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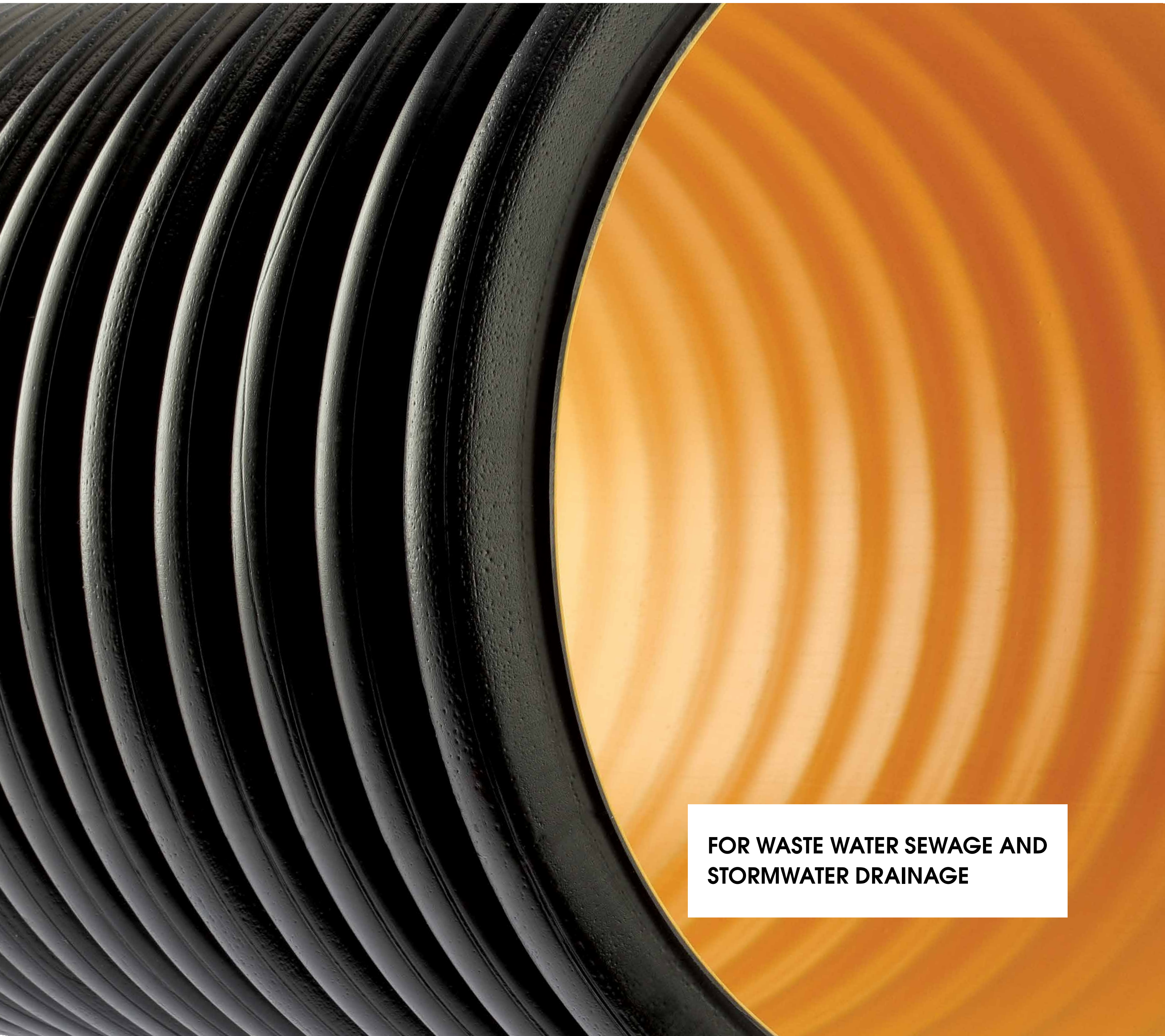
forever safe

GEOSAN® 2nd generation

Double structured wall
plastic pipes



FOR WASTE WATER SEWAGE AND STORMWATER DRAINAGE

GEOSAN® 2nd generation

maximum protection and higher watertightness with the most secure type of connection

GEOSAN® 2nd generation double structured wall pipes incorporate the most modern and secure connection method that exists in the field of waste water sewage for non - pressure networks.

The pipe is formed at its ends during the production process. The female end carries an elastomeric sealing ring at its inner wall while the male end comes with a smooth wall and a smaller outer diameter in order, when connecting each other, to achieve a secure connection and the necessary water tightness according to the requirements of the European Standard EN 1277.

Taking care of public health with techno-economic, ecological and modern pipe systems

waste water sewage

Waste water sewage and stormwater drainage is one of the most important infrastructure projects for an urban area, as it directly affects its citizens' health and quality of life.

The absence or incorrect installation of a sewage network may lead to the pollution of the subsoil and, by extension, to the contamination of the aquifer. Similarly, an incomplete stormwater drainage network may constitute a cause for overflow of the ground, floods, currents and similar effects.

Collection of waste water and stormwater is implemented using pipes that are installed underground. Their construction specifications are very strict and demanding, covering lifetime, resistance to mechanical and chemical corrosion, leak-tightness, ease of use, hydraulic performance, etc.

For over 100 years the materials used for their production were clay, concrete and asbestos, until the emergence of plastic pipes made of polyvinyl chloride (PVC) with a smooth compact wall; with certain key advantages, such as leak-tightness and chemical resistance, they were an "honest" solution for the specific application field.

However certain problems, such as weight, installation time, material sensitivity, large environmental footprint, etc., still remained and in an attempt to evolve the product and relieve the environment, **double structured wall plastic pipes** were developed; these pipes are now the latest technology in the sewage sector.

Double structured wall plastic pipes have been produced in Europe for the last 25 years using constantly evolving production materials such as polyethylene (PE); they have impressive advantages over traditional sewage systems made of PVC and are the most reliable and sustainable solution for the most demanding fields of application.

double structured wall pipes

- small environmental footprint
- intelligent design
- very high performance

Collection, transport, treatment and disposal of wastewater from the Koropi-Peania areas, Perfecture of Attica

reasons to use double structured wall plastic pipes

What are the key advantages of double structured wall pipes versus traditional sewage systems made of PVC or cement?

The following table illustrates the performance of sewage pipes made of HDPE or, PVC and cement in relation to a number of key characteristics:

Characteristics	Cement	PVC	HDPE
Environmental friendliness	Low	Low	Excellent
Mechanical strengths	Excellent	Medium	Excellent
Weight	Low	Medium	Excellent
Ease of transport	Low	Medium	Excellent
Installation time	Low	Medium	Excellent
Resistance to deformation	Low	Low	Excellent
Material flexibility	Low	Medium	Excellent
Connectivity	Low	Excellent	Excellent
Dimensions	Excellent	Medium	Excellent
Ease of cutting	Low	Excellent	Excellent
Resistance to abrasion	Low	Medium	Excellent
Chemical resistance	Low	Medium	Excellent
Reliability	Medium	Medium	Excellent
Transport	Low	Medium	Excellent
Material cost	Low	Low	Excellent

NOTE: The above are valid for non-structured wall PVC pipes

The increased weight of a cement pipe poses increased difficulties during installation and may also lead to serious injuries in case of an accident.

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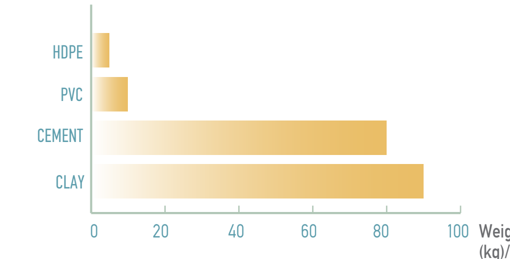
lighter

50% lighter than their PVC counterparts
5% of the total weight of their cement counterparts

The special geometry of the double wall plastic pipe requires the use of less material, while not affecting its mechanical strengths. This results in a much lower weight that facilitates transport and installation of the pipes and reduces relevant costs.

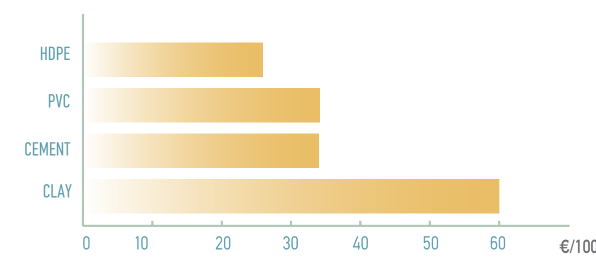


map 1

more cost-effective

up to **40%** in material costs in comparison to pipes made of PVC or CEMENT

The reduction in costs and installation time is huge, taking into account that material costs are much lower, and that the low weight, ease of transport and tool-free assembly ensure a quick and safe installation!

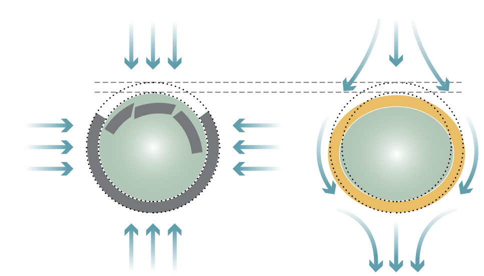


Purchase cost for 1500m of sewage pipes with an internal diameter of ID300 and an SN4 ring stiffness rating

map 2

timeless

Structured wall plastic pipes are much stronger due to their flexibility and their shape memory ability. Specifically they absorb potential ground movements, while traditional rigid pipes made of PVC or cement cannot compensate for ground movements, resulting in cracks.



PVC pipes / Cement | HDPE pipes

100% environmentally friendly

HDPE plastic pipes do not contain halogen substances, are fully recyclable and have a very small environmental footprint.

NOTE 1
The weights illustrated in Figure 1 are approximate and refer to sewage pipes with an internal diameter of ID300 and SN8 ring stiffness.

NOTE 2
Prices shown in Figure 2 come from the Table of uniform pricelists for hydraulic projects which is included in the published Official Government Gazette issue 363B dated **19.02.2013.**

HDPE

SN4, SN8

OD160 to OD630

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GEOSAN® 2nd generation sewage pipes

Checked and certified according to EN 13476-3:2018 by Bureau Veritas

The new GEOSAN® pipes are double structured wall pipes, corrugated on the outside, in black RAL 9004 color, and smooth inside, in yellow RAL 1017 color. They are produced according to the European standard EN 13476-3:2007+A1:2009 (type B) from specially stabilized raw materials of high density polyethylene (HDPE) and are classified as SN4 and SN8 according to their ring stiffness. They are available in 6m straight bars they are formed at their ends during the production process, incorporating the most modern and secure connection method that exists in the field of waste water sewage for non - pressure networks. (see p. 15)

FIELDS OF APPLICATION

They are intended for waste water collection in sewage networks as well as for the drainage of stormwater in road networks. They are also suitable for a multitude of free-flow sewage applications, such as in airports, tunnels, parking spaces, structural projects etc.

TECHNICAL CHARACTERISTICS OF GEOSAN® PIPES

Properties	Measurement method	HDPE
Material characteristics		
Modulus of Elasticity		≥800 MPa
Average Density	EN ISO 1183-1	≈940 Kg/m3
Melt mass-flow rate	EN ISO 1133:2005	≤1,6 g/10min
Resistance to heating (oven test)	EN ISO 12091	(110±2)^{0}C
Heat capacity		≈2300-2900 Jkg-1K-1
Thermal conductivity		≈0.36-0.50 Wk-1m-1
Surface drag		>1013 Ω
Pipe's mechanical strength		
Ring Stiffness	EN ISO 9969	SN4, SN8
Impact resistance	EN 744	TIR≤10%
Ring Flexibility	EN ISO 13968	RF30 (30%)
Creep Ratio	EN ISO 9967	≤ 4 at 2 years extrapolation
Water Tightness	EN 1277	No leakage

decisive advantages of pipes GEOSAN® 2nd generation

GEOSAN® double structured wall plastic pipes are manufactured and tested according to the European standard EN 13476-3:2007+A1:2009 and certified by the accredited international certification body Bureau Veritas.

