TOM

The new generation of PVC-O pipes

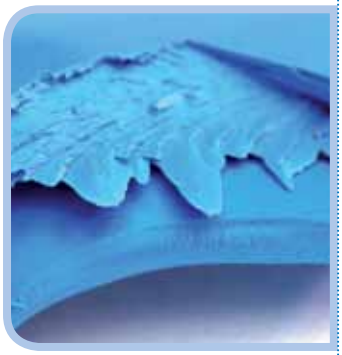




▸ **Excellence in high-pressure water piping**

MOLECOR
canalizaciones

Molecular Orientation, a revolution in PVC

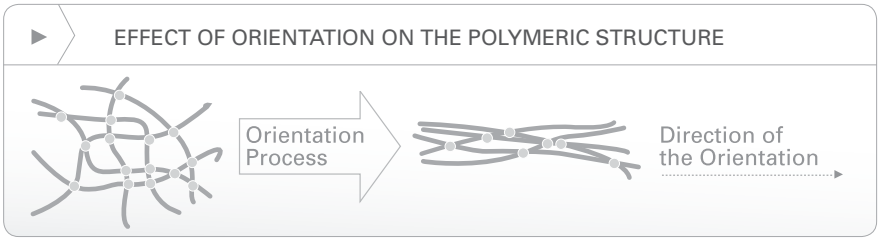


When PVC with its amorphous structure (lower section) is subjected to the orientation process, a laminate structure is obtained (upper section)

TOM© PVC-O pipes are the most advanced pipes for the conveyance of high-pressure water currently available on the market, with a number of exceptional features for this kind of application, thanks to the process of molecular orientation.

PVC is essentially an amorphous polymer in which the molecules are located randomly. However, under certain conditions of pressure, temperature and speed, by stretching the material, it is possible to orient the polymer molecules in the same direction as which the material has been stretched.

Depending on the process parameters used and mostly strecht ratio, a higher or lower orientation degree will be obtained. The result is a plastic with a layered structure which layers can be seen at a glance.



The molecular orientation process modifies the PVC's structure by giving the polymer's molecules a linear orientation.

A plastic with unbeatable properties

The process of molecular orientation greatly enhances PVC's physical and mechanical properties and gives it a number of exceptional features, without altering the advantages and properties of the original polymer. This makes for a plastic with unbeatable qualities in terms of **resistance to traction and fatigue, flexibility and impact resistance.**

When used in high-pressure water pipelines **this type of piping has a high resistance and an extremely long lifetime.** Moreover, the pipe is highly energy-efficient and eco-friendly not only for the way it is made but also because of its subsequent use. Other advantages include reductions in costs and installation times.

For all these reasons, TOM© PVC-O pipes are the best solution for medium and high pressure water networks for irrigation systems, potable water supply, fire extinguishing networks and pumping systems, among other applications.

TOM© pipes.

Cutting-edge technology for water

TOM© PVC-O pipes have been developed by MOLECOR, the only company in the world conceived and dedicated entirely to researching and manufacturing PVC-O pipes. Our manufacturing process is absolutely innovative and uses the most advanced and most reliable technologies currently available.

Up until now, although PVC-O pipes are recognized as providing the highest specifications, the technical limitations of the different manufacturing processes and the shortcomings of those processes in terms of efficiency were a barrier to the extensive use of this kind of pipes.

The technology developed by MOLECOR means that these limitations have now been overcome and it has also helped to make **considerable improvements** in TOM© pipes.

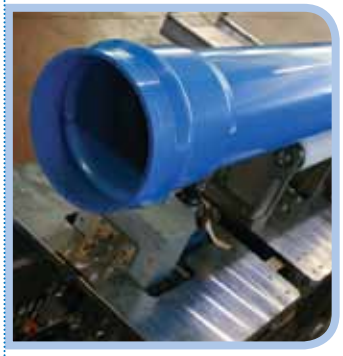
- Molecular Orientation is achieved by applying the precise and homogenous distribution of temperature and high pressures (up to 35 bars) thanks to **quality control checks** carried out on each individual pipe and throughout the entire manufacturing process.

- The TOM© pipes manufacturing process is continuous and fully-automated (as opposed to the traditional discontinuous method), providing **greater control over the end product and ensuring the uniform quality of each pipe.**

Maximum Reliability and Security

Thanks to the extraordinary technical advances of MOLECOR's manufacturing system, TOM© pipes offer the maximum reliability and security, as well as other attractive advantages over other products:

- **Maximum Molecular Orientation:** Class 500, according to the ISO 16422:2006 Standard, the highest orientation degree offering the best mechanical properties.
- **Greater reliability** of the end product.
- Strict dimensional tolerances.
- Homogeneous behavior of the materials used.
- Reinforced socket, shaped during the orientation process.



Manufacturing process developed by Molecor uses most advanced technologies and it is completely automatized. This gives TOM© pipe maximum guarantee and quality.

TOM©: The best choice
for high-pressure fluid transport

The impact of a 500 kg rock dropped from a height of 3 metres leaves a TOM© pipe completely unscathed.

Unbeatable impact resistance

TOM© pipes have **a high resistance to shock .** This means that are minimized breakages during installation or during on-site trials caused by dropping or by impacts from stones.

Furthermore, Molecular Orientation prevents the propagation of cracks and scratches and eliminates the risk of rapid crack behaviour. The result is a spectacular increase in the product's useful life.

High short- and long-term hydrostatic resistance

TOM© pipes offer a resistance to internal pressure of up to **two times the nominal pressure** (32 bars in PN16 bar pipes or 400 psi in PN 200 psi), which means that they can bear sporadic excessive pressure such as water hammers and other malfunctions in the network. Moreover, the material creep behavior is very low, ensuring the durability of the pipe working at nominal pressure for over a hundred years.

Excellent response to water hammers

TOM© pipes offer lower celerity than other piping systems (four times less than ductile iron pipes), which means less water hammers caused by sudden variations in water volume and pressure. This reduces and almost **eliminates the possibility of breakage** during opening and closing in the water network and when pumping gets under way, protecting every component of the network.

Increased hydraulic capacity

Molecular Orientation reduces the pipe wall thickness, giving TOM© pipes a **greater internal diameter and flow section.** Also, the internal surface is extremely smooth, reducing load loss and making it more difficult for deposits to be formed on the inner walls.

As a result, TOM© pipes offer between **15% - 40% more hydraulic capacity** than pipes made from other materials and with the same external dimensions.

Maximum flexibility

Thanks to their excellent elasticity, TOM© pipes can bear **deformation of up to 100 percent of their internal diameter.** When crushed, or in the event of a mechanical accident, TOM© pipe immediately goes back to its original shape, thus minimizing the risk of potential breakage by soil subsidence or sharp edges on rocks or machinery, for example. And thanks to their considerable capacity for bearing heavy loads, TOM© pipes ensure **optimum performance once laid underground.**

Completely corrosion-resistant

Oriented PVC is immune to corrosion and to natural chemical substances, as well as to aggression from micro- and macro-organisms. **TOM© pipes, therefore, are not degradable.** Moreover, they do not require any type of special protection or coating, which means cost-savings.

Total water quality

The quality of the fluid that circulates in TOM© pipes will **always remain unaltered,** given that the material neither suffers corrosion nor migrations within the pipes or in their coating. Mandatory tests such as those made according to the Spanish Law, RD 140/2003 and RD 866/2008, have been made and show that the excellent qualities of these pipes comply with the required health standards for water for human consumption, along with the list of materials and plastic objects made in order to be in contact with food. Also TOM© pipe has the ACS (Sanitary Certification) according French legislation.

Consequently, TOM© pipes **are considered the best application for high-pressure water transport, particularly drinking water, for water supply networks.**

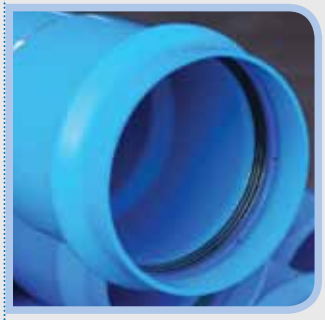
Completely water-tight

Joints are 100 percent watertight and are guaranteed not to displace once the pipes have been installed. TOM© pipes are **easy to join** and can be installed by lower-qualified workers.

Lower cost and easier installation

TOM© PVC-O pipes are **lighter and easier to handle** than other pipes made from other materials: in most cases, handling does not require machinery. What's more, due to the easiness union, flexibility and impact resistance, they make a positive stand out in terms of **cost, performance and installation speed compared to other pipes.**

TOM© pipes will take any kind of deformation without suffering structural damage.

