by cutting off part of the upper neck or, if the difference in elevation is very large, corrugations may be removed from the manhole neck (each one measures approximately 10 cm).



INSPECTION MANHOLE CROWN FINISH.

2.4. Cascading manholes

The SANECOR® manhole system also includes the installation of sealed cascading manholes. These elements are employed in situations where the collector route follows very pronounced slopes.

Because in general, the collector must not have slopes exceeding 3º, cascading manholes are used to reduce such slopes.

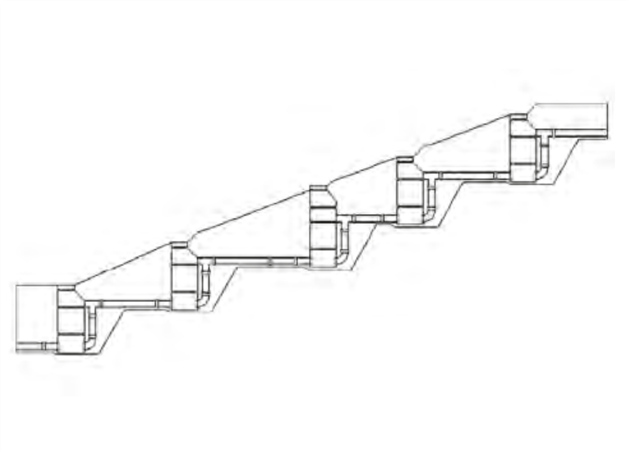
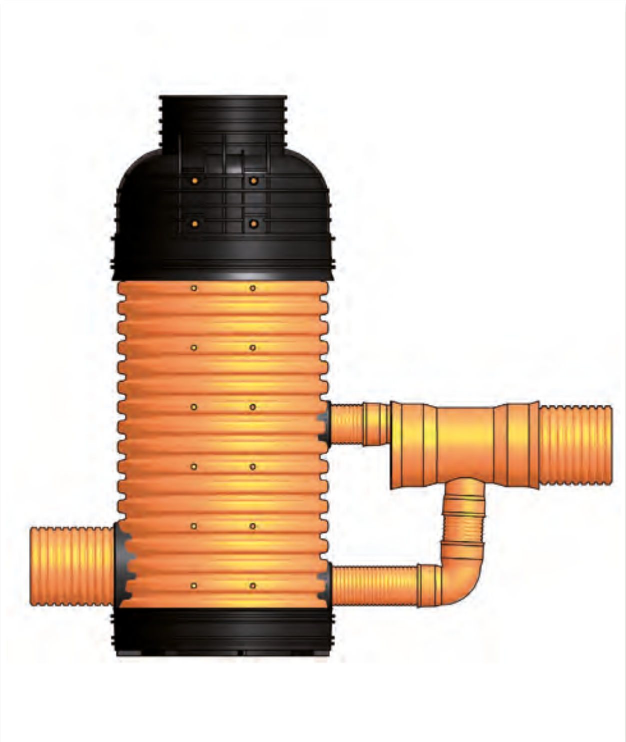


DIAGRAM OF CASCADING MANHOLE ARRANGEMENT.