Some of their main characteristics are analyzed below:

MATERIAL

Polyethylene (PE) are among the best known thermoplastic materials used in the production of sewage and drainage pipes. They have an unusually high resistance to chemicals and acids, exceptional mechanical strengths against impact and very high resistance to abrasion. They are 100% environmentally friendly, fully recyclable, with a small environmental footprint and have a lifetime of at least 50 years.

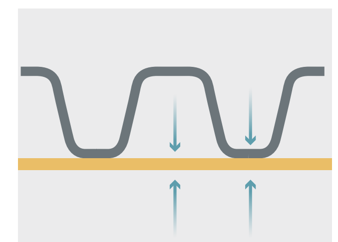
GEOSAN® 2nd generation pipes are manufactured from specially stabilized polymers:

- High-density polyethylene (HDPE)

RING STIFFNESS

The pipes' resistance to external loads is very important and the heavy and intense loading caused in applications such as highways must be compensated without causing any damage.

Due to the double structured walls and their specially stabilized raw material, GEOSAN® 2nd generation pipes achieve exceptional ring stiffness, covering alternative fields of application.



PROPERTIES

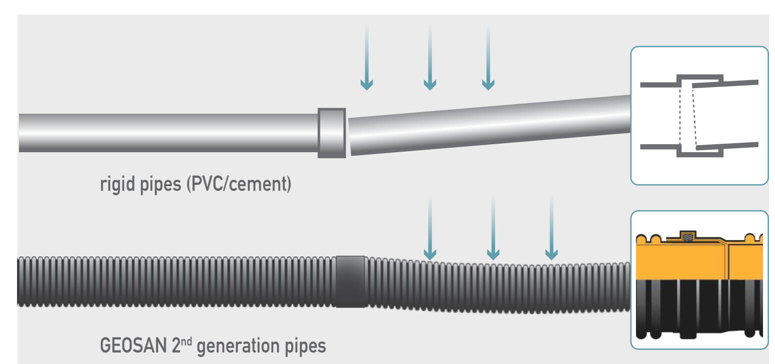
Ring stiffness	SN4 (Equivalent with 4 kN/m²) SN8 (Equivalent with 8 kN/m²)
Control Standard	EN ISO 9969

RING FLEXIBILITY

Pipe flexibility is important for the homogeneous absorption of static and dynamic loads generated, as well as the absorption of potential ground movements (e.g. earthquake).

The high flexibility of HDPE ensures that GEOSAN® 2nd generation pipes will remain flexible as long as necessary, withstanding long-term pressure without acquiring permanent deformations.

The accompanying diagram shows how a structured wall pipe remains flexible, absorbing all pressures from the ground, in contrast with a rigid pipe (e.g. made of concrete) which, due to its structure, cannot compensate for these forces.



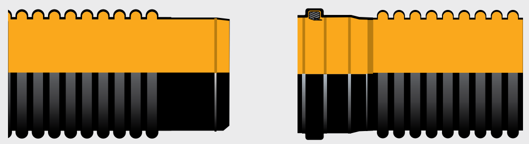
PROPERTIES

Ring flexibility	RF 30
Control Standard	EN ISO 13968

GEOSAN® 2nd generation

NEW CONNECTION METHODS

GEOSAN® 2nd generation pipes are manufactured as straight bars with a length of 6m (±10cm) in a variety of dimensions. There are four discrete connection methods:

a	 An integrated molded socket with a pre-installed elastomeric sealing ring at the end of the pipe is connected with the other, of a smaller outer diameter, molded end.	OD200 - OD630
b	 With the use of a separate coupler (socket)	OD160 - OD630

NOTE: The use of an elastomeric ring is required in all cases.

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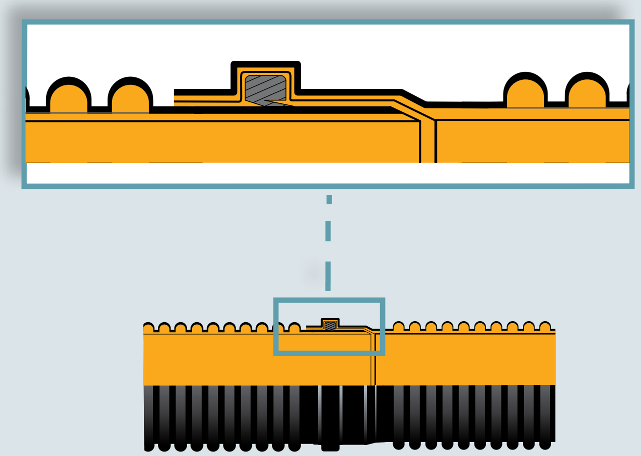
ADVANTAGES OF NEW CONNECTION METHOD

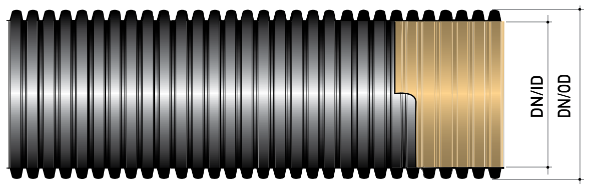
- Significant reduction of installation time since the elastomeric sealing ring is pre-installed at the inner wall of the female end.
- Much better water tightness due to the smooth design that both ends (male & female) have.
- Termination at the water tightness problems that have been arisen from the incorrect placement of the elastomeric sealing ring (wrong direction) of the first-generation pipes.



DIMENSIONS

GEOSAN® 2nd generation pipes are classified according to their nominal diameter (outside or inside), ring stiffness (SN4, SN8) and manufacturing material (HDPE).

The table below summarizes the entire range of GEOSAN® 2nd generation pipes:

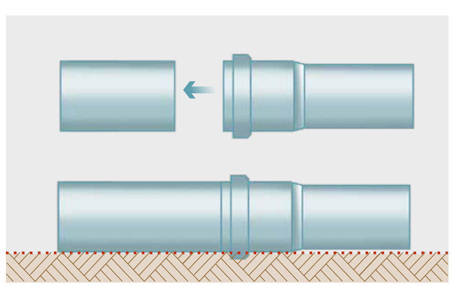


DN/OD	**160**	**200**	220	**250**	275	**315**	332	**400**	441	**500**	551	**630**	651
DN/ID	137	178	**200**	223	**250**	278	**300**	347	**400**	438	**500**	542	**600**
SN4|HDPE	•	•	-	•	-	•	-	•	-	•	-	•	-
SN8|HDPE	•	•	-	•	-	•	-	•	-	•	-	•	-

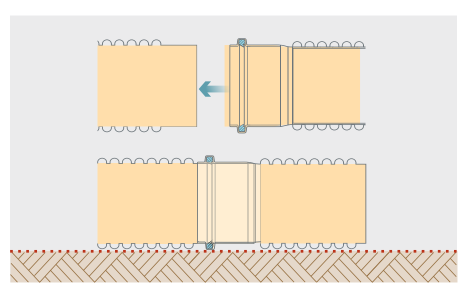
CONNECTION TECHNOLOGY

In PVC pipes with non-structured walls, the connector (coupler) is formed at the end of the pipe, after manufacturing, which results in the connector's outside diameter being different to the diameter of the rest of the pipe. As a consequence, when laying the pipe, inclinations are created at the points of connection which require additional works (local excavations) in order to be dealt with.

On the contrary, the connection technology of GEOSAN 2nd generation pipes does not create inclinations and ensures a uniform outside diameter along the whole sewage network. This is due to the special geometry of both ends formed during the pipes' production. The connector (coupler) is formed on one end and on the other end the corresponding male part is formed with a smaller diameter than the rest of the pipe, so that it can be connected more easily and safely without any local consequences on its laying.



Conventional PVC pipes



GEOSAN 2nd generation pipes

CHEMICAL RESISTANCE

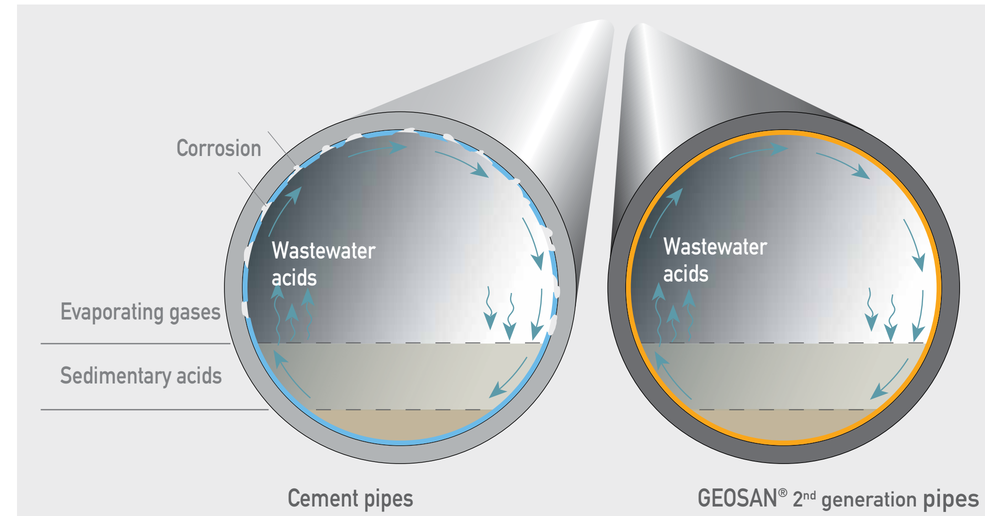
A common wear effect observed in traditional pipe systems (e.g. cement pipes) is the corrosion caused by toxic gases which evaporate from the waste water inside the pipes. This wear corrodes the pipe's inside walls and reduces its strengths, and consequently its hydraulic performance.

ISO 10358

GEOSAN® 2nd generation pipes are manufactured from plastic materials of an exceptional molecular structure which achieve exceptional resistance to diluted acids (pH<2), alkaline solutions (pH>12) and mold.

GOOD PRACTICES

In all cases, the project design should ensure adequate ventilation along the pipes to avoid anaerobic decomposition conditions.



Evaporating gases: Hydrogen sulphide (H_2S) which emerges from the waste water within the pipes gets oxidized in the presence of moisture ($H_2S + O_2$), turns into sulphuric acid (H_2SO_4) and essentially causes corrosion of the roof of the pipes.

Cement pipes are very vulnerable to chemical attacks and specifically to sulphuric acid, therefore a lot of wear is observed as time passes !

IMPACT STRENGTH

Impact strength may appear unnecessary, judging from the actual installation location of sewage/drainage pipes. However there are many cases where the pipe may get damaged, for example from earthquakes, intrusion by tree roots, as well as during the loading/unloading process when sharp objects or bad practices may cause damage.

PROPERTIES
Certification Standard **EN 744**

The specially stabilized manufacturing materials of GEOSAN® 2nd generation pipes, combined with their special geometry and resistance in low temperatures, achieve exceptional impact strength and therefore reduce the probability of cracks and damages.

PVC pipes are more fragile and sensitive to potential knocks, due to the high levels of calcium carbonate used during their manufacturing process for cost reduction purposes.

CLEANING AND INSPECTION

Diagnostic checks, maintenance and cleaning are regular tasks that are absolutely necessary and mandatory for a sewage or drainage network, so that it does not degrade and its hydraulic performance is protected.

A light yellow color RAL 1017 (saffron yellow) was selected for the inside of GEOSAN® 2nd generation pipes in order to facilitate as much as possible the work of the sewage network cleaning and inspection crews.

The light color inside GEOSAN® pipes will facilitate network diagnostic checks through video.