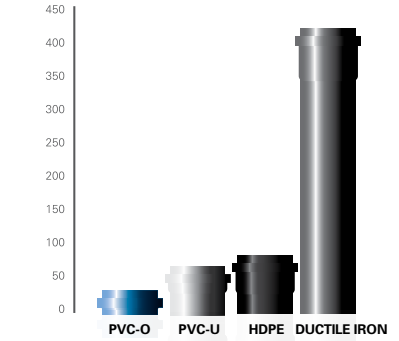


Locked-in ring seals ensure a perfect water-tight fit.

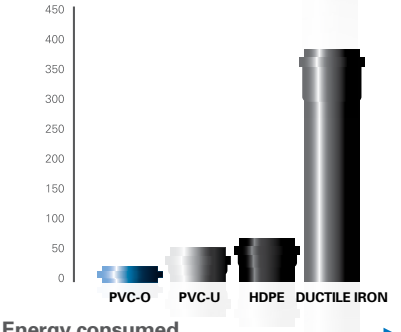
TOM© pipes are extremely lightweight.

The most eco-friendly pipes on the market

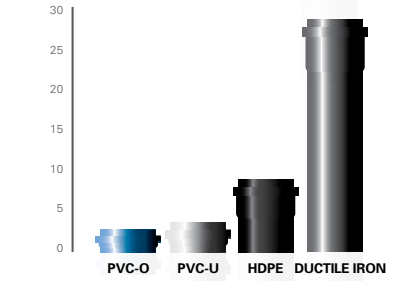
Energy consumed by pipes (raw materials + manufacture) (kWh)



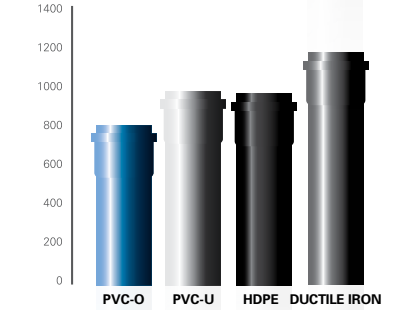
Energy consumed by raw materials (kWh)



Energy consumed in manufacturing (kWh)



Energy consumed by pumping (kWh)



Estimated energy consumption by PVC-O, PVC-U, HDPE and Ductile Iron piping production and use. Polytechnic University of Catalonia, Spain, December 2005.

TOM© makes the most eco-friendly pipes currently available anywhere, and they are also the most embodied-energy efficient.

Energy-efficient

The exceptional mechanical properties of these pipes mean **considerable savings in raw materials:**

- For the same external nominal diameter, TOM© requires less PVC because the pipe wall is thinner.
- Petrol consumption required for manufacture is lower than in other plastic solutions.
- Similarly, TOM© energy consumption in the manufacturing process is lower than in other PVC-O pipes, and unlike metal pipes manufacturing, **it does not require high energy expenses.**

The inner wall of TOM© pipes is extremely smooth, keeping load loss down to a minimum, so the energy required for the powered transporting of fluids is also lower. Throughout their entire lifecycle, TOM© pipes avoid the unnecessary use of considerable amounts of energy resources and reduce CO_2 emissions.

Optimal use of water resources

Thanks to their **long useful life and optimum water-tightness** –not only in normal operating conditions, but also in the event of accidents in the flow network or on the site where they are laid–, TOM© pipes are the best ally for the rational use of water resources.

Water supply networks that used traditional materials are currently registering a leakage rate of up to 25 percent of channeled water, and the latter's chemical deterioration means that some water conduits are currently being replaced despite having been laid only a few years ago. Infrastructures created with TOM© piping are a **tool for managing water resources for generations to come.**

100% recyclable

TOM© products are 100 percent recyclable: they can be ground and reprocessed for reuse in the manufacture of other plastic products.

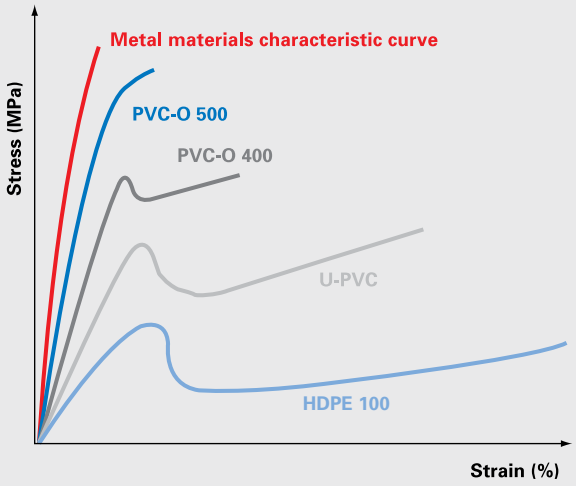
The best mechanical properties

Tensile resistance

In terms of performance, PVC-O shows a very different stress-strain curve when compared conventional plastics and comes very close to the curve of metals.

Mechanical properties complete transformation of PVC-O compared to conventional PVC can only be achieved in the higher class PVC-O class 500, such as TOM© pipes.

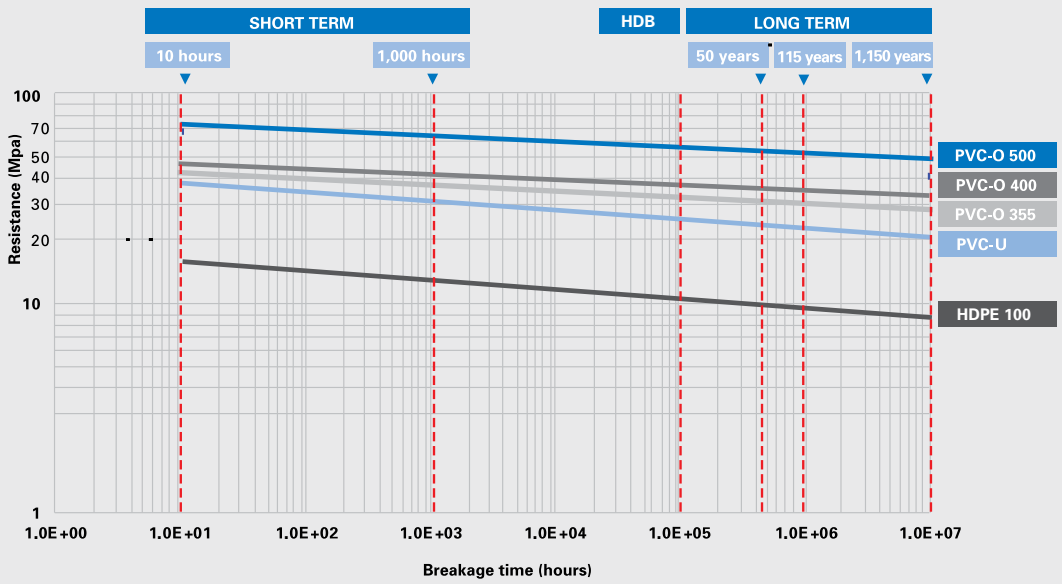
STRESS-STRAIN CURVES



Long-term hydrostatic resistance

Materials lose their mechanical properties when they are subjected to strain over a long period of time. This characteristic, known as creep , appears to a far lesser extent in PVC-O 500 than in conventional plastics, which means better properties over the long term. Bearing in mind that PVC-O is exceptionally resistant to fatigue and has a very good chemical resistance, in common with conventional PVC, it is no exaggeration to say that this kind of piping is capable of withstanding the pressures of work for over a hundred years.

STRESS REGRESSION LINE



Piping and material mechanical properties

The following table summarizes the technical characteristics of TOM© PVC-O pipes in comparison with other plastic pipes.

		TOM© PVC-O 500	PVC	HDPE-100	HDPE-80
Product Standard	**Units**	**ISO 16422**	**EN 1452**	**EN 12201**	**EN 12201**
Minimum required strength (MRS)	MPa	50.0	25.0	10.0	8.0
Overall service coefficient (C)	[]	1.4	2.0(1)	1.25	1.25
Design Stress (σ)	MPa	36.0	12.5	8.0	6.3
Short-term elasticity modulus (E)	MPa	> 4,000	> 3,000	1,100	900
Resistance to axial traction	MPa	> 48	> 48	19	19
Resistance to tangential traction	MPa	> 90	> 48	19	19
Shore Hardness D	[]	81 - 85	70 - 85	60	65

(1) For pipes with a DN ≥110.

Other material characteristics

The table below shows other, non-mechanical characteristics of PVC-O 500.