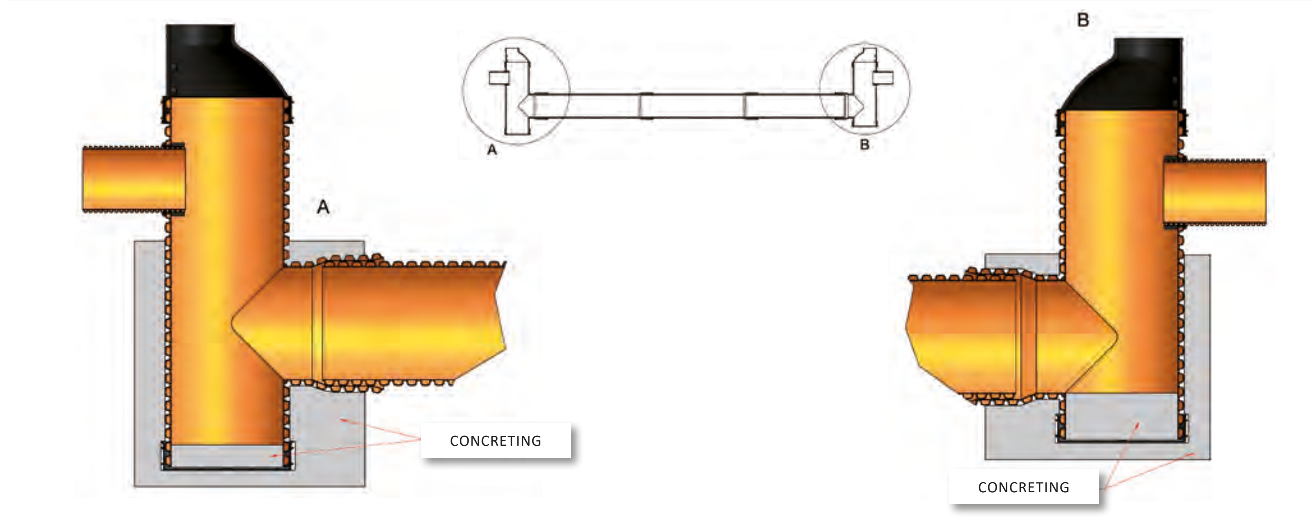


SANECOR® CASCADING MANHOLE.

The following figures show the versatility of the SANECOR® system. The photo below is a cascading manhole used for the Canal de Isabel II when the difference in elevations between the collector inlet and outlet exceeds one metre. The manhole water inlet is diverted towards the base to prevent water falling from above.

CASCADING MANHOLES WITH THE SANECOR® MANHOLE SYSTEM (MADRID TYPE ON THE LEFT).

Cascading manholes are also employed when executing siphons in order to pass obstacles that interfere along the route. These manholes permit siphon inspection.



SANECOR® CASCADING MANHOLES IN SIPHON.

2.5. Special waste boxes and manholes

Waste box connection

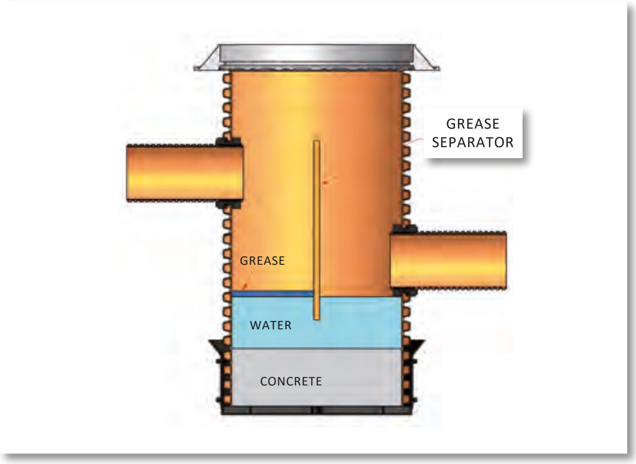
SANECOR® piping includes waste box connection in DN160 and D200 diameters. They are manufactured from high-quality polypropylene and have excellent mechanical strength because of their prismatic central body design that provides a highlyreliable alternative to conventional solutions for these elements.
Sealing is guaranteed by elastic joints that absorb angular soil deviations and settling and they comply with existing standards. The joints are EPDM with PP reinforcement ring in accordance with UNE-681, which ensure full installation sealing. These joints are also dismantable. Moreover, hydraulic capacity is optimised via the 3.5% slope and the internal smoothness of the main channel that prevents sediment accumulation. Its installation can be improved by:

• Having an open lower base that facilitates concrete settling, levelling and penetration during installation.
• Avoiding displacements by the slots in the waste box body section, to be filled and compacted with concrete or sand.
• Having graphic arrow symbology indicating flow direction to prevent incorrect installation.

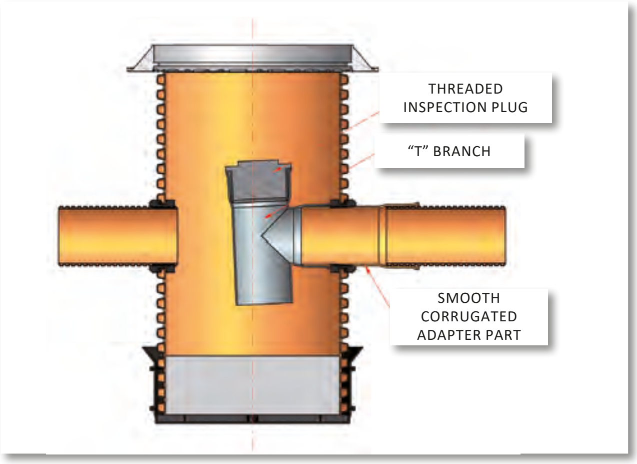
SANECOR® WASTE BOX CONNECTION.