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INGRESS PROTECTION

Ingress protection in all potential pipe connections is one of the most important issues that need to be ensured in order for the network to achieve duration and performance. Checks using the strict European standard EN 1277 are imperative.The new connection method of GEOSAN 2nd generation pipes ensures the maximum ingress protection (see advantages of new connection method page 15)

The special sealing elastomeric rings (EPDM), in combination with the geometry of the external wall of **GEOSAN®** 2nd generation pipes, fulfill EN1277 by ensuring permanent leak-tightness, prevent the outflow and inflow of liquids, thus protecting the network system, and also cover potential errors during connection or burying.

The use of a lubricant before each connection is deemed necessary.
(refer to page 43 for instructions on pipe connection)

EN 1277

PROPERTIES
Certification Standard **EN 681-1**

IN HARMONY WITH THE ENVIRONMENT

Yet another important factor in the assessment of a sewage network is its environmental footprint. Materials that do not pollute the environment and cover the required specifications are a key priority in any modern structural project.

GREEN PRODUCT KOUVIDIS

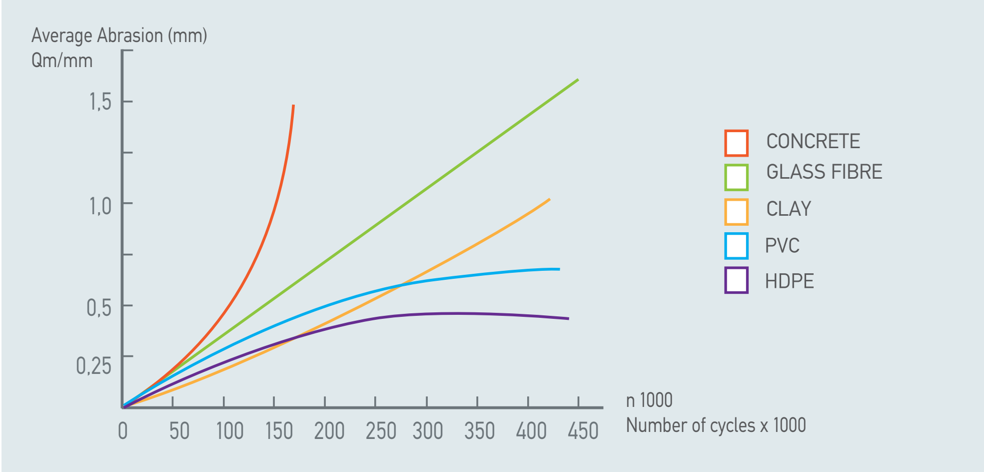
GEOSAN® 2nd generation pipes fully satisfy the European REACH Regulation and the European RoHS Directive on the use of chemical and hazardous substances respectively. They are produced in highly energy-efficient automated production lines using 100% recyclable plastic raw materials and at the end of their life cycle they can be recycled without adverse effects for the environment.

special characteristics

RESISTANCE TO ABRASION

The accumulation of debris or unclean materials inside the pipes may prevent the smooth flow of waste water due to attrition wear. Polyethylene and polypropylene's abrasion resistance is far superior to that of traditional systems, thus preventing their corrosion.

GEOSAN® 2nd generation pipes have an excellent abrasion behavior versus traditional cement or PVC pipes, thus preventing the depositing of dirty materials (fat, salts, etc.) in their smooth internal wall.



According to the EN 295-3 standard and the Darmstadt method developed by the Darmstadt Institute of Hydraulic Engineering and Hydrology, Germany, the abrasion resistance of pipes is shown in the accompanying diagram. This particular test simulates a natural lifetime of 100 years.

RESISTANCE TO SOLAR RADIATION

The large surfaces of sewage pipes and their field of application (infrastructure projects) may require their constant exposure to solar radiation (UV). Resistance to ageing may sound unreasonable but is deemed necessary.

GEOSAN® 2nd generation pipes have an increased resistance to solar radiation for at least 24 months, thanks to the black colored material from which their outside wall is produced, which is stabilized against solar radiation.

For longer exposure periods it is recommended to protect the pipes by storing them in a shaded area.

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GEOSAN® PE 2nd generation

Double structured HDPE wall pipes for wastewater sewage & stormwater drainage.

GEOSAN® PE

13,6 m

DN/OD mm	ID mm	Packaging bars (m)	Packaging bundles (m)	Truck (m)	SN 4 Part No	SN 8 Part No
160	137	6.00	210.0	2520	1615160	1605160
200	178	6.02	120.4	1806	6220200	6200200
250	223	6.00	72.00	960.00	6220250	6200250
315	278	5.98	71.76	574.08	6220315	6200315
400	347	5.94	53.46	427.68	6220400	6200400
500	438	5.93	23.72	237.20	6220500	6200500
630	542	5.90	29.50	188.80	6220630	6200630

NOTE 1: Diameter OD160, SN4 & SN8, is only available with an assembled separated molded coupler and an elastomeric sealing ring.
NOTE 2: Diameters OD200 & OD250, SN4 & SN8, are also available with assembled separated couplers and an elastomeric sealing ring. The reference part numbers are 1615200, 1615250 and 1605200, 1605250 for SN4 and SN8 respectively.

PROPERTIES

Certification Standard	EN 13476-3
Ring stiffness	SN4 SN8
Raw material	HDPE

Dout OD160-630

Outer layer	RAL 9004
Inner layer	RAL 1017

BUREAU VERITAS Certificate 756/005

MOLDED FITTINGS FOR GEOSAN® PE 2nd generation pipes

Connection couplers

Matching Pipe (DN)	Part No
OD160	6103016
OD200	6103017
OD250	6103018
OD315	6103003
OD400	6103004
OD500	6103005
OD630	6103006

Repair couplers

Matching Pipe (DN)	Part No
OD160	6114000
OD200	6114001
OD250	6114002
OD315	6114003
OD400	6114004
OD500	6114005
OD630	6114006

Elastomeric sealing ring

NOTE: This specific elastomeric sealing ring is necessary for the following fittings: Connection Couplers, Bends, Branch 45° and Tee Branch 90° when those connected with the free, without any formation, end of the pipe.

Matching Pipe (DN)	Part No
OD160	6104025
OD200	6104036
OD250	6104037
OD315	6104038
OD400	6104039
OD500	6104040
OD630	6104041

Elastomeric sealing ring for female end

NOTE: This specific elastomeric sealing ring is for the inner wall of the molded female end of the pipe.

Matching Pipe (DN)	Part No
OD200	6104030
OD250	6104031
OD315	6104032
OD400	6104033
OD500	6104034
OD630	6104035

ATTENTION: The pipes are produced and offered with the current elastomeric sealing ring (pre-installed).

Bends 45°

DN/OD mm	Part No
OD160	6105000
OD200	6105001
OD250	6105002
OD315	6105003
OD400	6105004
OD500	6105005

Bends 90°

DN/OD mm	Part No
OD160	6106000
OD200	6106001
OD250	6106002
OD315	6106003
OD400	6106004
OD500	6106005

Branch 45⁰

DN/OD mm	Part No
OD160	6107000
OD200	6107001
OD250	6107002
OD315	6107003
OD400	6107004

Tee Branch 90⁰

DN/OD mm	Part No
OD160	6108000
OD200	6108001
OD250	6108002
OD315	6108003
OD400	6108004

Male end caps

DN/OD mm	Part No
OD160	6111000
OD200	6111001
OD250	6111002
OD315	6111003
OD400	6111004
OD500	6111005
OD630	6111006

NOTE: Male caps are placed at the female end of the pipe.

Female end caps

DN/OD mm	Part No
OD160	6112000
OD200	6112001
OD250	6112002
OD315	6112003
OD400	6112004
OD500	6112005
OD630	6112006

NOTE: Female caps are placed at the male end of the pipe.

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Reducing Branch 45°

DN mm	Part No
OD160/200	6120000

Drilling Crown

Diameter hole (mm)	Part No
127 mm	6000017
170 mm	6000023
177 mm	6000018
208 mm	6000019
263 mm	6000020
320 mm	6000021
412 mm	6000022

Lateral connector (saddle)

Main sewer DN/OD	Branch Pipe DN/OD	Drill hole (mm)	Part No
250/315/400	110	127	6109000
630/800/1000	110	127	6109001
300/400/500	160	177	6109002
250/315	160	170	6109011
400	160	170	6109012
630/800/1000	160	177	6109003
315	200	208	6109004
400/500	200	208	6109005
630/800/1000	200	208	6109006
400/500	250	263	6109007
630/800/1000	250	263	6109008
630/800/1000	315	320	6109009
1000/1200	400	412	6109010

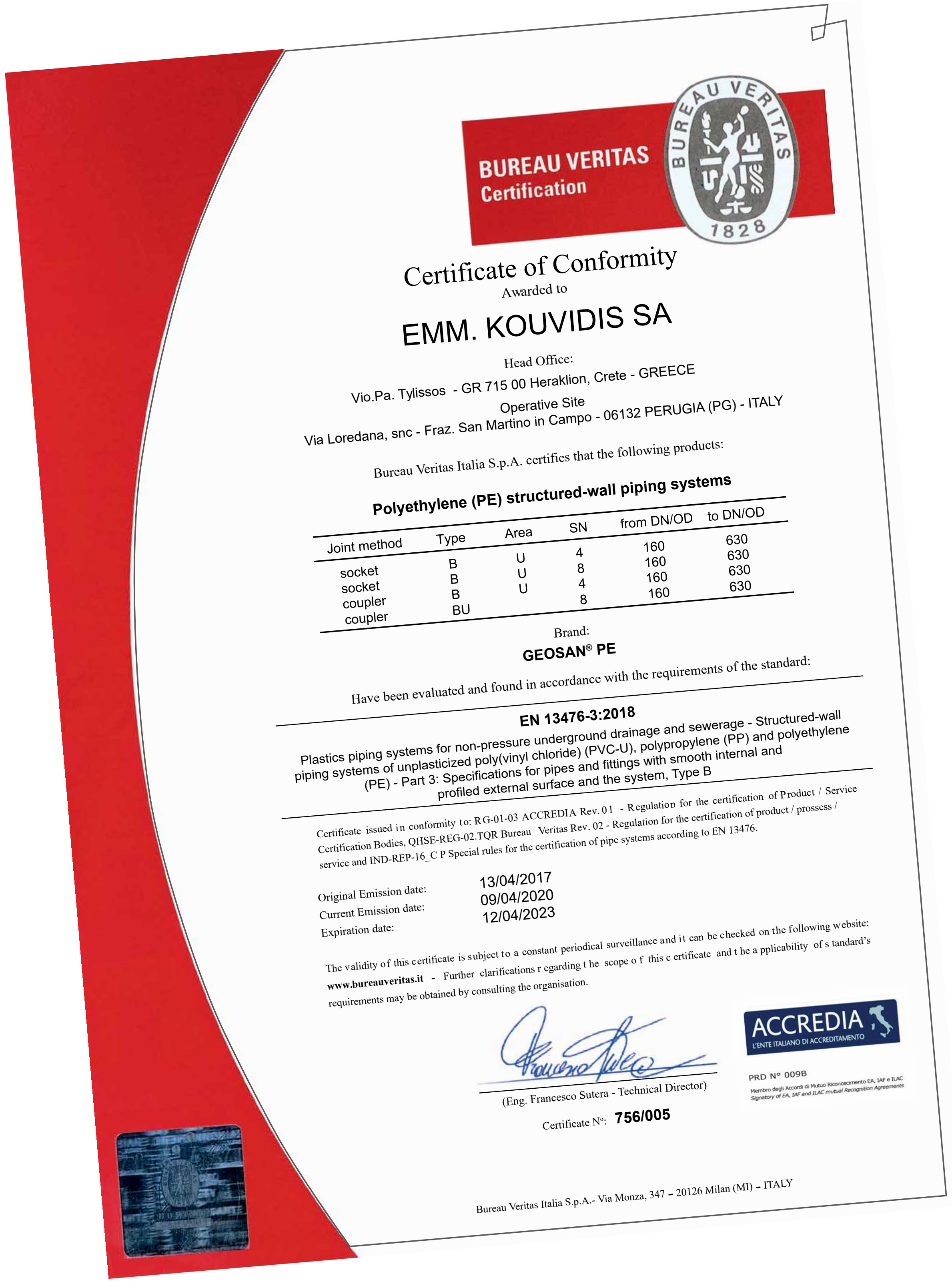
Ο κωδικός 6109002 αφορά κεντρικό αγωγό εσωτερικής διαμέτρου (ID).