CHARACTERISTIC	UNITS	VALUE
Density	Kg/dm^3	1.35 - 1.46(1)
PVC Resin k value	[]	> 64
Shore Hardness D at 20º C	[]	81 – 85
Poisson Coefficient	[]	0.35 - 0.41
Vicat Temperature	ºC	> 80
Lineal expansion coefficient	$ºC^{-1}$	$0.8 \cdot 10^{-4}$
Thermal conductivity	Kcal/mhºC	0.14 - 0.18
Specific heat at 20º C	cal/gºC	0.20 - 0.28
Dielectric stiffness	Kv/mm	20 – 40
Dielectric constant at 60 Hz	[]	3.2 - 3.6
Transverse resistivity at 20º C	Ω/cm	$> 10^{16}$
Absolute roughness (ka)	mm	0.007
Absolute roughness (Hazen Williams)	[]	150
Manning Roughness Coefficient	[]	0.009

(1) Although the standard allowance includes this range, TOM© PVC-O pipe is between 1.39 and 1.43 kg/dm^3

Characteristics of the water-tight joint

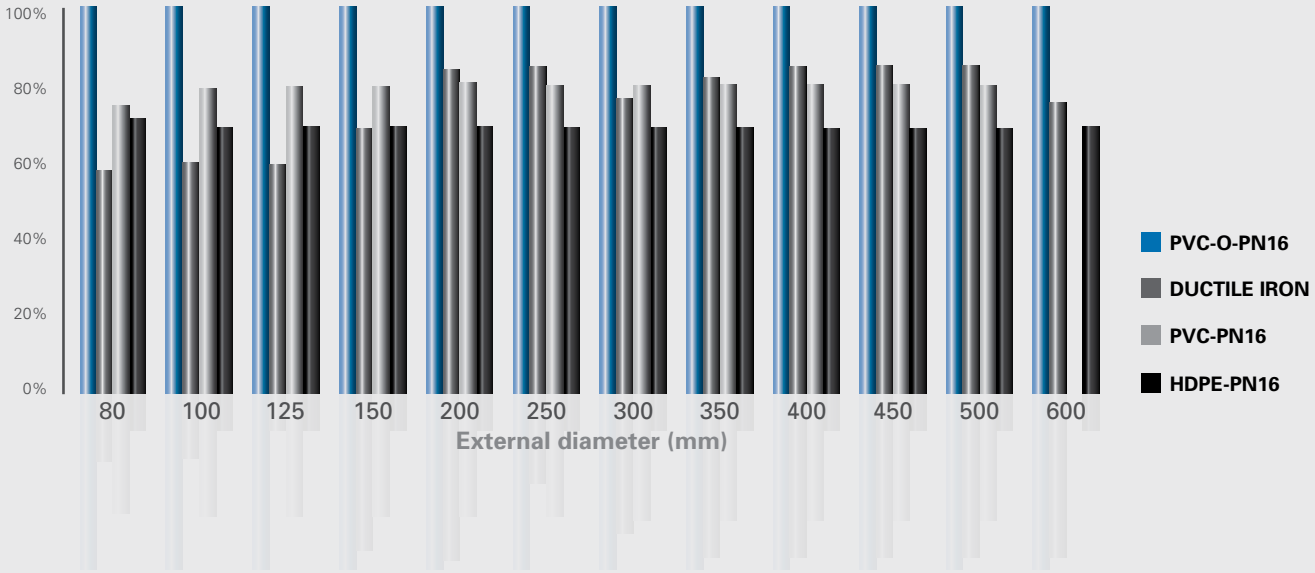
CHARACTERISTIC	UNITS	VALUE
Elastomer hardness	IRHD	60±5

Unbeatable Hydraulic Properties

Hydraulic capacity

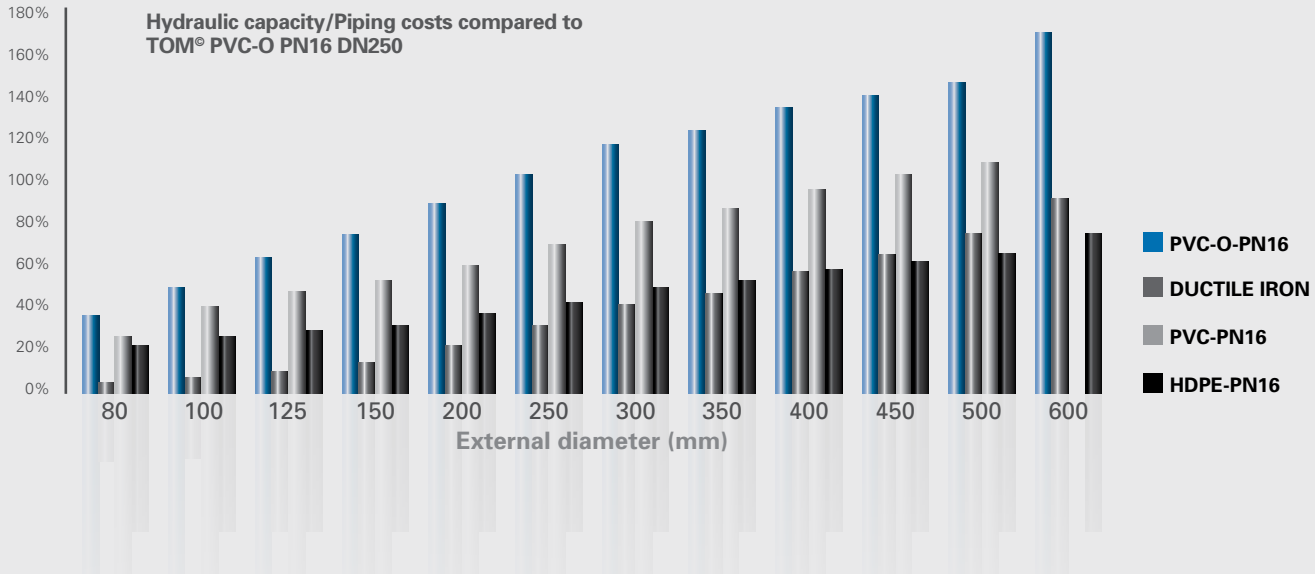
Water pipe requirements are not only related to pressure resistance; they also have to **transport the highest amount of water while consuming the least energy**. TOM© pipe walls are thinner than conventional plastic ones and are smoother inside than metals, which means greater hydraulic capacity is attained

Comparison of hydraulic capacity: TOM© PVC-O PN16 pipes vs other materials (constant load loss)



Using pipes with a lower hydraulic capacity involves necessarily using a larger nominal diameter, which has a negative effect on both profitability and infrastructure investment costs. **Using TOM© means you get more hydraulic capacity for your investments costs.**

Hydraulic capacity/Piping costs compared to TOM© PVC-O PN16 DN250



Water Hammer

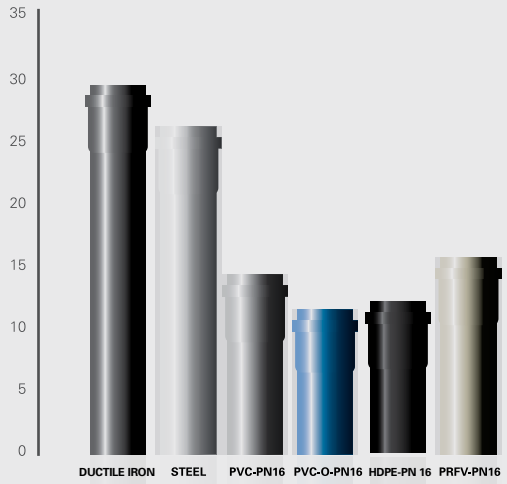
Water hammers occur when liquid flowing through piping stops suddenly when a valve is open or closed, if a pump is stopped or started or by airlocks shifting within the pipe. Water hammers can **place greater pressure on a pipe's working pressure and lead to breakage,** particularly when the pipe has already been damaged by impacts or corrosion.

Water hammers (P) depend on the celerity (a), which is the wave speed, and the fluid's change of speed (V) The celerity depends basically on the pipe's dimensions (the relationship between the external diameter and the minimum thickness) and the specifications of the material with which the tube is made (Young's E module).

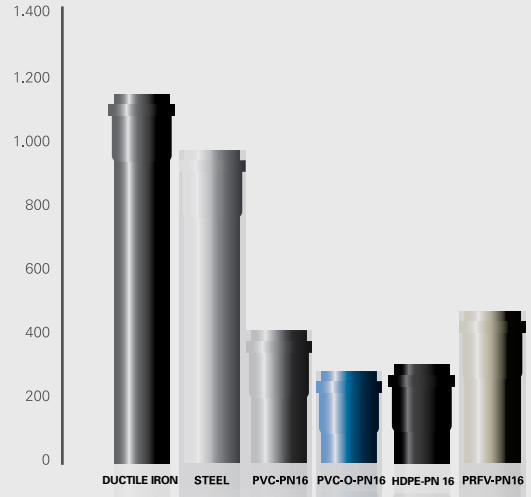
$$P = \frac{a \cdot V}{g}; \qquad a = \frac{1420}{\sqrt{1+\left(\frac{k}{E}\right)\cdot\left(\frac{De}{e_{min}}-2\right)}}$$

TOM©'s PVC-O pipes have a significantly lower celerity than pipes made from other materials, particularly so with metal piping.