Other applications with SANECOR® waste box and manholes

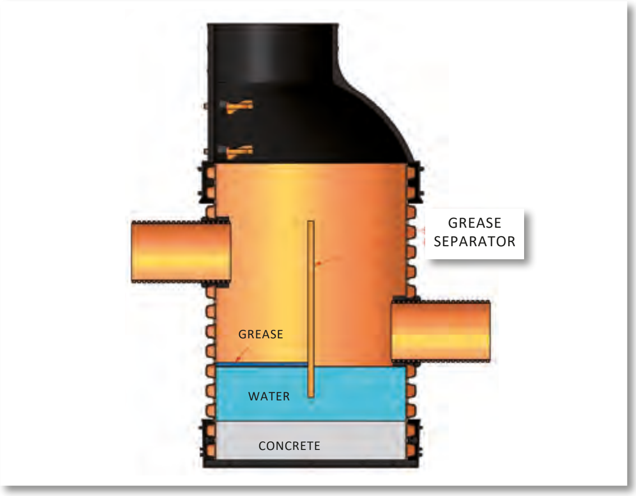
A wide variety of waste boxes and manhole solutions can be executed for various applications with the SANECOR® system. The following figures provide some examples that are self-explanatory.

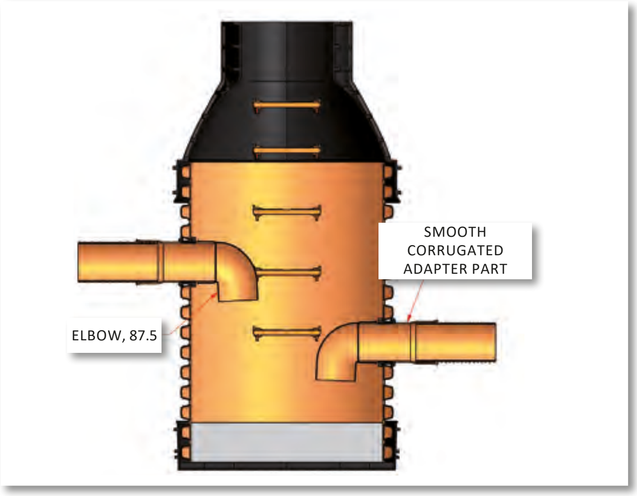


GREASE SEPARATION WASTE BOX.

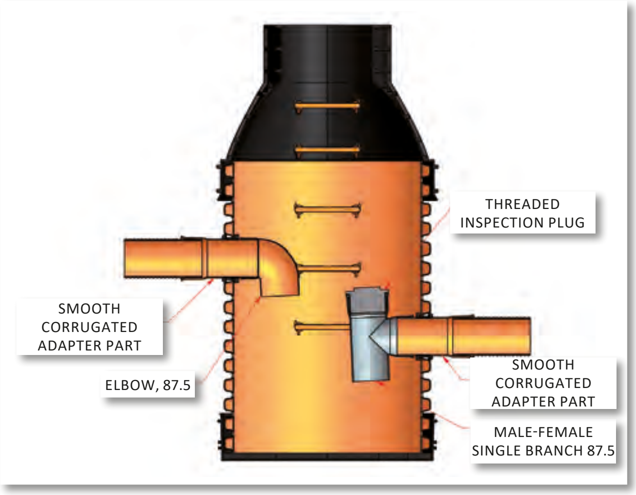


SIPHON WASTE BOX

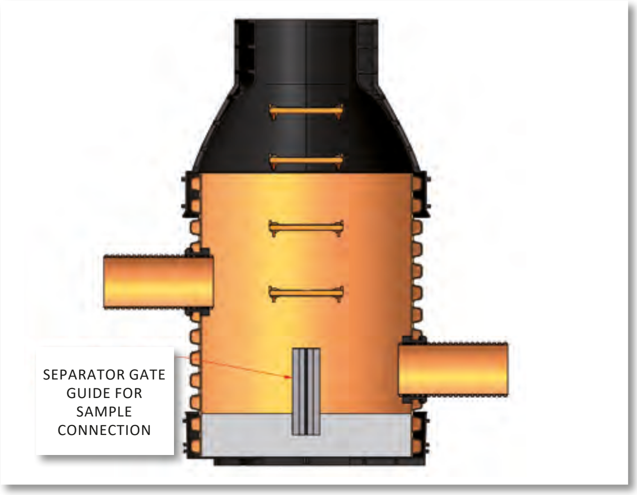




GREASE SEPARATION MANHOLES.