KOUVIDIS Lubricant for connection of pipes & fittings

Packaging	Part No
5 kg	6001005

KOUVIDIS adhesive & sealant

Packaging	Part No
6x310 ml	6001004



BUREAU VERITAS
Certification
BUREAU VERITAS 1828

Certificate of Conformity

Awarded to

EMM. KOUVIDIS SA

Head Office:
Vio.Pa. Tylissos - GR 715 00 Heraklion, Crete - GREECE

Operative Site
Via Loredana, snc - Fraz. San Martino in Campo - 06132 PERUGIA (PG) - ITALY

Bureau Veritas Italia S.p.A. certifies that the following products:

Polyethylene (PE) structured-wall piping systems

Joint method	Type	Area	SN	from DN/OD	to DN/OD
socket	B	U	4	160	630
socket	B	U	8	160	630
coupler	B	U	4	160	630
coupler	BU		8	160	630

Brand:
GEOSAN® PE

Have been evaluated and found in accordance with the requirements of the standard:

EN 13476-3:2018

Plastics piping systems for non-pressure underground drainage and sewerage - Structured-wall piping systems of unplasticized poly(vinyl chloride) (PVC-U), polypropylene (PP) and polyethylene (PE) - Part 3: Specifications for pipes and fittings with smooth internal and profiled external surface and the system, Type B

Certificate issued in conformity to: RG-01-03 ACCREDIA Rev. 01 - Regulation for the certification of Product / Service Certification Bodies, QHSE-REG-02.TQR Bureau Veritas Rev. 02 - Regulation for the certification of product / prossess / service and IND-REP-16_C P Special rules for the certification of pipe systems according to EN 13476.

Original Emission date: 13/04/2017
Current Emission date: 09/04/2020
Expiration date: 12/04/2023

The validity of this certificate is subject to a constant periodical surveillance and it can be checked on the following website: **www.bureauveritas.it** - Further clarifications regarding the scope of this certificate and the applicability of standard's requirements may be obtained by consulting the organisation.

(Eng. Francesco Sutera - Technical Director)

ACCREDIA L'ENTE ITALIANO DI ACCREDITAMENTO
PRD N° 009B

Certificate N°: **756/005**

Bureau Veritas Italia S.p.A.- Via Monza, 347 – 20126 Milan (MI) – ITALY

legislation

EUROPEAN SPECIFICATIONS

The EN 13476 series of standards, initially issued in November 2007, provides detailed descriptions of the design, production and testing procedures for plastic pipes and components intended for the collection of (sewer) waste water and the drainage of stormwater without pressure. Its exact title is:

"Plastics piping systems for non-pressure underground drainage and sewerage made of unplasticized polyvinyl chloride (PVC-U), polypropylene (PP) and polyethylene (PE)"

It consists of the following parts:

- **Part 1**: General requirements and performance characteristics;
- **Part 2**: Specifications for pipes and fittings with smooth internal and external surface and the system, Type A;
- **Part 3**: Specifications for pipes and fittings with smooth internal and profiled external surface and the system, Type B;
- **Part 4**: Guidance for the assessment of conformity;
- **Part 5**: Guidance for installation;

GREEK LEGISLATION

The use and full application of the above EN 13476 series of standards is MANDATORY in Greece according to the ministerial decision No. 14097/757/4.12.2012 "Testing technical specifications in plastic pipes and their components used to transport drinkable water, waste water and for underfloor heating" published in the Official Government Gazette issue B 3346/14.12.2012.

According to this decision, pipes that will be used in any project related to waste water sewage or stormwater drainage system MUST fully comply with the aforementioned standard.

Specifically, plastic pipes made of unplasticized polyvinyl chloride (PVC-U), polyethylene (HDPE), polyethylene (PE) with structured walls which are used in unpressured underground stormwater drainage and sewage networks must fulfill the requirements of the above standard, as applicable, this standard being mandatory for the safety of structural projects and constructions and the protection of users and consumers.

It is forbidden to produce, import, supply in the Greek market, or use any of the aforementioned products if they do not comply with the requirements of the technical specifications defined in EN 13476.

The lawful supply of products in the Greek market requires a Certificate of Conformity issued by an acknowledged and accredited (according to Regulation (EC) No. 765/2008) conformity assessment organization, in the case of products manufactured in the European Economic Area, or a competent body designated under Greek legislation in the case of Greek products. For products of third countries outside the EU a control certificate is required, also from the competent body designated under Greek legislation.

The strict framework of the above legislation clearly expresses the necessary CAUTION that is required before selecting appropriate pipes in order to ensure a VALID certificate of conformity and therefore assure the project design's required specifications, avoid possible failures due to non-conformity of the products and ensure the quality of the final project.

Visit www.kouvidis.gr and download all the above mentioned documentation

hydraulic calculation

For all issues related to drain and sewer networks, the use of the specifications of European standard EN 752 (Drain and sewer systems outside buildings) is recommended.

Regarding their types, sewer networks are classified as separated or combined. A separated system operates using independent conduits for wastewater and stormwater. A combined system operates using common sewer conduits for wastewater and stormwater.

Regarding the configuration of the conduits, the network can be radial, transverse or parallel, with main sewer conduits, primary, secondary and tertiary conduits.

FLOW CONDITIONS AND ASSUMPTIONS

The selection of the appropriate dimensions of the GEOSAN sewer pipe system requires the calculation of hydraulic quantities such as flow, velocity, fill ratio, network gradient and inside diameter

For the calculation of the above quantities it is taken into consideration that the GEOSAN pipe is suitable for non-pressure gravity pipe networks, while, according to Greek specifications (Presidential Decree 696/74), it is considered to operate with a free surface, so that the upper part of its geometrically closed cross-section is not used for a hydraulic purpose but only as a safety margin and as a ventilation channel for the sewer network.

The exact calculation of the hydraulic quantities related to a free-surface flow, as opposed to the flow in a closed conduit under pressure, is particularly complex. In order to simplify the calculation we make appropriate assumptions according to which the sewer conduit is under conditions of permanent and

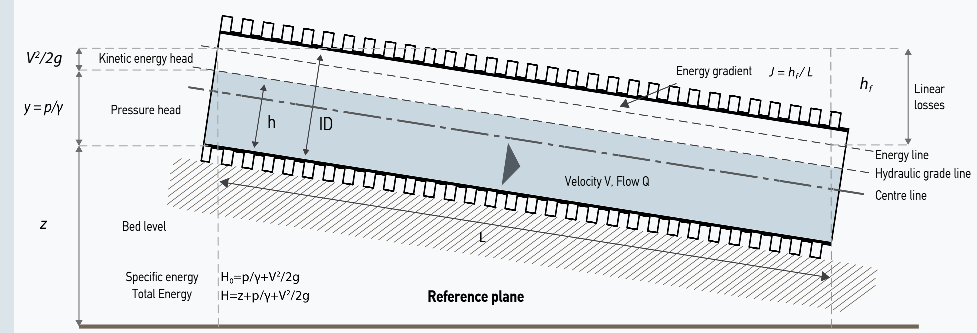


Figure 1

uniform flow. Therefore the flow, energy line, hydraulic grade line (hydraulic gradient) and the free surface line are considered to be parallel to the conduit bed (see figure 1).

For free-surface flow we can use equations that associate partially filled and fully filled conduits.

GREEK SPECIFICATIONS

Equations

According to the Greek specifications related to wastewater and stormwater conduits and specifically Articles 208 and 209 of P.D. 696/74, specific calculation types are set out as well as specific values and limits that must be adhered to for quantities such as minimum diameter, pipe fill percentage, flow velocity, gradients, as well as flow and friction coefficients.Specifically, the Chezy empirical relationship is set out:

Specifically, the Chezy empirical relationship is set out:

$$V = C \times \sqrt{R \times J}$$

V: flow velocity in m/s
C: flow coefficient
R: hydraulic radius of the pipe in m
J: hydraulic gradient of the pipe, equal to the energy gradient i in m/m for a uniform flow

The flow coefficient for wastewater and stormwater conduits is proposed to be calculated using the Bazin and Kutter formulae, while the Manning formula is also proposed for stormwater conduits:

Manning

$$C = \frac{1}{n} \times R^{1/6}$$

The Manning flow velocity formula results from the substitution of the flow coefficient in the Chezy formula as follows:

$$V = K \times R^{2/3} \times J^{1/2} \quad \text{where} \quad K = \frac{1}{n}$$

n : conduit friction coefficient in $m^{-1/3}s$

Bazin

$$C = \frac{87}{1 + \frac{\gamma}{\sqrt{R}}}$$

γ: conduit friction coefficient in $m^{1/2}$

Kutter

$$C = \frac{100 \times \sqrt{R}}{m + \sqrt{R}}$$

m: conduit friction coefficient in $m^{1/2}$

Limiting values

The following limiting values are also defined:

Size	Wastewater conduits	Stormwater conduits
Min conduit diameter	200mm	ID400mm
Max conduit fill ratio h/ID		70% (max 1m)
- diameter up to 400mm	50%	
- diameter from 500 to 600mm	60%	
- diameter greater than 600mm	70%	
- existing conduits with controlled flow capacity	80%	
Conduit friction coefficient γ as per Bazin	0,25 $m^{1/2}$	0,46 $m^{1/2}$
Conduit friction coefficient m as per Kutter	0,35 $m^{1/2}$	0,35 $m^{1/2}$
Max flow velocity for partial fill V	6 m/s	6 m/s
Regarding the minimum self-cleansing gradient, the min partial fill velocity V for Q/Q_0=10%	>0,3 m/s	>0,6 m/s
Regarding the minimum self-cleansing gradient, the min full fill velocity[1] V_0	>0,56 m/s	>1,11 m/s

Note 1: calculated by the nomogram (see below) of hydraulic quantities Q/Q0, V/V0, n/n0, as a function of the h/ID ratio and for a variable roughness coefficient n.

Deviations from the above calculation relationships are conditionally allowed if the relevant need is fully documented and an approval from the competent authority exists.

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KEY PIPE DIMENSIONING EQUATIONS

Calculation steps

One of the most important concerns related to the hydraulic calculation of sewer networks is the issue of dimensioning for conduits of a circular cross-section.

In order to resolve this issue, it is suggested that the specifications set out in the Greek legislation be supplemented with the European standard EN 752 (Drain and sewer systems outside buildings). This standard proposes 2 equations for the hydraulic calculations, the Colebrook-White and the Manning equation. The final calculation equations presented below result from the Manning formula, which is proposed due to its advantages (non-dimensional relationships, independent of diameter and flow characteristics, calculation accuracy).