Water Hammer (P) in bars



Celerity (a) in m/s



Overpressure produced by suddenly pipe shut down with water flowing at 2.5 m/s.

A range for all **kinds of applications**

TOM© offers a broad range of piping covering all medium- and high-pressure needs.

Applicable Laws and Standards

TOM© PVC-O pipes are manufactured in accordance with ISO 16422:2006 standards, applied to *"Pipes and joints made of oriented unplasticized poly(vinyl chloride) (PVC-O) for the conveyance of water under pressure"* and also according to the French Standard NF T54-948:2010 *"Tubes en poly(chlorure de vinyle) orienté biaxial (PVC-BO) et leurs assemblages"*. (Pipes and joints made of biaxially oriented polyvinyl chloride (PVC-BO)

Other international standards applicable to PVC-O are as follows. Molecor could manufacture pipes according to these standards under request.

- USA: ASTM F 1483-05 "Standard Specification for Oriented Poly(Vinyl Chloride), PVCO, Pressure Pipe"; and "ANSI/AWWA C909-02 Molecularly Oriented Polyvinyl Chloride (PVCO) Pressure Pipe for Water Distribution."
- Australia: AS/NZS 4441:2008 "Oriented PVC (PVC-O) pipes for pressure applications."
- South Africa: SANS 16422:2007 "Pipes and joints made of oriented unplasticezed pol(vinyl) chloride (PVC-O) for the conveyance of water under pressure".
- Spain: UNE-ISO 16422 standard applicable to "Tubos y uniones de poli(cloruro de vinilo) orientado (PVC-O) para una conducción de agua a presión".
- Canada : CSA B137,3,1-09 Molecularly oriented polyvinychoride (PVCO) pipe for pressure applications

Material classification

ISO 16422:2006 standard covers several types of PVC-O material, classified according to their MRS (Minimum Required Strenght), because molecular orientation can be achieved to a greater or lesser extent through different manufacturing processes. **TOM© PVC-O pipe is manufactured only in the highest class (PVC-O 500),** which offers the highest degree of orientation and thus ensures the best mechanical performance. Subsequently, TOM© pipes presents higher advantages compared to other materials

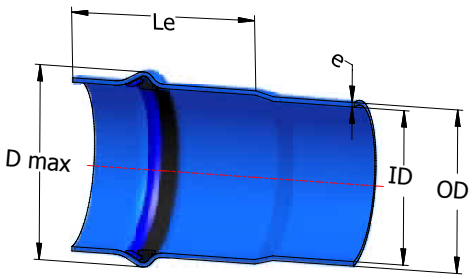
	TOM© PVC-O 500 PIPE			
	PN 12,5	PN 16	PN 20	PN 25
Material Class	500	500	500	500
MRS (MPa)	50.0	50.0	50.0	50.0
Nominal Pressure (bars)	12.5	16.0	20.0	25.0
Burst Pressure over 50 years (bars) (1)	17.5	22.4	28.0	35.0
Burst Pressure over 10 hours (bars) (1)	25.0	30.0	37.0	48.0
Maximum trial pressure onsite (bars) (2)	17.5	21.0	25.0	30.0
Circumferential stiffness (kN/m²)	>5	>7	>11	>20
Colour (3)	blue/purple	blue/purple	blue/purple	blue/purple

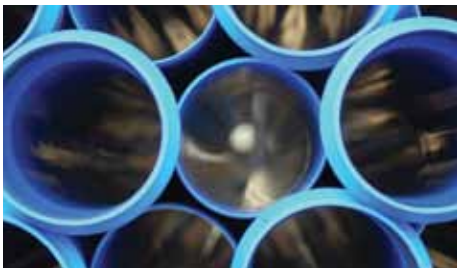
(1) At 20ºC
(2) According the EN 805:2000 standard with estimated water hammer.
(3) Available in blue (water pressure applications), purple (reclaimed) and white (UV rays resistant). Special colours requests may be considered.

Dimensions

Nominal Diameter (DN)	Outside Diameter (OD)		TOM© PVC-O 500							
			PN12.5		PN16		PN20		PN25	
			Inside Diameter (ID)	Wall thickness (e)	Inside Diameter (ID)	Wall thickness (e)	Inside Diameter (ID)	Wall thickness (e)	Inside Diameter (ID)	Wall thickness (e)
	min.	max.	average	min.	average	min.	average	min.	average	min.
mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm
90	90.0	90.3	-	-	84.0	2.0	84.0	2.5	82.2	3.1
110	110.0	110.4	104.4	2.2	104.0	2.4	103.2	3.1	101.4	3.8
140	140.0	140.5	133.0	2.8	132.4	3.1	131.2	3.9	129.2	4.8
160	160.0	160.5	152.0	3.2	151.4	3.5	150.0	4.4	147.6	5.5
200	200.0	200.6	190.0	4.0	189.2	4.4	187.4	5.5	184.4	6.9
225	225.0	225.7	213.6	4.5	212.8	5.0	210.8	6.2	207.4	7.7
250	250.0	250.8	237.4	5.0	236.4	5.5	234.2	6.9	230.6	8.6
315	315.0	316.0	299.2	6.3	298.0	6.9	295.2	8.7	290.6	10.8
400	400.0	401.2	379.8	8.0	378.4	8.8	374.8	11.0	369.0	13.7
500	500.0	501.5	474.6	9.9	472.8	11.0	468.6	13.7	461.2	17.1
630	630.0	631.9	597.8	12.6	595.8	13.8	590.4	17.3	581.0	21.6

TOM© PVC-O pipes are supplied in total lengths of 6 metres (socket included). For other lengths for special projects, price on request.
Dimensions in inches are aproximately.





Packaging

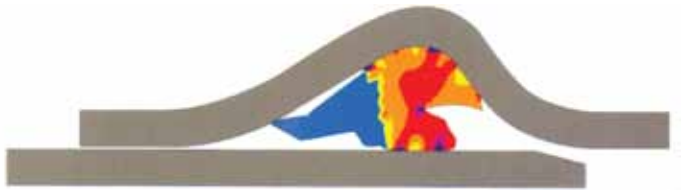
DN mm	PIPES PALLETS	PALLETS/ TRUCK	PIPES TRUCK	METRES[1]/ TRUCK	WIDTH PALLETS(mm)	KG/PALLETS PN16	PN20	PN25
90	69	16	1104	6624	1200	540	550	670
110	76	12	912	5472	1200	750	790	980
140	39	12	468	2808	1100	610	650	800
160	28	12	336	2016	1100	560	610	760
200	18	12	216	1296	1100	540	500	760
225	11	12	132	792	1050	450	610	600
250	11	12	132	792	1100	510	590	730
315	13	8	92-104	546-624	2300	960	1100	1350
400	9	6	54	324	2100	1070	1250	1500
500	4	8	32	192	2300	750	900	1050
630	3	6	18	108	1900	900	1050	1250

(1) Nominal meters (6 meter per pipe).In order to obtain the effectiv length: meters - depth of engagement.

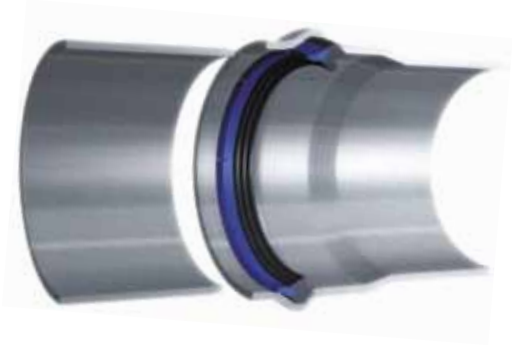
Dimensions in inches are aproximately.

Joints and Watertight Seals

TOM© PVC-O pipes use the sector's most reputable seal for high pressure drinking water pipes: the Anger-LockTM, by Trelleborg Forsheda Pipe Seals. The seal comprises a PP ring and a synthetic rubber lip that is an integrated part of the pipe, avoiding displacement from its setting or movement when installation is taking place.



DN/OD	DEPTH OF ENGAGEMENT (DE)	MAXIMUN DIAMETER (DMAX)
mm	mm	mm
90	170	117
110	175	140
140	190	174
160	200	197
200	225	243
225	250	271
250	270	301
315	325	374
400	375	472
500	375	587
630	425	710



Assembly

In order to do the assembly is necessary to apply lubricant on the chamfer of the spigot end and in the rubber ring joint, and push by hand until the mark of the spigot end is no longer seen.

Apply lubricant on the chamfer of the spigot end and in the rubber ring joint.

Align the pipe and place the spigot end inside the socket or bell.

Firmly push the free end into the other pipe. Introduce until the end marked is no longer seen.

Fittings

TAPPING SADDLES

Allow connecting the pipe in the perpendicular direction to all kinds of fittings (house connections, valves, purges, vents, etc. They are available with screws ends and flange ends.