SIPHON MANHOLE WITH GREASE SEPARATOR.



SAMPLING MANHOLE.

3. SANECOR® piping references

SANECOR® corrugated piping has been in production since 1992. Since then it has been employed in thousands of works distributed throughout Spain as well as France and Portugal. Most of them were sewage installations and gravity drainage, for both waste and rain water, although pipelines have also been executed using this solution for nonpressurised agricultural irrigation, mainly in works to convert ditches into buried pipelines.

The installed piping length is almost 50,000 kilometres, 90% of which is installed in Spain. A list of the kilometres of piping installed in each autonomous community with details by province is given below.

SANECOR® PVC corrugated piping references (in kilometres)

		HUESCA	810
MADRID	5.946	TERUEL	625
ALBACETE	937	ZARAGOZA	930
CIUDAD REAL	1.082	ARAGÓN	2.366
CUENCA	693	BARCELONA	1.018
GUADALAJARA	1.564	GIRONA	664
TOLEDO	3.655	LLEIDA	375
CASTILLA-LA MANCHA	7.932	TARRAGONA	424
BADAJOZ	1.050	CATALU—A	2.480
CÁCERES	664	BALEARES	1.158
EXTREMADURA	1.960	ALICANTE	1.312
A CORUÑA	1.144	CASTELLÓN	550
LUGO	286	VALENCIA	2.006
ORENSE	74	COM.VALENCIANA	3.867
PONTEVEDRA	1.518	MURCIA	1.246
GALICIA	3.022	CÁDIZ	2.752
ASTURIAS	627	HUELVA	1.231
CANTABRIA	632	MÁLAGA	1.284
ÁVILA	257	SEVILLA	1.601
BURGOS	401	ALMERÍA	443
LEÓN	1.100	CÓRDOBA	1.541
PALENCIA	430	GRANADA	341
SALAMANCA	960	JAÉN	1.213
SEGOVIA	533	ANDALUCÍA	10.406
SORIA	254	CEUTA	206
VALLADOLID	1.370	MELILLA	66
ZAMORA	182	LAS PALMAS	2.759
CASTILLA-LEÓN	5.487	TENERIFE	156
ÁLAVA	29	CANARIAS	2.916
GUIPÚZCOA	17	**TOTAL NATIONAL**	**50.739**
VIZCAYA	76	PORTUGAL	2.884
PAIS VASCO	122	FRANCE	1.527
NAVARRA	181	REST OF EXPORT	91
RIOJA	119	**TOTAL SANECOR®**	**55.241**

4. Standards and certification

The product standard for SANECOR® corrugated PVC piping is UNE-EN 13476: "Channelling systems in plastic materials for buried non-pressurised evacuation and sewage". SANECOR® piping bears AENOR marking according to Certificate No 001/005573. Furthermore, the production centre holds AENOR Management Quality Certificate UNE-EN ISO 9001, No ER-0440/1996, and Environmental Management UNE-EN ISO 14001, No GA-2001/0255.

AENOR product certificate

AENOR
Confía

Certificado AENOR de Producto

001/007322

AENOR certifica que la organización

MOLECOR CANALIZACIONES S.L.

con domicilio social en	CTRA M-206, S/N 28890 LOECHES (Madrid - España)
suministra	**Tubos de poli (cloruro de vinilo) no plastificado, de pared estructurada para aplicaciones de saneamiento subterráneo sin presión. Superficie interna lisa y externa perfilada.**
conformes con	UNE-EN 13476-1:2018 (EN 13476-1:2018) UNE-EN 13476-3:2019 (EN 13476-3:2018)
Marca comercial	SANECOR
	Más información en el anexo.
Centro de producción	P.I. Alces - AV. de los Vinos, 24 13600 Alcázar de San Juan - Ciudad Real (España)
Esquema de certificación	Para conceder este Certificado, AENOR ha ensayado el producto y ha comprobado el sistema de la calidad aplicado para su elaboración. AENOR realiza estas actividades periódicamente mientras el Certificado no haya sido anulado, según se establece en el Reglamento Particular RP 01.45.
	Este certificado anula y sustituye al 001/007322, de fecha 2021-11-25
Fecha de primera emisión	2021-11-12
Fecha de modificación	2022-12-19
Fecha de expiración	2024-02-17