Therefore, for a uniform flow (i=J) and if the following quantities are known

- the flow Q
- the gradient J and
- the fill percentage h/ID
- the roughness coefficient of the conduit for a full fill n_0

then the pipe diameter can be calculated using the following formulae:

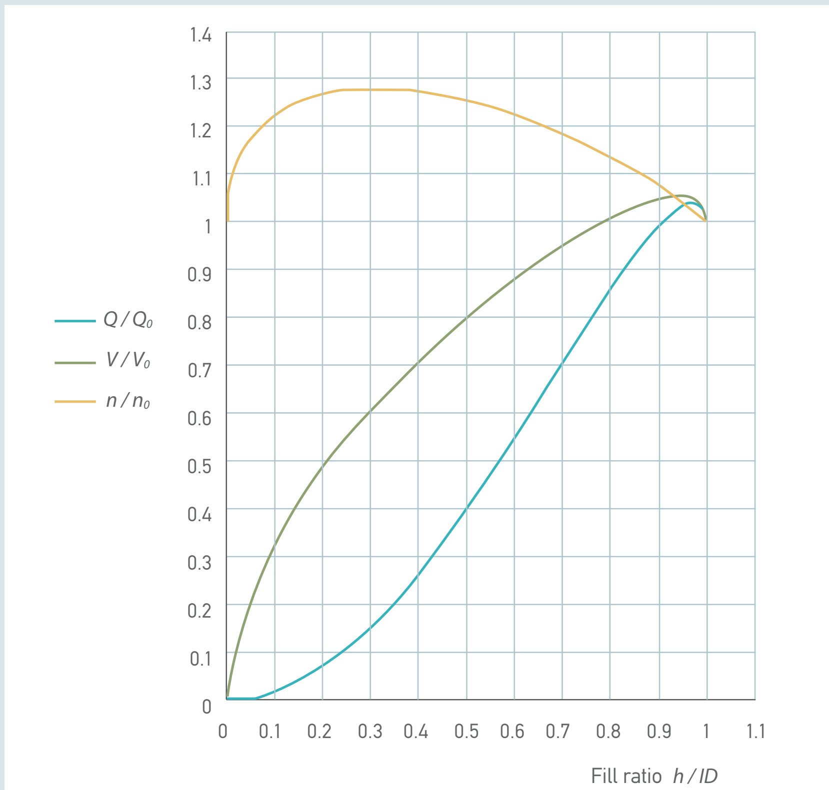
Step 1	Check whether the Greek specification limits are adhered to	Max fill percentage of pipe
Step 2	Angle θ is calculated	$\theta = 2 \cdot \cos^{-1}\left(1-2\cdot\frac{h}{ID}\right)$
Step 3	Ratio n/n_0 is calculated	$\frac{n}{n_0} = 1 + 0{,}62\cdot\left(\frac{h}{ID}\right)^{0,4}\cdot\left(1-\frac{h}{ID}\right)^{0,9}$
Step 4	Full flow Q_0 is calculated	$Q_0 = Q \cdot \frac{n}{n_0} \cdot \frac{2\cdot\pi}{\theta} \cdot \left(1-\frac{\sin\theta}{\theta}\right)^{-5/3}$
Step 5	The pipe's inside diameter ID is calculated	$ID = \left(\frac{4^{5/3}\cdot n_0\cdot Q_0}{\pi\cdot J^{1/2}}\right)^{3/8}$
Step 6	The next greater inside diameter of the GEOSAN pipe is selected	See GEOSAN dimension table (p. 20)
Step 7	Check whether the Greek specification limits are adhered to; if not, repeat the corresponding calculation steps	Min pipe diameter Max flow velocity Min flow velocity Min self-cleansing gradient

ID: inside diameter of the GEOSAN pipe in m
h: fill height of the GEOSAN pipe in m
h/ID: fill ratio in %
θ: fill angle in rad
Q_0: full flow (that is, for h/ID =1), in m^3/s
Q: partial flow (that is, for h/ID <1), in m^3/s
n/n_0: ratio of the roughness coefficients for full and partial fill, non-dimensional quantity
n_0: roughness coefficient for a full fill of the pipe (that is, h/ID =1), in $m^{-1/3}s$
J: hydraulic gradient of the pipe in %

The calculations proposed above are approximate and briefly present the main framework of equations and steps involved in hydraulic calculations. In each case, the researcher must take into account the technical experience and additional parameters contained in the relevant bibliography, in Greek as well as foreign specifications, in order to perform an accurate and detailed calculation of sewer networks.

Nomogram

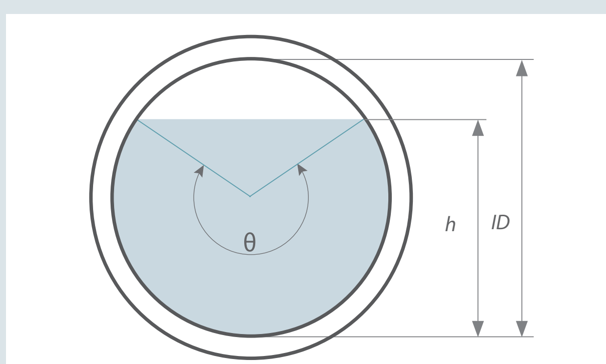
Alternatively, steps 2 to 4 and the calculation of the full flow Q_0, can be performed using the following nomogram that provides the hydraulic quantities Q/Q_0, V/V_0, n/n_0, as a function of the pipe's h/ID fill ratio:



Fill angle

The angle that is directly related to the pipe's fill ratio h/ID is depicted in the graph below.

Where h is the pipe fill height and ID is the pipe's inside diameter.



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Roughness coefficient

As results from the above equations and as confirmed by research, the roughness coefficient n varies with flow depth. Specifically, the coefficient n for partial fill conditions may be greater (up to 28%) than the corresponding roughness coefficient no for a full fill of the conduit.

For calculations according to Manning, it is suggested that for the roughness coefficient n_o values between 0,011 - 0,015 $m^{-1/3}s$ be selected for a full conduit fill. Specifically, n_0 = 0,015 $m^{-1/3}s$ may be selected to calculate the total hydraulic friction losses in the pipe network and n_o = 0,013 $m^{-1/3}s$ if we calculate separately and locally any losses at points of connection accessories, manholes et al. In cases of existing networks that are not in a good condition, values up to no = 0.020 $m^{-1/3}s$ have been recorded experimentally.

Maximum velocity

HAdherence to maximum velocities protects the pipe from its bottom's corrosion, which depends on the size and quantity of solid materials contained in wastewater or stormwater. At the same time, it decreases the risk of flow instability caused by sudden velocity changes. International bibliography proposes a maximum flow speed of 3 m/s, as opposed to Greek specifications that propose 6 m/s.

Due to the serious problems that may emerge in the network's operation and in particular for wastewater sewer pipes, we propose the adherence to the strictest international specification, i.e. a maximum velocity of 3 m/s. Regarding stormwater drainage pipes, where flow varies greatly and the specific specification leads to much greater pipe dimensions, it may be overlooked and adherence to the Greek specification of 6 m/s may apply. However, in any case, when the flow velocity exceeds 3 m/s, it is advisable to perform very thorough hydraulic calculations, taking into account additional control data such as critical flow and non-uniform flow.

Minimum velocity

Very low flow velocity results in the creation of solid material deposits which form sediments in the bottom of the sewer pipes. For this reason it is necessary to adhere to the minimum values of flow velocity. However, this is not always feasible as pipes do not only function at the nominal flow but at smaller flows as well. The problem is even greater in tertiary conduits, where flow may be extremely small. Due to the aforementioned difficulties, the pipes' minimum gradient can alternatively be controlled as described in the following section.

Minimum gradient

The following table can be used in order to check minimum gradients according to the specifications set out in Greek legislation (P.D. 696/74).

TYPE OF	Wastewater			Stormwater		
min V_0	0,56 m/s			1,11 m/s		
n_0	0,015					
Internal diameter	Minimum gradient	Fill	Flow	Minimum gradient	Fill	Flow
ID	*J*	*h/ID*	*Q*	*J*	*h/ID*	*Q*
mm	m/km	%	l/s	m/km	%	l/s
200	3,8	50	7,0	-	-	-
250	2,8	50	10,9	-	-	-
300	2,2	50	15,7	-	-	-
350	1,8	50	21,5	-	-	-
400	1,5	50	28,0	6,0	70	99
500	1,1	60	59,8	4,4	70	155
600	1,0	60	93	3,5	70	225

Note: Minimum gradients smaller than 1.0 m/km are not recommended.

SEWER NETWORK MAINTENANCE

The adherence of competent authorities to an appropriate maintenance schedule is crucial to the proper operation of the network.

Regarding this issue, the European standard EN 752 sets out an important framework of specifications governing network operation and maintenance.

Adherence to the appropriate maintenance works ensures to a large extent the preservation of the pipes' hydraulic characteristics and consequently their adequate performance and hydraulic behaviour during their whole life cycle.

Part of the network maintenance works may be visual inspection using appropriate CCTV camera systems and pressure flushing using cleaning machines. For years, the specific equipment has been part of the maintenance equipment of the majority of competent authorities (municipalities, municipal water and sewage companies).

Regarding pipe flushing in particular, it is ensured that the network's hydraulic performance shall be preserved in cases where the flow velocity or hydraulic gradient cannot ensure adequate self-cleansing conditions, as has been discussed in previous sections. The implementation of an efficient operation and maintenance system requires the collection and recording of appropriate data and the use of information systems. To this end, a GIS (Geographical Information System) may constitute a dynamic tool for sewer network management.

static calculation

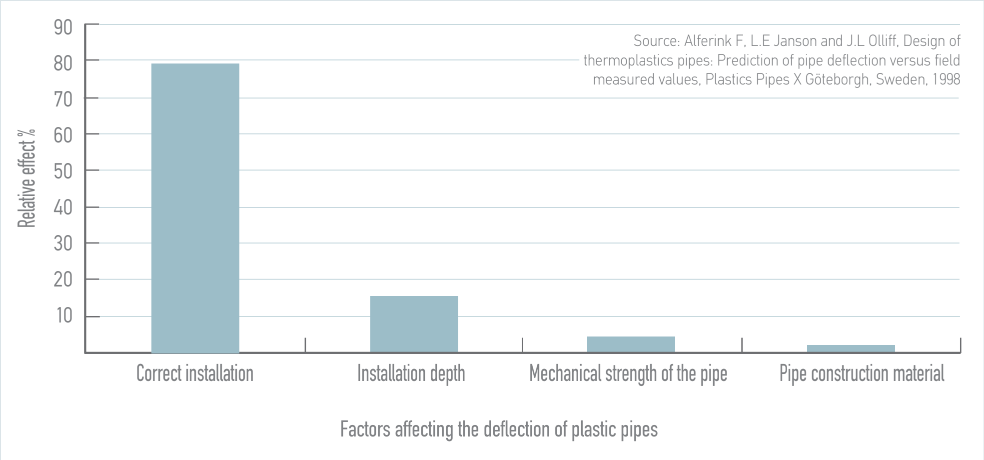
IMPOSITION OF LOAD ON BURIED PIPES

In sewer network pipes, it is important to ensure the safe collection and transport of wastewater. A potential failure of buried pipes may lead to significant risks for public health as well as for the environment.

The deflection of buried sewer pipes may be mainly caused by loads originating from the soil itself, vehicle traffic on the ground, as well as forces exerted by water in the aquifer.

The soil plays an important part in sewer network design and its properties largely depend on its compaction, therefore also on the quality of the installation.

Correct installation is the most significant factor affecting buried plastic pipes' behaviour and longevity. Other factors are the installation depth, the pipe's mechanical strength and the type of the pipe's material. The following chart depicts the importance of these factors in pipe deflection.



GEOSAN 2nd generation double structured wall plastic pipes offer significant advantages regarding their behaviour when buried, compared to theoretically rigid concrete pipes and aluminosilicate pipes, as well as pliable compact-wall plastic pipes made of PVC.