The saddle must become in solidarity with the pipe. Multidiameter saddles must not be used, but specific PVC saddles for each DN.

FLANGE WITH ANTI-TRACTION SYSTEM

Allows connecting the spigot ends to all kinds of fittings with connection to a flange (valves, elbows, t´s, DN reductions, caps, etc).

Anti-traction system makes the pipe absolutely fixed to the flange.

FITTINGS WITH PLUGS EURO TYPE

Connected directly with the pipe allow to have deviations, reductions and connections on the net (elbows, t´s, DN reductions, etc).

It is very important to fix the fitting to the ground in order to guaranty the net structural resistance.

A wide range of fittings can be used with TOM© pipe. Our technical service will provide you advice in case you need it.

Applications

SUPPLYING (blue TOM©)

Conduits for potable water transport. It is included both water abstraction and water distribution network to city centers, urban network and industrial areas, and water transfer to tanks and reservoirs.



RECLAIMED WATER (purple TOM©)

Pipelines for transport of water that have been treated to remove impurities.



IRRIGATION (blue TOM©)

Water transport pipes for irrigation purposes. It includes irrigated land pipelines, water transfer to tanks and reservoirs.



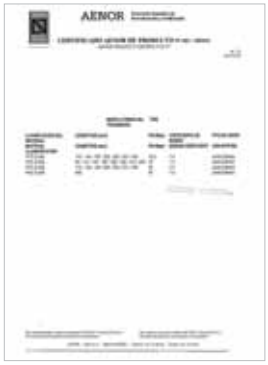
OTHER APPLICATIONS

Sewage
Fire Protection Nets
Industrial Applications
Infrastructural Nets

Certificates

Quality System Certification according to UNE-EN ISO 9001:2000.

AENOR product certification according to UNE ISO 16422:2008. Mark.



AFNOR product certification according to NF T54-948:2010. Mark.

Attestation de Conformite Sanitarie (ACS) according to Frengh legislation.

Sanitary certificate HYDROCHECK (Belgium)

Approval test of RD 140/2003 *"Criterios Sanitarios de la calidad del agua de consumo humano"* (Sanitary Criteria for human water quality consumption).

Tests for obtaining the approval of the RD866/2008 *"materiales y objetos plásticos destinados a entrar en contacto con los alimentos"* (plastic objects and materials in contact with food).

Latest certificates can be downloaded at **www.molecor.com**

Key Factors for **Optimizing Design**

Hydraulic Design

Whether designing a pumping system or a gravity-enabled pipe system, deciding the dimensions of the pipes involves calculating losses in the terms of load, flow-volume and flow speed.

There are several methodologies for calculating these values. The most commonly used are the Hazen-Williams and Prandtl-Colebrook-White formulas.

$$Flow\text{-}volume\ (l/s) = speed\ (m/s) \cdot section \cdot (m^2)\ 10^3$$

Hazen-Williams Formula

$$V = 0.355 \cdot C \cdot D_i^{0.63} \cdot J^{0.54}$$

Prandtl -Colebrook-White Formula

$$V = -2\ \sqrt{2 \cdot g \cdot D_i \cdot J} \cdot \log\left(\frac{K_a}{3.71 \cdot D_i} + \frac{2{,}51\ \upsilon}{D_i\sqrt{2 \cdot g \cdot D_i \cdot J}}\right)$$

V = Average Speed in m/s
D_i = Internal Diameter in m
J = Pressure loss in m/m
C = Hazen-Williams Roughness Constant (for PVC-O; C = 150)
g = Gravity acceleration in m/s^2
k_a = Absolute roughness in metres (for PVC-O; $k_a = 0{,}007 \cdot 10^3$ m)
υ = Kinematic viscosity of the fluid (m^2/s) (for water at 20ºC; $v = 1{,}0 \cdot 10^{-6}$)

Another factor to be taken into account is the load loss produced by accessories (elbows, reducers, tees etc) and valves.

There are tables available for calculating load loss, flow-volume and speeds using the Hazen-Williams formula.

When determining water speed, economic factors must be taken into account: (optimization of the investment in terms of water pumping) as well as the admissible values for water hammers.

Generally speaking, the minimum value used for avoiding sediments is 0.5 m/s, and the maximum values are between 2.0 and 2.5 m/s, depending on the diameter of the pipe.

Pressure loss tables

TOM© PVC-O 500 PN16 (235 psi)