Rafael GARCÍA MEIRO
Director General

AENOR INTERNACIONAL S.A.U.
Génova, 6. 28004 Madrid. España
Tel. 91 432 60 00.- www.aenor.com

Entidad de certificación de producto acreditada por ENAC con acreditación nº 1/C-PR271

AENOR
Confía

AENOR Product Certificate

001/007322

AENOR certifies that the organization

MOLECOR CANALIZACIONES S.L.

registered office	CTRA M-206, S/N 28890 LOECHES (Madrid - España)
supplies	**Unplasticized polyvinyl chloride (PVC-U) structured-wall pipes for non-pressure underground drainage and sewerage. Smooth inner surface and outer profiled surface.**
in compliance with	UNE-EN 13476-1:2018 (EN 13476-1:2018) UNE-EN 13476-3:2019 (EN 13476-3:2018)
Trademark	SANECOR
	See annex for more information.
Production site	P.I. Alces - AV. de los Vinos, 24 13600 Alcázar de San Juan - Ciudad Real (España)
Certification scheme	In order to grant this Certificate, AENOR has tested the product and has verified the quality system implemented for its manufacture. AENOR performs these tasks periodically while the Certificate has not been cancelled, in accordance with Specific Rules RP 01.45.
	This certificate supersedes 001/007322, dated 2021-11-25
First issued on	2021-11-12
Modified on	2022-12-19
Validity date	2024-02-17

Rafael GARCÍA MEIRO
Chief Executive Officer

AENOR INTERNACIONAL S.A.U.
Génova, 6. 28004 Madrid. España
Tel. 91 432 60 00.- www.aenor.com

Product certification body accredited by ENAC, number 1/C-PR271

CERTIF product certificate

certif Certificado

PRODUTO CERTIFICADO certif

Certificado nº / *Certificate no.* TMP-004/2023

Nome e morada do titular do certificado: *Name and address of certificate holder*	MOLECOR CANALIZACIONES S.L. Carretera M-206 S/N 28890 Loeches (Madrid) Spain
Nome e morada do fabricante: *Manufacturer's name and address*	MOLECOR CANALIZACIONES S.L. Avenida de los Vinos, 24 – Polígono Industrial Alces 13600 Alcazar de San Juan (Ciudad Real) Spain
Produto: *Product*	Tubos de parede estruturada de poli(clorelo) de vinilo não plastificado (PVC-U) para drenagem e saneamento, enterrados, sem pressão. Superfície interior lisa e exterior perfilada. Tipo B *Unplasticized poly(vinyl chloride) (PVC-U) structured-wall pipes for non pressure underground drainage and sewrage. Smooth internal and profiled external surface Type B*
Referências: *Type references.*	Ver anexo / *See annex*
Marca(s) comercial(is): *Trademark(s)*	SANECOR
Características técnicas: *Technical characteristics:*	Ver anexo / *See annex*
Este produto está em conformidade com: *This product is in conformity with*	NP EN 13476-1:2019; NP EN 13476-3:2019
Relatórios de ensaios nº(s) / emitidos por: *Test report(s) no. / issued by*	PLA-0522/20-2; PLA-0522/20-1 / CEIS
Informação adicional (se existir): *Additional information (if any)*	No produto pode ser colocada esta marca ◁Certif▷ *Can be placed on the product the following mark*
Este certificado é válido até: *This certificate is valid until.*	2026-02-23
e substitui o certificado nº: *and supersedes certificate no:*	TMP-001/2022
Data de emissão: *Date of issue*	2023-03-03

Francisco Barroca
Diretor Geral / *General Manager*

Este Certificado é constituido por um Anexo com 1 (uma) página
This Certificate includes one Annex with 1 (one) page

Certif – Associação para a Certificação
Rua José Afonso, 9 E – 2810-237 Almada – Portugal – Tel.: 351. 21 258 69 40 – E-mail: mail@certif.pt