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EMPIRICAL CALCULATION OF PIPE DEFLECTION

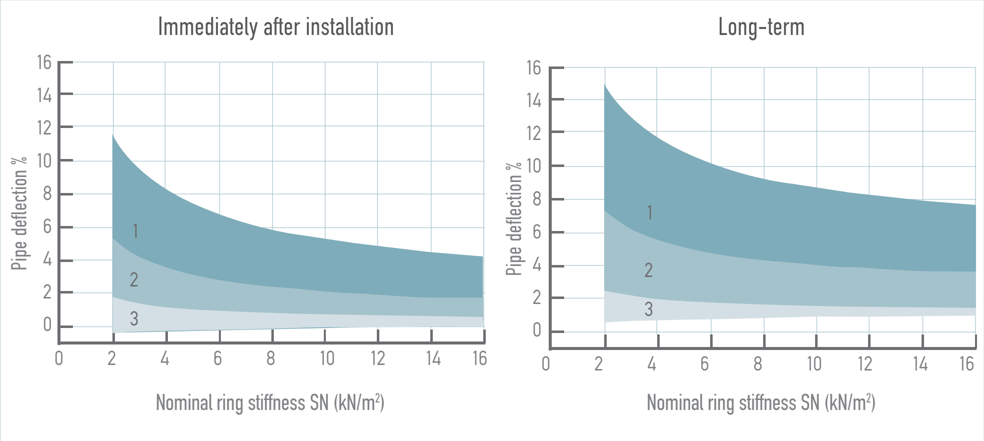
Deflection charts

Selection of the appropriate ring stiffness for the GEOSAN sewer pipe system may be performed using empirical data referred to in European standards EN 13476, CEN/TS 15223, CEN/TR 1046.

Utilisation of these empirical data results in charts that depict pipe deflection immediately after installation, as well as in the long term, for 3 soil compaction quality classes.

1. No compaction
2. Moderate compaction, typical SPD values between 87% and 94%
3. Good compaction, typical SPD values 94%

% SPD - Standard Proctor Density, according to EN 13286-2



The upper boundary of each area depicted in the charts corresponds to the maximum expected deflection and the lower boundary corresponds to the mean expected deflection.

Through the use of the above charts it is possible, under certain conditions, to select the sewer pipe with the appropriate ring stiffness class for a specific quality of installation.

Conditions

Use of the empirical charts presupposes adherence to the conditions described below:

Pipe system	Compliance with the requirements of standard EN 13476-3+A1:2009
Installation depth	From 0.80m to 6.00m
Installation depth	Included for all possible cases
Maximum pipe diameter	≤1100mm

Aquifer	No limitation
Ratio of the coverage height to the external pipe diameter	≥2

Regarding the installation quality, the "good", "moderate" (and "none") categories must correspond to the quality of the report that the designer is using as a basis.

"Good" compaction	The granular material of the conduit zone is carefully placed on the upper bedding zone (which corresponds to 1/3 of the pipe diameter as per EN 1610) and is carefully compacted in layers of a maximum thickness of 30 cm. The pipe must be covered by at least a 15-cm-thick layer. The trench is then filled with soil material of any type and compacted. Typical SDR values are above 94%..
"Moderate" compaction	The granular material of the conduit zone is carefully placed in layers of a maximum thickness of 50 cm which are carefully compacted. The pipe must be covered by at least a 15-cm-thick layer. The trench is then filled with soil material of any type and compacted. Typical SDR values are between 87% and 94%.
No compaction ("None")	Any heaps of leaves must be removed before compaction, according to the recommendations of standard EN 1610. However, if the heaps of leaves are removed after compaction, then compaction quality is reduced from "good" or "moderate" to "none".

Empirical calculation

Deflection of buried plastic pipes may occur in two stages. Immediately after installation, the pipe acquires an initial deflection percentage which often ranges between 2% and 4% on average, according to Annex B of technical report CEN/TR 1046 issued by the European Committee for Standardization (CEN).

After the initial installation and for a period that ranges between one or even two years, the pipe acquires its final deflection which remains relatively constant over time.

Final deflection may occur sooner if there is traffic load from vehicles in the area. The final deflection percentage depends on the quality of the installation and therefore the compaction quality.

$$\left(\frac{\delta}{D_n}\right)_{\substack{final\\deflection}} = \left(\frac{\delta}{D_n}\right)_{\substack{initial\\deflection}} + C_f$$

(final deflection = initial deflection + deflection coefficient)

δ/Dn: pipe deflection in %

δ: pipe deflection in mm

Dn: the pipe's outside diameter (OD) in mm

Cf: deflection coefficient in %

Compaction quality	Compaction quality
"good"	Cf = 1
"moderate"	Cf = 2
"none" for granular soils	Cf = 3
"none" for cohesive soils	Cf = 4

Use of the above formula requires first the calculation of the initial deflection using the chart that describes deflection "immediately after installation" (see deflection charts) depending on soil compaction quality and nominal ring stiffness and then the calculation of the deflection coefficient, so that the sum can yield the final deflection..

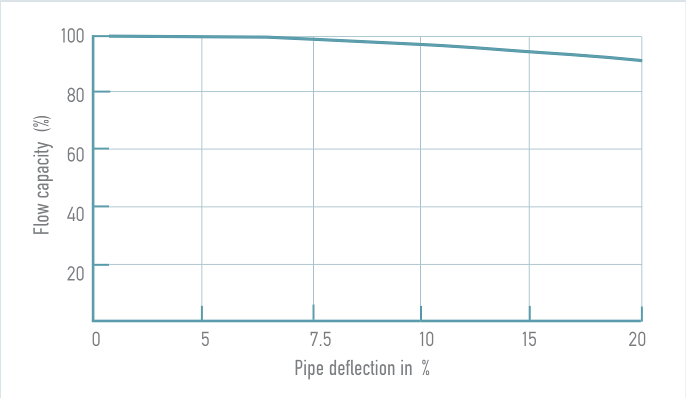
The above method covers the requirements of paragraph 4.2 of European standard EN 1610.

Alternatively, the final deflection of a buried plastic pipe may be directly calculated empirically using the chart corresponding to the "long-term" deflection of the pipe (see deflection charts).

According to CEN/TR 1046, immediately after installation:

- the percentage (%) of the mean acceptable deflection may be <8%,
- while the percentage (%) of the maximum acceptable deflection may be <12%.

The pipe's deflection affects its hydraulic behaviour. According to European specification CEN/TS 15223, for a pipe with a mean deflection of 10% the flow capacity may be reduced by 2%. The following chart depicts the relationship between the pipe's flow capacity and deflection, as stated in the relevant European technical specification.



installation guide

INSTRUCTIONS FOR USE

INSTRUCTIONS for storage

Pipes may be placed either telescopically, i.e. one inside the other, or in stacks. Always on clean flat surfaces free of foreign bodies, e.g. sharp stones that might cause possible damage, and never next to open trenches.

While in storage they are placed in such a way that the integrated couplers on their ends are not in contact with each other.

If wooden frames are used, make sure that the frame is not placed on surfaces with sharp objects that might damage the pipes.

If the pipes are not packaged, they may be stacked one on top of the other, placing the largest diameters at the lower layers. Suitable supports are required in all cases.

CAUTION: It is possible to store pipes and components in open spaces, thanks to their resistance to ultraviolet solar radiation. This does not apply to elastomeric gaskets, as their exposure to the sun can result in serious wear.

INSTRUCTIONS for loading

The loading/unloading area must be free of sharp objects that might damage the pipes.

Loading and unloading must be performed using a forklift truck that may be equipped with special forks. When loading large-diameter pipes, if the forks are not sufficient then special polyester straps must be used symmetrically to the pipes; these straps must fulfill specific specifications to cover the required loading weight. Incorrect binding or the use of chains or ropes may result in injury.

CAUTION: In the case of manual loading/unloading it is recommended to use appropriate personal protective equipment (shoes, helmets, gloves, etc.) to achieve better handling and prevent possible injuries.

INSTRUCTIONS for sealing ring placement

connection methods "b" (see page 14)

Sealing gaskets are placed in the gap created by the grooves of the outside wall of GEOSAN® pipes. The gasket is placed on the first groove from the straight end of the pipe. Before connecting a pipe with another pipe or component it is required to use a lubricant.

CAUTION: Please place elastomeric rings in the right direction in order to ensure the sealing of the connection.

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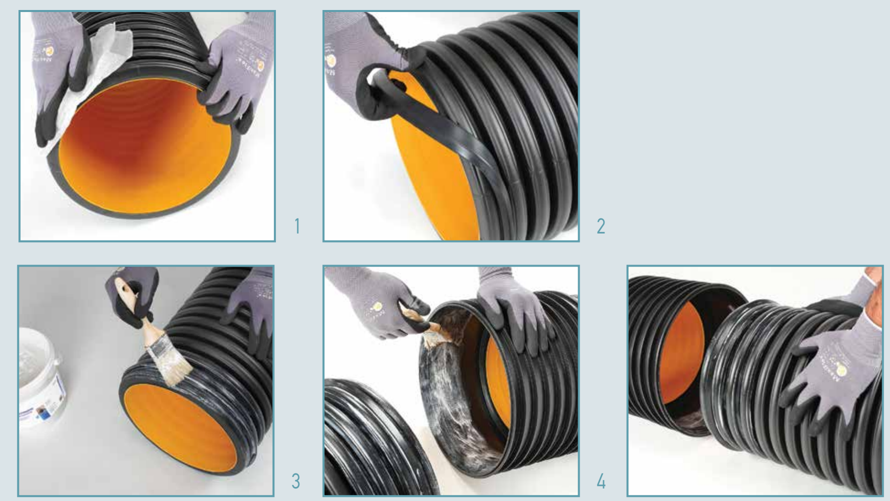
INSTRUCTIONS
for cutting connection method "b'' (see page 14)

An appropriate cutting tool is required when cutting GEOSAN® pipes. During the cutting process, the knife must move vertically and within the groove of the pipe, without damaging the trapezoid form of the outside wall. After cutting it is recommended to clean rough surfaces using sand paper or a cutter.

CAUTION: In the case of a bad cut, the pipe must be replaced or mended where it has been damaged. In order to avoid unexpected damage, it is not recommended to connect pipes that have not been cut properly.



1 2 3 4 5

INSTRUCTIONS
for connecting pipes with couplers

1. After ensuring that the parts to be connected are not worn, clean the surfaces to be assembled so that they are free of dust and fatty substances.
2. Place the sealing elastomeric ring in the first groove in the correct direction.
3. Coat the whole of the external surface to be connected (including the ring) with an appropriate lubricant. Be careful to avoid using oils or greases.
4. Then use a coat of lubricant on the inner surface of the pipe/component that you want to connect.
5. Finally, connect the two parts up to their point of termination.