INTERNAL DIAMETER	DN90 PN16 84.0		DN110 PN16 104.0		DN140 PN16 132.4		DN160 PN16 151.4		DN200 PN16 189.2		DN225 PN16 212.8		DN250 PN16 236.4		DN315 PN16 298.0		DN400 PN16 378.4		DN500 PN16 472.8		DN630 PN16 595.8	
Speed m/s	Flow l/s	J m/km	Flow l/s	J m/km	Flow l/s	J m/km	Flow l/s	J m/km	Flow l/s	J m/km	Flow l/s	J m/km	Flow l/s	J m/km	Flow l/s	J m/km	Flow l/s	J m/km	Flow l/s	J m/km	Flow l/s	J m/km
0.1	0.55	0.16	0.85	0.13	1.38	0.09	1.80	0.08	2.81	0.06	3.56	0.05	4.39	0.05	6.97	0.04	11.2	0.03	17.6	0.02	27.9	0.02
0.2	1.11	0.58	1.70	0.45	2.75	0.34	3.60	0.29	5.62	0.22	7.11	0.20	8.78	0.17	13.9	0.13	22.5	0.10	35.1	0.08	55.8	0.06
0.3	1.66	1.23	2.55	0.96	4.13	0.72	5.40	0.62	8.43	0.48	10.7	0.42	13.2	0.37	20.9	0.28	33.7	0.21	52.7	0.16	83.6	0.12
0.4	2.22	2.09	3.40	1.63	5.51	1.23	7.20	1.05	11.2	0.81	14.2	0.71	17.6	0.63	27.9	0.48	45.0	0.36	70.2	0.28	111.5	0.21
0.5	2.77	3.17	4.25	2.47	6.88	1.86	9.00	1.59	14.1	1.23	17.8	1.07	21.9	0.95	34.9	0.72	56.2	0.55	87.8	0.42	139.4	0.32
0.6	3.33	4.44	5.10	3.46	8.26	2.61	10.8	2.23	16.9	1.72	21.3	1.50	26.3	1.33	41.8	1.01	67.5	0.77	105.3	0.59	167.3	0.45
0.7	3.88	5.90	5.95	4.60	9.64	3.47	12.6	2.97	19.7	2.29	24.9	1.99	30.7	1.76	48.8	1.35	78.7	1.02	122.9	0.79	195.2	0.60
0.8	4.43	7.56	6.80	5.89	11.0	4.44	14.4	3.80	22.5	2.93	28.5	2.55	35.1	2.26	55.8	1.72	90.0	1.30	140.5	1.01	223.0	0.77
0.9	4.99	9.40	7.65	7.33	12.4	5.53	16.2	4.73	25.3	3.64	32.0	3.18	39.5	2.81	62.8	2.14	101.2	1.62	158.0	1.25	250.9	0.96
1.0	5.54	11.43	8.49	8.91	13.8	6.72	18.0	5.75	28.1	4.43	35.6	3.86	43.9	3.42	69.7	2.61	112.5	1.97	175.6	1.52	278.8	1.16
1.1	6.10	13.6	9.34	10.6	15.1	8.02	19.8	6.85	30.9	5.28	41.1	5.04	48.3	4.08	76.7	3.11	123.7	2.35	193.1	1.81	306.7	1.39
1.2	6.7	16.0	10.2	12.5	16.5	9.42	21.6	8.05	33.7	6.21	42.7	5.41	52.7	4.79	83.7	3.65	135.0	2.77	210.7	2.13	334.6	1.63
1.3	7.2	18.6	11.0	14.5	17.9	10.9	23.4	9.34	36.5	7.20	46.2	6.28	57.1	5.55	90.7	4.24	146.2	3.21	228.2	2.47	362.4	1.89
1.4	7.8	21.3	11.9	16.6	19.3	12.5	25.2	10.7	39.4	8.26	49.8	7.20	61.4	6.37	97.6	4.86	157.4	3.68	245.8	2.84	390.3	2.17
1.5	8.3	24.2	12.7	18.9	20.7	14.2	27.0	12.2	42.2	9.39	53.3	8.18	65.8	7.24	104.6	5.52	168.7	4.18	263.4	3.22	418.2	2.46
1.6	8.9	27.3	13.6	21.3	22.0	16.0	28.8	13.7	45.0	10.6	56.9	9.22	70.2	8.16	111.6	6.23	179.9	4.71	280.9	3.63	446.1	2.77
1.7	9.4	30.5	14.4	23.8	23.4	18.0	30.6	15.4	47.8	11.8	60.5	10.32	74.6	9.13	118.6	6.96	191.2	5.27	298.5	4.06	474.0	3.10
1.8	10.0	33.9	15.3	26.4	24.8	20.0	32.4	17.1	50.6	13.2	64.0	11.5	79.0	10.1	125.5	7.74	202.4	5.86	316.0	4.52	501.8	3.45
1.9	10.5	37.5	16.1	29.2	26.2	22.1	34.2	18.9	53.4	14.5	67.6	12.7	83.4	11.2	132.5	8.56	213.7	6.48	333.6	4.99	529.7	3.81
2.0	11.1	41.2	17.0	32.1	27.5	24.3	36.0	20.7	56.2	16.0	71.1	13.9	87.8	12.3	139.5	9.41	224.9	7.12	351.1	5.49	557.6	4.19
2.1	11.6	45.1	17.8	35.2	28.9	26.5	37.8	22.7	59.0	17.5	74.7	15.3	92.2	13.5	146.5	10.3	236.2	7.79	368.7	6.01	585.5	4.59
2.2	12.2	49.2	18.7	38.4	30.3	28.9	39.6	24.7	61.9	19.1	78.2	16.6	96.6	14.7	153.4	11.2	247.4	8.50	386.2	6.55	613.4	5.00
2.3	12.7	53.4	19.5	41.6	31.7	31.4	41.4	26.9	64.7	20.7	81.8	18.1	101.0	16.0	160.4	12.2	258.7	9.23	403.8	7.11	641.2	5.43
2.4	13.3	57.8	20.4	45.1	33.0	34.0	43.2	29.1	67.5	22.4	85.4	19.5	105.3	17.3	167.4	13.2	269.9	9.98	421.4	7.70	669.1	5.88
2.5	13.9	62.4	21.2	48.6	34.4	36.7	45.0	31.4	70.3	24.2	88.9	21.1	109.7	18.6	174.4	14.2	281.1	10.8	438.9	8.30	697.0	6.34
2.6	14.4	67.1	22.1	52.3	35.8	39.4	46.8	33.7	73.1	26.0	92.5	22.7	114.1	20.0	181.3	15.3	292.4	11.6	456.5	8.93	724.9	6.82
2.7	15.0	71.9	22.9	56.0	37.2	42.3	48.6	36.2	75.9	27.9	96.0	24.3	118.5	21.5	188.3	16.4	303.6	12.4	474.0	9.57	752.8	7.31
2.8	15.5	76.9	23.8	59.9	38.5	45.2	50.4	38.7	78.7	29.8	99.6	26.0	122.9	23.0	195.3	17.5	314.9	13.3	491.6	10.2	780.6	7.82
2.9	16.1	82.1	24.6	64.0	39.9	48.3	52.2	41.3	81.5	31.8	103.1	27.7	127.3	24.5	202.3	18.7	326.1	14.2	509.1	10.9	808.5	8.34
3.0	16.6	87.4	25.5	68.1	41.3	51.4	54.0	43.9	84.3	33.9	106.7	29.5	131.7	26.1	209.2	19.9	337.4	15.1	526.7	11.6	836.4	8.88
3.1	17.2	92.9	26.3	72.4	42.7	54.6	55.8	46.7	87.2	36.0	110.3	31.4	136.1	27.8	216.2	21.2	348.6	16.0	544.3	12.4	864.3	9.44
3.2	17.7	98.5	27.2	76.8	44.1	57.9	57.6	49.5	90.0	38.2	113.8	33.3	140.5	29.4	223.2	22.5	359.9	17.0	561.8	13.1	892.2	10.0
3.3	18.3	104.3	28.0	81.3	45.4	61.3	59.4	52.4	92.8	40.4	117.4	35.2	144.8	31.2	230.2	23.8	371.1	18.0	579.4	13.9	920.0	10.6
3.4	18.8	110.2	28.9	85.9	46.8	64.8	61.2	55.4	95.6	42.7	120.9	37.2	149.2	32.9	237.1	25.1	382.4	19.0	596.9	14.7	947.9	11.2
3.5	19.4	116.3	29.7	90.6	48.2	68.4	63.0	58.5	98.4	45.1	124.5	39.3	153.6	34.8	244.1	26.5	393.6	20.1	614.5	15.5	975.8	11.8
3.6	20.0	122.5	30.6	95.5	49.6	72.0	64.8	61.6	101.2	47.5	128.0	41.4	158.0	36.6	251.1	28.0	404.9	21.2	632.0	16.3	1003.7	12.5
3.7	20.5	128.9	31.4	100.5	50.9	75.8	66.6	64.8	104.0	50.0	131.6	43.6	162.4	38.5	258.1	29.4	416.1	22.3	649.6	17.2	1031.6	13.1
3.8	21.1	135.4	32.3	105.5	52.3	79.6	68.4	68.1	106.8	52.5	135.2	45.8	166.8	40.5	265.0	30.9	427.3	23.4	667.2	18.0	1059.4	13.8
3.9	21.6	142.1	33.1	110.7	53.7	83.5	70.2	71.4	109.6	55.1	138.7	48.0	171.2	42.5	272.0	32.4	438.6	24.5	684.7	18.9	1087.3	14.4
4.0	22.2	148.9	34.0	116.1	55.1	87.6	72.0	74.9	112.5	57.7	142.3	50.3	175.6	44.5	279.0	34.0	449.8	25.7	702.3	19.8	1115.2	15.1

The values for TOM© PN12.5 are very similar to those for the previous ones wich means that the same table may be used for calculations

TOM© PVC-O 500 PN25 (360 psi)