Quality Management System Certificate

AENOR Confía

Certificado del
Sistema de Gestión de la Calidad

AENOR GESTIÓN DE LA CALIDAD

ER-0440/1996

AENOR certifica que la organización

MOLECOR CANALIZACIONES S.L.

dispone de un sistema de gestión de la calidad conforme con la Norma ISO 9001:2015

para las actividades: Detalladas en el anexo al Certificado

que se realizan en: A) CR. NACIONAL II, KM 47,5.. 19208 - ALOVERA (GUADALAJARA)
B) PI DE ANTEQUERA - AV DEL ROMERAL, 15. 29200 - ANTEQUERA (MÁLAGA)
C) PI ALCES - AV DE LOS VINOS, 24. 13600 - ALCÁZAR DE SAN JUAN (CIUDAD REAL)

Fecha de primera emisión: 1996-09-23
Fecha de última emisión: 2021-03-20
Fecha de modificación: 2021-12-13
Fecha de expiración: 2024-03-20

Rafael GARCÍA MEIRO
Director General

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Tel. 91 432 60 00.- www.aenor.com

Original Electrónico

IQNet THE INTERNATIONAL CERTIFICATION NETWORK

CERTIFICATE

AENOR has issued an IQNet recognized certificate that the organization:

MOLECOR CANALIZACIONES S.L.

A) CR. NACIONAL II, KM 47,5.. 19208 - ALOVERA (GUADALAJARA)
B) PI DE ANTEQUERA - AV DEL ROMERAL, 15. 29200 - ANTEQUERA (MÁLAGA)
C) PI ALCES - AV DE LOS VINOS, 24. 13600 - ALCÁZAR DE SAN JUAN (CIUDAD REAL)

has implemented and maintains a

Quality Management System

for the following scope:

SPECIFIED IN ANNEX TO THE CERTIFICATE

which fulfills the requirements of the following standard

ISO 9001:2015

First issued on: **1999-08-01** *Last issued:* **2021-12-13** *Validity date:* **2024-03-20**

This attestation is directly linked to the IQNet Partner's original certificate and shall not be used as a stand-alone document

Registration Number: **ES-0440/1996**

Alex Stoichitoiu
President of IQNet

Rafael GARCÍA MEIRO
Chief Executive Officer

Original Electronic Certificate

IQNet Partners*:
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* The list of IQNet partners is valid at the time of issue of this certificate. Updated information is available under www.iqnet-certification.com

Environmental Management System Certificate

AENOR Confía

Certificado del
Sistema de Gestión Ambiental

AENOR GESTIÓN AMBIENTAL ISO 14001

GA-2001/0255

AENOR certifica que la organización

MOLECOR CANALIZACIONES S.L.

dispone de un sistema de gestión ambiental conforme con la Norma ISO 14001:2015

para las actividades: Detalladas en el anexo al Certificado

que se realiza/n en: A) CR. NACIONAL II, KM 47,5.. 19208 - ALOVERA (GUADALAJARA)
B) PI DE ANTEQUERA - AV DEL ROMERAL, 15. 29200 - ANTEQUERA (MÁLAGA)
C) PI ALCES - AV DE LOS VINOS, 24. 13600 - ALCÁZAR DE SAN JUAN (CIUDAD REAL)

Fecha de primera emisión: 2001-09-19
Fecha de última emisión: 2021-03-20
Fecha de modificación: 2021-12-13
Fecha de expiración: 2024-03-20

Rafael GARCÍA MEIRO
Director General

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Génova, 6. 28004 Madrid. España
Tel. 91 432 60 00.- www.aenor.com

Original Electrónico

IQNet THE INTERNATIONAL CERTIFICATION NETWORK

CERTIFICATE

AENOR has issued an IQNet recognized certificate that the organization:

MOLECOR CANALIZACIONES S.L.

A) CR. NACIONAL II, KM 47,5.. 19208 - ALOVERA (GUADALAJARA)
B) PI DE ANTEQUERA - AV DEL ROMERAL, 15. 29200 - ANTEQUERA (MÁLAGA)
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ISO 14001:2015

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Registration Number: **ES-2001/0255**

Alex Stoichitoiu
President of IQNet

Rafael GARCÍA MEIRO
Chief Executive Officer

IQNet Partners*:
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Smart water

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

AENOR GESTIÓN AMBIENTAL ISO 14001 GA-2001/0255

IQNET RECOGNIZED CERTIFICATION

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