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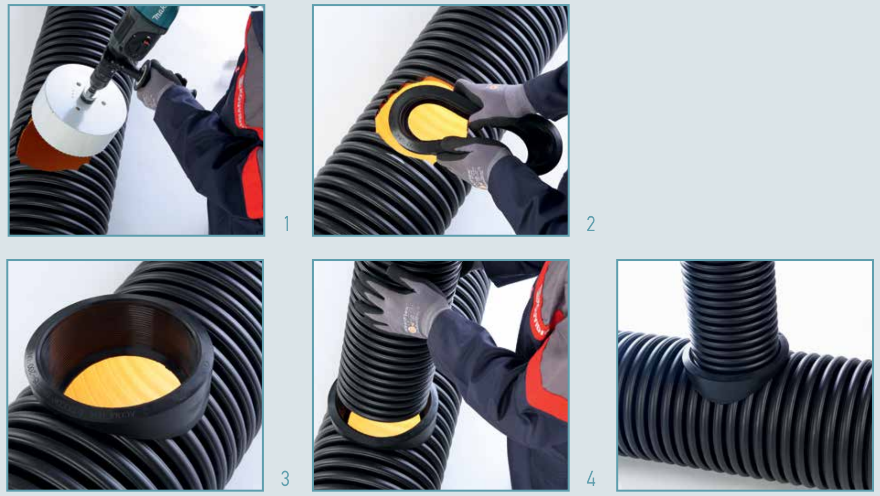


INSTRUCTIONS for connecting an elastomeric branch connector

1. Locate and mark the point where you wish to create a branch. Create a hole using a KOUVIDIS hole cutter of an appropriate diameter according to the following table:

Branch Sewer DN/OD	Main Sewer DN/OD	Drill hole (mm)
110	250/315/400	127
110	630/800/1000	127
160	300/400/500	177
160	250/315	170
160	400	170
160	630/800/1000	177
200	315	208
200	400/500	208
200	630/800/1000	208
250	400/500	263
250	630/800/1000	263
315	630/800/1000	320
400	1000/1200	412

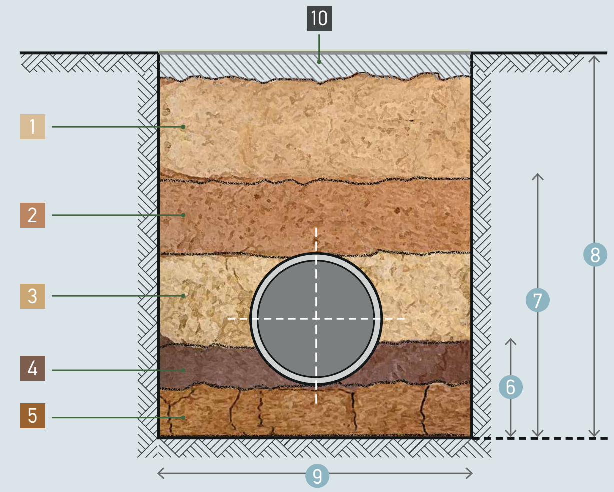
CAUTION: Elastomeric connectors (saddles) of specific diameters are available for connecting a main pipe with a branch pipe. Check carefully the parameters of the connector as specified in the project design in order to create an appropriate hole diameter.

2. Ensure that the elastomeric connector is free of dirt and place it inside the hole. The use of a lubricant is deemed necessary.
3. Ensure that the elastomeric connector has been placed in the correct direction by applying pressure along the perimeter so that it fully fits on the main pipe.

4.5. Connect the branch pipe to the elastomeric connector and press up to the end point. The branch is ready for use.

INSTRUCTIONS for installation

The installation of plastic sewage/drainage pipes requires a series of works that need to be carried out as specified in the project design so as to ensure the safety of the works and the hydraulic installation itself. Some details on best practice for safe installation in accordance with the European standard EN 1610 as well as the relevant specifications are given below:



DESCRIPTION OF FILLING TRENCH ZONES

1. Main backfill
2. Initial backfill
3. Sidefill
4. Upper bedding
5. Lower bedding
6. Depth of bedding
7. Depth of embedment
8. Trench depth
9. Trench width
10. Bottom of road construction, if any

BASIC INFORMATION ON TRENCHES

When digging a trench for conduit installation care must be taken in order to ensure a smooth, even underlying surface. It is best that trenching is performed as late as possible before the laying of the conduits and for backfilling to take place as soon as possible after their laying. Some basic accuracy checking criteria for the trench works are:

- Slope and level of the bottom of the trench in accordance with the differences in height provided for.
- Dimensions of the excavated sections.
- Pipe diameters and mechanical strengths
- Evenness of the trench surfaces, bottom and walls.
- Removal of surface and ground water.
- Selection, reuse and temporary storage of the excavated materials and removal of those which are unsuitable.
- Removal of inappropriate units

TRENCH DIMENSIONS

The trenches should have the width and depth specified in the design. This should be the minimum required for a workmanlike installation of the underground network and compaction of the backfilling materials in accordance with the diameter of the conduit and its depth of installation. It is recommended that the minimum width of the trench be the greater than the values shown in the 2 tables below:

Differences may occur in the above minimum recommended widths in the case of works which do not require a person to be inside the trench or in other special circumstances. A very important factor that needs to be taken into account at the time of selecting from the above sizes is the installation of more than one conduit in the trench.

Minimum recommended width of trench in relation to outside diameter of conduit

Nominal diameter (DN)	Minimum trench width (OD + Xm)
≤ 225	OD + 0,4
> 225 to ≤ 350	OD + 0,5
> 350 to ≤ 700	OD + 0,7
> 700 to ≤ 1200	OD + 0,85
> 1200	OD + 1,0

Minimum recommended width of trench in relation to trench depth

Trench depth (m)	Minimum trench width (m)
< 1	No minimum width required
≥ 1 ≤ 1,75	0,80
> 1,75 ≤ 4,00	0,90
> 4,00	1,00

conduits with outside diameter OD up to 200 mm

TRENCH MATERIALS

The suitability of the ground materials for backfilling the trenches for underground networks depends on their geotechnical properties and their capacity for compaction. The backfill materials can be taken from the excavated materials. When these materials do not meet the requirements, are non-existent or unavailable then suitable materials must be chosen as specified in the design. It is best to preclude the presence of backfill materials that are larger than 22 mm in diameter. It is also necessary that the backfill materials are free from organic substances (such as leaves, roots, grass etc.), snow and ice since their water content affects compaction. The trenches must be protected from surface water. It would be good to use pumps to remove and drain off any water towards nearby natural receptacles or other suitable receptacles.

RECEPTION AND TRANSPORTATION TO THE INSTALLATION POINT

The pipes and their fittings must be inspected upon delivery, to see that they bear the correct labels and markings and meet all the necessary specifications laid down in the design. Prior to installation they must be carefully checked for any signs of damage.

STORAGE

The conduits must be stored in such a way as to ensure that they remain incorruptible. They must not be placed next to open trenches and their storage area must be clean and free from any foreign bodies such as sharp stones that could cause damage. The use of specially customized forks or special polyester straps is indispensable (see instruction above).

LAYING

Place the pipes in such way ensuring that their surface, alongside their length, lies completely on the bottom of the trench. In the case of interruption of the installation process, or due to a temporary break in the works, or in view of connection at a later date, the ends of the pipes must be sealed with protective caps. The caps must not be removed before the connection process. The area of the pipe that will come into contact with the connection fitting (coupler) must be clean and show no signs of damage.

CONNECTION

During the connection process (coupler, well, etc.) it must be ensured that no foreign bodies can get inside the pipes. In order to achieve this, particular care must be taken when cutting and assembling the conduit (see instruction above).

TRENCHING

After completion of the works for digging, shaping and inspecting the bottom of the trench, the next step is the laying of the conduit and backfilling with the material provided for in the design. It is recommended that the conduit be laid over a substrate (underlying layer) of 100 mm in the case of soil and 150 mm for stony or hard ground, and covered respectively to a height of 300 mm above the highest point of the outside diameter of the conduit (see diagram). It is recommended that the filling and compaction of the trench be carried out simultaneously on both sides of the conduit. It is suggested that the compaction, the degree of which must be provided for in the design, be carried out from the wall of the trench towards the conduit in uniform layers using manual equipment. Compaction using mechanical means must not be performed in an area above the zone of the pipe that is less than 300 mm deep. When choosing the mechanical means of compaction, the number of drillings and the thickness of the layers of compaction, it is necessary to take into account the type of compaction material and the type of conduit that will be laid in the trench. Compliance of the above with the specifications provided for in the design must be a priority.

INSPECTION

During the installation, in addition to visual checks, the following checks must also be performed: checks for any deformation of the pipes, change in degree of compaction and the adequacy and effectiveness of the laying. The surface on which the conduits are laid must be thoroughly inspected and meet the requirements of the design regarding its degree of slope and evenness.

ATTENTION: The above information comprises an informative guide for the safe digging of trenches and installation of conduits for cable protection as defined by European standard EN 1610. In NO way must it be used as a specification or be confused with the specifications laid down in each individual design.

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technical appendix

TECHNICAL INSTRUCTIONS

MARKING OF PIPES

Number of conformity standard	EN 13476-3
Diameter	DN 200/178
Manufacturer's name KOUVIDIS	KOUVIDIS
Product name	GEOSAN
Ring stiffness	SN 8
Ring flexibility	RF 30
Production material	HDPE
Application field	U
Production date	Lot number

EXPLANATION OF GEOSAN LABEL

In every GEOSAN pipe there is a label that facilitates the identification of the product and the explanation of its specific properties.

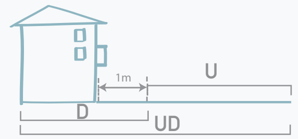
The labels clearly state the following characteristics:

ANNOTATION

DN	Nominal size
OD	Outside diameter
ID	Inside diameter
HDPE	High density polyethylene
RF	Ring flexibility
SN	Ring stiffness
U	Application area code (outside a building structure)
TIR	True impact rate
EPDM	Ethylene propylene diene monomer

APPLICATION AREA

U	Pipes and fittings which are to be used buried in the ground outside a building structure only (at least 1m from the structure)
D	Pipes and fittings which are to be used buried in ground within a building structure
UD	Pipes and fittings which are to be used buried in ground both outside and within a building structure



CHEMICAL RESISTANCE

The chemical resistance of high-density polyethylene (HDPE) and polypropylene (PP) plastics against indicative chemical compounds according to the ISO 10358 standard is provided below.

Chemical substances	HDPE	
	20^{0}C	60^{0}C
Acetaldehyde (40%)	S	L
Acetic acid (<10%)	S	S
Acetic acid (10 to 40%)	S	-
Acetic acid (>40%)	S	-
Acetic anhydride	S	L
Acetone (liquid)	L	L
Acrylonitrile	-	-
Allyl alcohol	S	S
Aluminium patassium sulphate	S	S
Aluminium chloride	S	S
Aluminium sulphate	S	S
Ammonia,aqueous	S	S
Ammonium chloride	S	S
Ammonium fluoride	S	S
Ammonium nitrate	S	S
Amyl acetate	S	L
Aniline (liquid)	S	L
Antimony (III) chloride	S	S
Barium chloride	S	S
Beer	S	S
Benzaldehyde (liquid)	S	L
Benzene	L	L
Benzoic acid	S	S
Benzyl alcohol	-	-
Boric acid (≤10%)	S	S
Butane,gas	S	S
n-Butanol	S	S
Butyl acetate	-	-
Butyl glycol	-	-
Butyric acid (liquid)	S	L
Calcium chloride	S	S
Chlorine,dry gas	L	NS
Chlorosulphonic acid	NS	NS
Chromic acid (20%)	S	L
Citric acid	S	S
Copper chloride	S	S
Copper sulphate	S	S
Cresols	-	-
Cyclohexane	-	-
Cyclohexanol (liquid)	S	S
Cyclohexanone	S	L
Decalin	S	L
Developers (photographic)	S	S
Dextrin (>10%)	S	S
Dichloroacetic acid	-	-
Dichloroethylenes	-	-
Diethyl ether	-	-
Dioxane	S	S
Ethanol (40%)	S	L
Ethyl acetate	S	NS
Ferrous chloride	S	S
Formaldehyde (30% to 40%)	S	S
Formic acid (10%)	S	S
Formic acid (40%)	S	S
Furfuryl alcohol	S	L
Gasoline (fuel)	S	L
Gelatine	S	S
Glycerine	S	S
Glycolic acid	S	S
Hydrobromic acid (<20%)	S	S
Hydrobromic acid (<48%)	S	S

Chemical substances	HDPE	
	20^{0}C	60^{0}C
Hydrochloric acid (10% to 20%)	S	S
Hydrocyanic acid (10%)	S	S
Hydrofluoric acid (<10%)	S	S
Hydrofluoric acid (60%)	S	L
Hydrogen	S	S
Hydrogen petroxide (>10%)	S	S
Hydrogen petroxide (30%)	S	S
Isopropyl alcohol	-	-
Lactic acid (10%)	S	S
Lactic acid (10% to 90%)	S	S
Lead acetate (≤10%)	S	S
Magnesium chloride	S	S
Maleic acid (Dec.at 160oC)	S	S
Mercury	S	S
Mineral oils	S	L
Nitric acid (25%)	S	S
Nitric acid (>50%)	NS	NS
Oils and fats	S	L
Oleic acid	S	S
Oleum	NS	NS
Oxygen,gas	S	L
Ozone,gas	L	NS
Paraffin oil (F65)	-	-
Petroleum ether (ligroin)	-	-
Phenol (>10%)	S	S
Phosphoric acid (>50%)	S	S
Potassium chloride	S	S
Potassium dichromate	S	S
Potassium nitrate	S	S
Potassium permanganate (20%)	S	S
Propionic acid	S	S
Pyridine	S	L
Sodium bisulphate	S	S
Sodium carbonate	S	S
Sodium chlorate	S	S
Sodium chloride	S	S
Sodium chlorite	S	
Sodium hydroxide	S	S
Sodium silicate	S	S
Sulphur trioxide	NS	NS
Sulphuric acid (>10%)	S	S
Sulphuric acid (50%)	S	S
Sulphuric acid (98%)	S	NS
Sulphurous acid	S	S
Tannic acid	S	S
Tertaric acid (Dec.)	S	S
Tetrahydrofuran	-	-
Tetralin	-	-
Thionyl chloride	NS	NS
Thiophene	-	-
Toluene	L	NS
Trichloroethylene	NS	NS
Triethanolamine	S	L
Urea	S	S
Urine	S	S
Water	S	S
Water,sea	S	S
Xylenes	L	NS
Yeast	S	S
Zinc chloride	S	S

NOTE: This table is an informative guide on the chemical resistance of HDPE and PP raw materials against various chemical substances according to the ISO 10358 standard. In no case does it constitute a substitute for checking the application conditions per case.