INTERNAL DIAMETER	DN90 PN25 82.2		DN110 PN25 101.4		DN140 PN25 129.2		DN160 PN25 147.6		DN200 PN25 184.4		DN225 PN16 207,4		DN250 PN25 230.6		DN315 PN25 290.6		DN400 PN25 369.0		DN500 PN25 461.2		DN630 PN25 581.0	
Speed m/s	Flow l/s	J m/km	Flow l/s	J m/km	Flow l/s	J m/km	Flow l/s	J m/km	Flow l/s	J m/km	Flow l/s	J m/km	Flow l/s	J m/km	Flow l/s	J m/km	Flow l/s	J m/km	Flow l/s	J m/km	Flow l/s	J m/km
0.1	0.53	0.16	0.81	0.13	1.31	0.10	1.71	0.08	2.67	0.06	3.38	0.06	4.18	0.05	6.63	0.04	10.7	0.03	16.7	0.02	48.6	0.05
0.2	1.06	0.59	1.62	0.47	2.62	0.35	3.42	0.30	5.34	0.23	6.76	0.20	8.35	0.18	13.3	0.14	21.4	0.10	33.4	0.08	53.0	0.06
0.3	1.59	1.26	2.42	0.99	3.93	0.74	5.13	0.64	8.01	0.49	10.1	0.43	12.5	0.38	19.9	0.29	32.1	0.22	50.1	0.17	79.5	0.13
0.4	2.12	2.15	3.23	1.68	5.24	1.27	6.84	1.08	10.7	0.84	13.5	0.73	16.7	0.64	26.5	0.49	42.8	0.37	66.8	0.29	106.0	0.22
0.5	2.65	3.25	4.04	2.54	6.56	1.92	8.56	1.64	13.4	1.26	16.9	1.10	20.9	0.97	33.2	0.74	53.5	0.56	83.5	0.43	132.6	0.33
0.6	3.18	4.55	4.85	3.56	7.87	2.68	10.3	2.30	16.0	1.77	20.3	1.55	25.1	1.37	39.8	1.04	64.2	0.79	100.2	0.61	159.1	0.46
0.7	3.71	6.05	5.65	4.74	9.18	3.57	12.0	3.06	18.7	2.36	23.6	2.06	29.2	1.82	46.4	1.39	74.9	1.05	116.9	0.81	185.6	0.62
0.8	4.25	7.75	6.46	6.07	10.5	4.57	13.7	3.91	21.4	3.02	27.0	2.63	33.4	2.33	53.1	1.78	85.6	1.34	133.6	1.04	212.1	0.79
0.9	4.78	9.64	7.27	7.55	11.8	5.69	15.4	4.87	24.0	3.76	30.4	3.27	37.6	2.89	59.7	2.21	96.2	1.67	150.4	1.29	238.6	0.98
1.0	5.31	11.72	8.08	9.17	13.1	6.91	17.1	5.92	26.7	4.56	33.8	3.98	41.8	3.52	66.3	2.68	106.9	2.03	167.1	1.57	265.1	1.20
1.1	5.84	14.0	8.88	10.9	14.4	8.25	18.8	7.06	29.4	5.45	37.2	4.75	45.9	4.19	73.0	3.20	117.6	2.42	183.8	1.87	291.6	1.43
1.2	6.4	16.4	9.7	12.9	15.7	9.69	20.5	8.30	32.0	6.40	40.5	5.58	50.1	4.93	79.6	3.76	128.3	2.85	200.5	2.19	318.1	1.68
1.3	6.9	19.0	10.5	14.9	17.0	11.2	22.2	9.62	34.7	7.42	43.9	6.47	54.3	5.72	86.2	4.36	139.0	3.30	217.2	2.55	344.7	1.94
1.4	7.4	21.9	11.3	17.1	18.4	12.9	24.0	11.0	37.4	8.51	47.3	7.42	58.5	6.56	92.9	5.01	149.7	3.79	233.9	2.92	371.2	2.23
1.5	8.0	24.8	12.1	19.4	19.7	14.6	25.7	12.5	40.1	9.67	50.7	8.43	62.6	7.45	99.5	5.69	160.4	4.30	250.6	3.32	397.7	2.53
1.6	8.5	28.0	12.9	21.9	21.0	16.5	27.4	14.1	42.7	10.9	54.1	9.50	66.8	8.40	106.1	6.41	171.1	4.85	267.3	3.74	424.2	2.86
1.7	9.0	31.3	13.7	24.5	22.3	18.5	29.1	15.8	45.4	12.2	57.4	10.63	71.0	9.39	112.8	7.17	181.8	5.43	284.0	4.18	450.7	3.20
1.8	9.6	34.8	14.5	27.2	23.6	20.5	30.8	17.6	48.1	13.6	60.8	11.8	75.2	10.4	119.4	7.97	192.5	6.03	300.7	4.65	477.2	3.55
1.9	10.1	38.5	15.3	30.1	24.9	22.7	32.5	19.4	50.7	15.0	64.2	13.1	79.4	11.5	126.0	8.81	203.2	6.67	317.4	5.14	503.7	3.93
2.0	10.6	42.3	16.2	33.1	26.2	25.0	34.2	21.4	53.4	16.5	67.6	14.4	83.5	12.7	132.7	9.69	213.9	7.33	334.1	5.65	530.2	4.32
2.1	11.1	46.3	17.0	36.2	27.5	27.3	35.9	23.4	56.1	18.0	70.9	15.7	87.7	13.9	139.3	10.6	224.6	8.03	350.8	6.19	556.8	4.73
2.2	11.7	50.5	17.8	39.5	28.8	29.8	37.6	25.5	58.8	19.7	74.3	17.1	91.9	15.1	145.9	11.6	235.3	8.75	367.5	6.74	583.3	5.15
2.3	12.2	54.8	18.6	42.9	30.2	32.3	39.4	27.7	61.4	21.3	77.7	18.6	96.1	16.4	152.5	12.6	246.0	9.50	384.2	7.32	609.8	5.59
2.4	12.7	59.3	19.4	46.4	31.5	35.0	41.1	29.9	64.1	23.1	81.1	20.1	100.2	17.8	159.2	13.6	256.7	10.28	400.9	7.92	636.3	6.05
2.5	13.3	64.0	20.2	50.1	32.8	37.7	42.8	32.3	66.8	24.9	84.5	21.7	104.4	19.2	165.8	14.7	267.4	11.1	417.6	8.55	662.8	6.53
2.6	13.8	68.8	21.0	53.8	34.1	40.6	44.5	34.7	69.4	26.8	87.8	23.4	108.6	20.6	172.4	15.8	278.0	11.9	434.4	9.19	689.3	7.02
2.7	14.3	73.7	21.8	57.7	35.4	43.5	46.2	37.2	72.1	28.7	91.2	25.0	112.8	22.1	179.1	16.9	288.7	12.8	451.1	9.85	715.8	7.53
2.8	14.9	78.9	22.6	61.7	36.7	46.5	47.9	39.8	74.8	30.7	94.6	26.8	116.9	23.7	185.7	18.1	299.4	13.7	467.8	10.5	742.3	8.05
2.9	15.4	84.2	23.4	65.9	38.0	49.7	49.6	42.5	77.4	32.8	98.0	28.6	121.1	25.3	192.3	19.3	310.1	14.6	484.5	11.2	768.8	8.59
3.0	15.9	89.6	24.2	70.2	39.3	52.9	51.3	45.3	80.1	34.9	101.4	30.4	125.3	26.9	199.0	20.5	320.8	15.5	501.2	12.0	795.4	9.15
3.1	16.5	95.3	25.0	74.6	40.6	56.2	53.0	48.1	82.8	37.1	104.7	32.3	129.5	28.6	205.6	21.8	331.5	16.5	517.9	12.7	821.9	9.72
3.2	17.0	101.0	25.8	79.1	42.0	59.6	54.8	51.0	85.5	39.3	108.1	34.3	133.6	30.3	212.2	23.1	342.2	17.5	534.6	13.5	848.4	10.3
3.3	17.5	106.9	26.6	83.7	43.3	63.1	56.5	54.0	88.1	41.7	111.5	36.3	137.8	32.1	218.9	24.5	352.9	18.5	551.3	14.3	874.9	10.9
3.4	18.0	113.0	27.5	88.5	44.6	66.7	58.2	57.1	90.8	44.0	114.9	38.4	142.0	33.9	225.5	25.9	363.6	19.6	568.0	15.1	901.4	11.5
3.5	18.6	119.3	28.3	93.3	45.9	70.4	59.9	60.2	93.5	46.5	118.2	40.5	146.2	35.8	232.1	27.3	374.3	20.7	584.7	15.9	927.9	12.2
3.6	19.1	125.6	29.1	98.3	47.2	74.1	61.6	63.5	96.1	48.9	121.6	42.7	150.4	37.7	238.8	28.8	385.0	21.8	601.4	16.8	954.4	12.8
3.7	19.6	132.2	29.9	103.5	48.5	78.0	63.3	66.8	98.8	51.5	125.0	44.9	154.5	39.7	245.4	30.3	395.7	22.9	618.1	17.7	980.9	13.5
3.8	20.2	138.9	30.7	108.7	49.8	81.9	65.0	70.1	101.5	54.1	128.4	47.2	158.7	41.7	252.0	31.8	406.4	24.1	634.8	18.6	1007.5	14.2
3.9	20.7	145.7	31.5	114.1	51.1	86.0	66.7	73.6	104.2	56.8	131.8	49.5	162.9	43.7	258.7	33.4	417.1	25.3	651.5	19.5	1034.0	14.9
4.0	21.2	152.7	32.3	119.5	52.4	90.1	68.4	77.1	106.8	59.5	135.1	51.9	167.1	45.8	265.3	35.0	427.8	26.5	668.2	20.4	1060.5	15.6

For TOM© PN20 refer to technical dossier or the Technical Department.

Water Hammer

To **calculate possible excess pressure** (P) produced by water hammers, the celerity (α) -which is a characteristic of the pipe and the fluid that it transports- must first be determined, and the possible change in water speed (V) owing to opening and closing in the water network and when pumping starts or ends, must be calculated.

$$P = \frac{a \cdot V}{g}; \qquad a = \frac{1420}{\sqrt{1+\left(\frac{k}{E}\right)\cdot\left(\frac{De}{e_{min}}-2\right)}}$$

TOM© PN16 (235 psi) PIPES

V	a	P (water hammer)	
m/s	m/s	m	bar
0.5	293	15	1.5
1.0	293	30	3.0
1.5	293	45	4.5
2.0	293	60	6.0
2.5	293	75	7.5
3.0	293	90	9.0
3.5	293	105	10.5
4.0	293	119	11.9

K9 DUCTILE IRON PIPES

V	a	P (water hammer)	
m/s	m/s	m	bar
0.5	1100	56	5.6
1.0	1100	112	11.2
1.5	1100	168	16.8
2.0	1100	224	22.4
2.5	1100	280	28.0
3.0	1100	336	33.6
3.5	1100	392	39.2
4.0	1100	449	44.9

Air locks in the pipes during filling can be highly damaging when water hammers arise and can cause excess pressure far beyond the levels established in the tables above. That is why it is important to follow the following recommendations:

- **Filling the pipe** should only be carried out at low speed (approximately 0.05 m/s) and at the lowest point in the pipe system.
- **When installing purging mechanisms** (double effect suction mechanisms) at the highest points on each section of pipe.
- During filling it is important to leave open the elements capable of **evacuating air** (valves), and close them from bottom to top in the pipe as the pipe fills up with water.

Reduction ratios: Temperature and Application

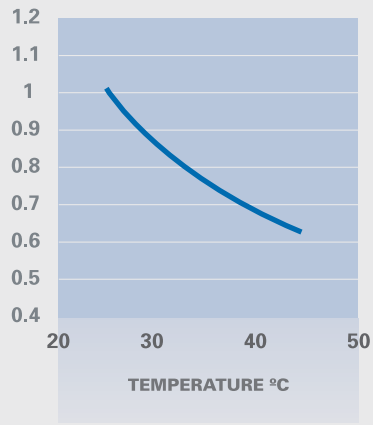
High temperatures (over 25ºC) or demanding or aggressive applications can reduce Allowable Operating Pressure **(PFA)** of pipes in comparison to the Nominal Pressure (NP).

$$PFA = PN \cdot f_T \cdot f_A$$

The derating factor (f_T) as function of operating temperature can be obtained from the graph on the right.
The derating factor related to application of the system (f_A) must be determined by the Project Manager.

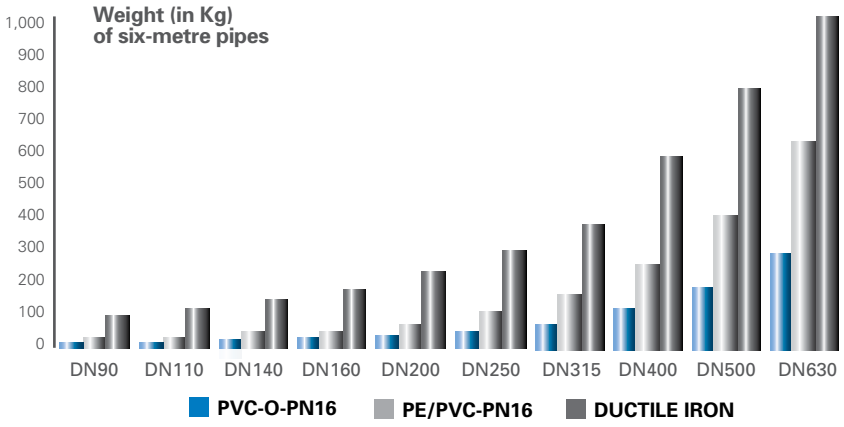
Note: Project design and execution is responsibility of the Project Manager and the Contractor, respectively.

Temperature Ratio Graph



Quick, low-priced installation

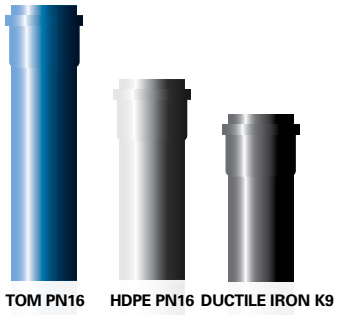
TOM© PVC-O pipes are less than half PVC and HDPE pipes weight: between six and twelve times less per linear metre than ductile iron pipes of the same nominal external diameter. Due to their lightness, **they can be lifted without mechanical assistance** (cranes, hoists, etc), up to a diameter of DN 315 mm, which brings down the overall cost of installation.



Because TOM© pipes have a high resistance, they offer considerable **advantages in terms of unloading, installation in trenches and pipe-to-pipe connection.** Moreover, these pipes are so easy to connect to one another that they offer very high performance: they can be handled and installed by lower-qualified workers and without machinery (up to DN315).

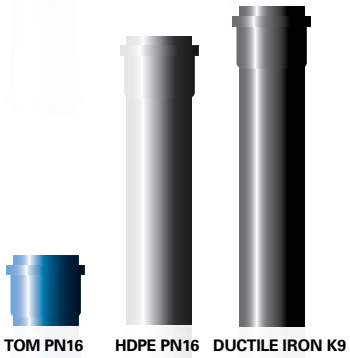
For all these reasons **TOM© offers huge advantages in terms of installation in metres/installation-hours** compared to other solutions.

Installation performance (m/hour)



Figures for DN 200-250

Installation Costs (euro/m)



Figures for DN 200-250

Transport and Storage

TOM© pipes characteristics make them easy to transport and store,which means considerable savings in costs.

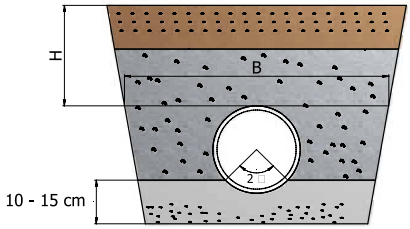
To optimize transport, it is advisable to stick to the following guidelines:

- If different diameters are going to be transported in the same batch, the biggest diameters must be placed below.
- Leave the sockets free, alternating sockets and free ends.

To avoid damaging pipes in storage, it is advisable to:

- Store the pipes horizontally on a flat surface, on supports spaced 1.5 metres apart, to keep the pipes from bowing.
- Do not stack higher than 1.5 metres
- Leave the sockets free, alternating sockets and free ends.
- If the pipes are stored in direct sunlight, cover the pallets with opaque material.

Trench dimensions



Excavation

Although other types of applications are possible, **TOM© pipes are particularly recommended for underground installation.** The dimensions of the trench will depend on the loads to which the pipes will be submitted (road traffic, soil types, etc). As a rule of thumb, when there is no road traffic involved, the pipes' crown will be at a minimum depth of 0.6 metres (60 cm); with road traffic, the minimum depth is 1 metre.

The **minimum width of the trench** can be calculated using the following tables:

DN (mm)	DN (inch)	Minium width of trench B (m)
90-250	3,5"-10"	0.60
315	12"	0.85
400	16"	1.10
500	18"	1.20
630	24"	1.35

Depth of trench H (m)	Minium width of trench B (m)
h < 1.00	0.60
1.00 < h < 1.75	0.80
1.75 < h < 4.00	0.90
h < 4.00	1.00

The trench **surface must** ensure homogeneous, uniform and solid support along the entire length of the pipe.

Assembly

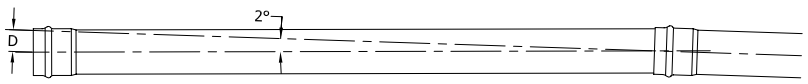
- Checks must be made to **ensure that joints are clean** both inside the pipe and outside.
- To facilitate assembly, it is advisable to **lubricate the sockets and free ends using lubricating soap.**
- **Align the pipe-ends** and slot the sockets into place.
- **Pipes can be slotted into one another** using levers (use only materials that will not damage the pipes, e.g. wood), or slings. With small diameters, however, owing to the elastic joint system and the lightness of the pipe, a short, sharp movement of the hand is enough to couple the pipes.

Angular Deviation

The installation allows for angular deviation in the joints between pipes, which means that the piping can be channeled following a desired line.

DN		Maximum angular deviation	Displacement between sockets
(mm)	(inch)	Angle (º)	D (mm) (1)
90-630	3.5"-24"	2º	200

(1) Pipes not exceeding 6 metres in length.



Anchoring

Pipes that are subjected to internal hydrostatic pressure are also subject of thrust forces at every point of change of direction (angular deviation of the pipe, elbows, curves, etc) and in parts and components that increase or reduce the pipe's cross-section, such as valves, branches, overflows, etc. These forces can be extremely strong and are even capable of moving the ground, causing pipes to uncouple. In general terms, the thrust forces can be gauged using the following formula

$$Force\ (Kg) = k \cdot Pressure\ (bars) \cdot Pipe\ Cross\text{-}Section\ (cm^2)$$

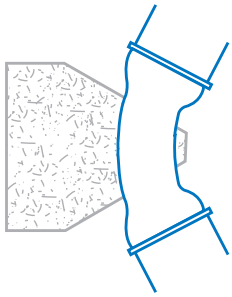
$$In\ caps\ and\ tees\ at\ 90^{\circ}:\ k = 1$$

$$In\ reducers:\ k = 1 - \frac{Smallest\ cross\text{-}section}{Biggest\ cross\text{-}section}$$

$$In\ changes\ of\ direction:\ k = 2 \cdot sen\ \frac{\beta}{2}$$

It is important to ensure that the concrete is poured directly onto the previously positioned ground and that it has the required mechanical resistance. When designing the anchoring, bear in mind that **the joints must be left free** to enable inspection during subsequent hydraulic trials.

Anchoring at points of change of direction



Bedding and Filling the Trench

To analyze the optimal and most efficient way for the preparation of bedding on which to settle the pipe and the subsequent filling and compacting the ground on the sides and top of the pipe, see our installation instructions or contact with our technical and commercial service

Field trials and Entry into Service

The EN 805: 2000 Water Supply Standard is applicable to all aspects of on-site trials and Entry into Service. During installation, it is important to carry out trials on the lengths of completely laid pipeline (the length can vary between 500 and 1,000 metres). The ends of each length of pipeline will be sealed off using the appropriate components, and the pipeline must be partly filled and with the joints in full view.

The trial pressure (STP) in N/mm^2 (0.1 N/mm^2 = 1 atm) will be as follows:

a) If the water hammer has been calculated precisely: STP = MDP + 0.1

b) If the water hammer is estimated, use the lesser of the following two values: STP = MDP + 0.5 and STP = 1.5 · MDP

MDP is the Maximum Design Pressure, i.e. the maximum allowable pressure in a pipe, including the effect of a water hammer.

The Entry into Service of piping for drinking water must comply with the required health standards for water for human consumption.

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