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Annotation

S	Satisfactory resistance	The pipes can be used for applications in which they are not subjected to pressure or other stresses.
L	Limited resistance	The pipes can be used for applications in which they are not subjected to pressure or other stresses, but in which a certain amount of corrosion can be accepted.
NS	Resistance not satisfactory	The pipes are seriously attacked: they shall not be used for either pressure or non-pressure applications.
-	No available date	

REFERENCES

Standard	Description
EN 13476-1	Plastics piping systems for non-pressure underground drainage and sewerage. I Structured-wall piping systems of unplasticized poly(vinyl chloride) (PVC-U), polypropylene (PP) and polyethylene (PE). I Part 1: General requirements and performance characteristics.
EN 13476-2	Plastics piping systems for non-pressure underground drainage and sewerage. I Structured-wall piping systems of unplasticized poly(vinyl chloride) (PVC-U), polypropylene (PP) and polyethylene (PE). I Part 2: Specifications for pipes and fittings with smooth internal and external surface and the system, Type A.
EN 13476-3+A1:2009	Plastics piping systems for non-pressure underground drainage and sewerage. I Structured-wall piping systems of unplasticized poly(vinyl chloride) (PVC-U), polypropylene (PP) and polyethylene (PE). I Part 3: Specifications for pipes and fittings with smooth internal and profiled external surface and the system, Type B.
EN 13476-4	Plastics piping systems for non-pressure underground drainage and sewerage. I Structured wall piping systems of unplasticized poly(vinyl chloride) (PVC-U), polypropylene (PP) and polyethylene (PE). I Part 4: Guidance for the assessment of conformity.
EN ISO 9969	Thermoplastics pipes. I Determination of ring stiffness (ISO 9969:1994).
ISO 13967	Thermoplastics fittings. I Determination of ring stiffness.
EN 728	Plastics piping and ducting systems. I Polyolefin pipes and fittings. I Determination of oxidation induction time.
EN 744	Plastics piping and ducting systems. I Thermoplastics pipes. I Test method for resistance to external blows by the round-the-clock method.
EN 1053	Plastics piping systems. I Thermoplastics piping systems for non-pressure applications. I Test method for watertightness.
EN 1055	Plastics piping systems. I Thermoplastics piping systems for soil and waste discharge inside buildings. I Test method for resistance to elevated temperature cycling.
EN 1277	Plastics piping systems. I Thermoplastics piping systems for buried non-pressure applications I Test methods for leaktightness of elastomeric sealing ring type joints.
EN 1437	Plastics piping systems. I Piping systems for underground drainage and sewerage. I Test method for resistance to combined temperature cycling and external loading.
EN 1446	Plastics piping and ducting systems. I Thermoplastics pipes. I Determination of ring flexibility
EN 1979	Plastics piping and ducting systems. I Thermoplastics spirally-formed structured-wall pipes I Determination of the tensile strength of a seam.
EN 12061	Plastics piping systems. I Thermoplastics fittings. I Test method for impact resistance.
EN 12256	Plastics piping systems. I Thermoplastics fittings. I Test method for mechanical strength or flexibility of fabricated fittings.
EN 12666-1	Plastics piping systems for non-pressure underground drainage and sewerage. I Polyethylene (PE). I Part 1: Specifications for pipes, fittings and the system.
EN 14741	Thermoplastics piping and ducting systems. I Joints for buried non-pressure applications. I Test method for the long-term sealing performance of joints with elastomeric seals by estimating the sealing Pressure.

EN 1852-1	Plastics piping systems for non-pressure underground drainage and sewerage. | Polypropylene (PP) | Part 1: Specifications for pipes, fittings and the system.
ISO/TR 10358	Plastics pipes and fittings. | Combined chemical-resistance classification table.
ISO 527-1	Plastics | Determination of tensile properties. | Part 1: General principles.
ISO 1183-1	Plastics | Methods for determining the density of non-cellular plastics. | Part 1: Immersion method, liquid pyknometer method and titration method.
EN ISO 580	Plastics piping and ducting systems. | Injection-moulded thermoplastics fittings. | Methods for visually assessing the effects of heating (ISO 580:2005)
EN 14758-1	Plastics piping systems for non-pressure underground drainage and sewerage. | Polypropylene with mineral modifiers (PP-MD). | Part 1: Specifications for pipes, fittings and the system.
EN ISO 1133	Plastics | Determination of the melt mass-flow rate (MFR) and the melt volume-flow rate (MVR) of thermoplastics (ISO 1133:2005).
EN ISO 1167-1	Thermoplastics pipes, fittings and assemblies for the conveyance of fluids. | Determination of the resistance to internal pressure. | Part 1: General method (ISO 1167-1:2006)
EN ISO 1167-2	Thermoplastics pipes, fittings and assemblies for the conveyance of fluids. | Determination of the resistance to internal pressure. | Part 2: Preparation of pipe test pieces (ISO 1167-2:2006)
EN ISO 3126	Plastics piping systems. | Plastics piping components. | Determination of dimensions (ISO 3126:2005).
EN ISO 9967	Plastics pipes. | Determination of creep ratio (ISO 9967:1994).
ISO 12091	Structured wall thermoplastics pipes | Oven test
ISO 13968	Thermoplastics fittings. | Determination of ring flexibility.
EN 681-1	Elastomeric seals. | Materials requirements for pipe joint seals used in water and drainage applications | Part 1: Vulcanized rubber.
EN 681-2	Elastomeric seals. | Materials requirements for pipe joint seals used in water and drainage applications. | Part 2: Thermoplastic elastomers.
EN 681-4	Elastomeric seals. | Materials requirements for pipe joint seals used in water and drainage applications. | Part 4: Cast polyurethane sealing elements.
EN 1610	Construction and testing of drains and sewers.
P.D. (Presidential Decree) 696 (1974)	Engineer's fees for the structure design, supervision, acceptance, etc. of Transportation, Hydraulic and Building Works, as well as Topographical, Cadastral and Cartographic Operations, and related technical specifications studies.
Koutsoyiannis D. (2011)	Urban wastewater management, Version 4, NTUA, Athens
EN 752	Drain And Sewer Systems Outside Buildings
CEN/TR 1046	Thermostatic piping and ducting systems - Systems outside building structures for the conveyance of water or sewage - practices for underground installation
EN 476	General requirements for components used in drains and sewers
ISO 11922-1	Thermoplastics pipes for the conveyance of fluids - Dimensions and tolerances
prCEN/TS 15223	Plastic piping systems - Validated design parameters of buried thermoplastic piping systems, Structural design of buried pipelines under various conditions of loading | Part 1: General requirements
EN 1295-1	Structural design of buried pipelines under various conditions of loading | Part 1: General requirements
CEN/TR 1295-2	Structural design of buried pipelines under various conditions of loading | Part 2: Summary of nationally established methods of design
CEN/TR 1295-3	Structural design of buried pipelines under various conditions of loading | Part 3: Common method
ATV-DVWK-A 127	Statische Berechnung von Abwasserkanälen und Leitungen, 3. Auflage; korrigierter Nachdruck 4/2008
Spangler M.G.	Stresses in pressure pipelines and protective casing pipes, Journal of the Structural Division, Vol. 82, No ST5, Sept. 1956
EN 13286-2	Unbound and hydraulically bound mixtures | Part 2: Test methods for laboratory reference density and water content - Proctor compaction
	Design of Buried Thermoplastics Pipes, Results of a European research project by APME & TEPPFA, © TEPPFA, March 1999
Janson L. E.,	Plastics Pipes for Water Supply and Sewage Disposal, 4th edition, Stenungsund : Borealis, 2003
Alferink F, L.E Janson and J.L Olliff	Design of thermoplastics pipes: Prediction of pipe deflection versus field measured values, Plastics Pipes X Göteborgh, Sweden, 1998
EN 476	General requirements for components used in drains and sewers

LEGEND

- Dout — Outer diametr (mm)
- Reduction of friction due to slippery inner surface of the pipe
- EN 1277 — Degree of tightness against solid particles and water (EN 60529)
- 2 years — Product with extra UV stability
- ISO 10358 — Raw material of production with very good behavior towards hazardous chemical substances
- GREEN PRODUCT KOUVIDIS — Environmentally friendly product.Halogen free, heavy metals free (RoHS), low smoke, SVHC-free (REACH) with 100% eco-friendly packaging
- VDE RoHS compliant ID 137347 — The product does not contain hazardous substances acc. to 2011/65/EU RoHS Directive. Certification body VDE
- REACH Compliant — Compliance with REACH Regulation EC/1907/2006 about chemicals
- BUREAU VERITAS — Audit and test certification by the international certification body Bureau Veritas
- ISO 9001 — Certification body of Quality Management System EN ISO 9001
- ISO 14001 — Certification body of Environmental Management System EN ISO 14001
- ISO 45001 — Certification body of Occupational Health and Safety Management System ISO 45001

KOUVIDIS has always been committed to providing correct and reliable information to the engineer/designer. This manual is a useful technical guide for plastic pipes for waste water sewage and stormwater drainage. It is considered useful to make a brief reference to the legal framework covering these products. For this reason, there are also references to control Standards, so that the user may quickly and safely select the appropriate product for each use. It is obvious that the information provided in this manual does not in any case substitute the content of the Standards or any other documents to which it refers. It is understood that the user must always check if the products are fit for purpose. In any case, you may consult our company's experts before each use.

3 rd version 09.2022

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WINNER

ISO 9001 ISO 14001 ISO 45001 VDE RoHS compliant ID 201572 REACH Compliant

KOUVIDIS was founded in 1979 when Emmanuel Kouvidis, an electrician-installer, decided to quit his job and set up a business of his own in order to produce high quality conduits which would not break and which would ensure the safety of electriciansinstallers. His vision came true and KOUVIDIS evolved to one of the largest Greek plastic pipe manufacturers characterized by continuous development and innovation. Recently KOUVIDIS received great distinction at the Manufacturing Awards 2021 where it was awarded with the gold award among the top plastic manufacturing companies in Greece. This distinction is yet another reward for the modern and systematic way that it's operating all these years. Keeping its people at the heart of all its actions and aiming to the sustainable development and the cycling economy, KOUVIDIS will continue to provide value added products and services and to constantly improve the installer's work.

Learn more about our
40+ years journey

www.kouvidis.com

KOUVIDIS

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