1. VICOPROP, origins, composition and applications

Polypropylene is a thermoplastic semi-crystalline polymer which is produced through a polymerisation of the polypropylene when in the presence of a catalytic stereospecific.

In its natural state, polypropylene is colourless, without any smell and translucent. The cristalinity of the polypropylene (isostatic) allows it to withdraw the advantages as a final product (low density, high rigidity, high resistance to heat, excellent chemical resistance and high resistance to impact).

Another characteristic of the polypropylene is its non-toxicity which allows the contact with alimentary products (ex. transport and storage of water for consumption). There is no danger when in contact with skin or inhalation of the polymer under normal conditions.

Although combustible, polypropylene is considered non inflammable. The combustion self-ignition point is of 380ºC, high above its fusion point. However, any contact with fire or ignition points during stockage should be avoided.

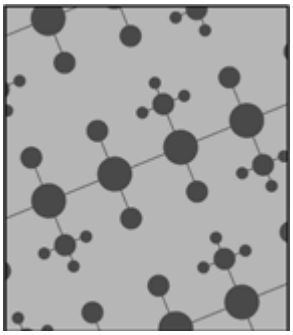


Fig. 1- Polypropylene chain

Chart 1 indicates the properties of PP-R, as raw material for the production of VICOPROP,

Properties	Measure unit	Method	Essay values
Fluidity index 190º C / 5 Kg	g/10 min	ISO 1133	0,5
Fluidity index 230º C / 2,16 Kg	g/10 min	ISO 1133	0,2
Resistance to impact (Charpy, 23º C)	kJ/m^2	ISO 179	23
Density	g/cm^3	ISO 1183	0,9
Fusion point	º C	DIN 53736 B2	150-154
Rupture Charge	MPa	ISO 527	26
Linear expansion coefficient	mm/m. º C	ASTM D696	150×10^{-3}
Thermal conductivity coefficient	W/m. º C	ISO 3146	0,17

Chart 1- PP-R properties

VICOPROP is a pipe manufactured by extrusion through the increase of temperature of this thermoplastic resin. For the fittings which compose the VICOPROP system, the technique of injection is used so that it is possible to have the desired shapes and dimensions.

Despite being strongly advised for sanitary installations, the application of the VICOPROP pipes, due to their characteristics, is diversified.

Image 2 - Example of sanitary installation

• Sanitary installations.

• Heating installations.

• Compressed air installations

• Thermal and salt waters installations

• Aggressive fluids industrial installations

• Alimentary fluid installations

2. VICOPROP characteristics

VICOPROP pipes are manufactured appealing to the specification DUOFIL/VICOPROP and the German standard DIN8077/78.

Chart 2 indicates the dimensional characteristics and weighs associated to the pipes,

	PN 10					PN 20				
Ø ext. (mm)	Ø int. (mm)	Esp. (mm)	Medium weight (g/m)	Medium weight with water (g/m)	Volume of contained water (l/m)	Ø int. (mm)	Esp. (mm)	Medium weight (g/m)	Medium weight with water (g/m)	Volume of contained water (ml/m)
20,0	16,2	1,9	97	302	0,206	13,2	3,4	159	295	0,137
25,0	20,4	2,3	147	473	0,327	16,6	4,2	246	462	0,216
32,0	26,0	3,0	245	774	0,531	21,2	5,4	404	756	0,353
40,0	32,6	3,7	378	1211	0,835	26,6	6,7	627	1182	0,556
50,0	40,8	4,6	587	1892	1,307	33,2	8,4	983	1846	0,866
63,0	51,4	5,8	933	3004	2,075	42,0	10,5	1550	2933	1,385
75,0	61,2	6,9	1321	4257	2,942	50,0	12,5	2197	4156	1,963
90,0	73,6	8,2	1886	6132	4,254	60,0	15,0	3163	5985	2,827
110,0	90,0	10,0	2812	9161	6,362	73,2	18,4	4739	8939	4,208

Chart 2-Dimensions of VICOPROP 1) water at 20ºC

VICOPROP pipes are supplied in bars of 4 m, in colour RAL 7032.

In chart 3 the maximum admissible operation pressures when using VICOPROP are indicated, regarding the estimated lifetime and the working temperature. Please verify, as an example, that the VICOPROP pipe whose nominal pressure indicates PN10, will have as maximum admissible pressure 10 bar for a working temperature of 20ºC and a lifetime of 50 years.

The pipes are always supplied with a complete identification. The information stated in the pipe is as follows:

Manufacturer • Nominal pressure • Model • Applied Standards • Raw material • Operator • Dimensions • time and date of production

Maximum admissible pressure						
Temperature	Nominal pressure	Estimated lifetime				
		1	5	10	25	50
10° C	PN 10	16,8	15,6	15,0	14,2	13,8
	PN 20	33,6	31,2	30,0	28,4	27,6
20° C	PN 10	13,8	12,6	12,1	11,6	10,0
	PN 20	27,2	25,2	24,8	23,6	20,0
30° C	PN 10	10,8	10,0	9,6	9,2	9,0
	PN 20	21,6	20,0	19,2	18,4	18,0
40° C	PN 10	8,4	8,0	7,6	7,2	6,6
	PN 20	16,8	16,0	15,2	14,4	13,2
50° C	PN 10	7,0	6,2	6,0	5,2	4,6
	PN 20	14,0	12,4	12,0	10,4	9,2
60° C	PN 10	5,6	5,0	4,4	3,6	3,2
	PN 20	11,2	10,0	8,8	7,2	6,4
70° C	PN 10	4,4	3,4	3,0	2,4	-
	PN 20	8,8	6,8	6,0	4,8	-
80° C	PN 10	3,4	2,4	2,0	1,8	-
	PN 20	6,8	4,8	4,7	3,6	-

Chart 3-Maximum Working Pressure (bar) of VICOPROP pipes

3. VICOPROP properties

VICOPROP pipes have a group of properties which are considered advantages in its use.

Chart 3 indicates the long lasting of the VICOPROP pipe, allowing to increase the profitability of the installation.

· The absolute **non-toxicity** allows the transport of fluids for human consumption.

· The **reduced coefficient of attrition** of the polypropylene gives the pipe a low loss of friction charge, allowing the reduction of pumping energy consumption. The appearance of inlays, usually calcareous when the transported fluid is water, is also minimised.

· The **low coefficient of thermal conductivity** allows an approach of the transported fluid temperature downstream and upstream. The effects of the external condensations are also reduced when VICOPROP pipe is compared with the metallic pipes, which allows minimising the deterioration of the walls where the pipe is embedded.

· The **low coefficient of electric conductivity** prevents the appearance of perforations caused by the electrostatic currents, phenomenon which occurs in the metallic pipes.

·The **high acoustic isolation** is also a characteristic of this pipe, minimising the noises existing sometimes in the transport of fluids in metallic pipes.

· The **low density** of the VICOPROP system, allowing the realisation of installations completely stanching, contributes to a profitable installation. The reduced time of welding also contributes for this profitability.

· The high **resistance to corrosion** allows to use VICOPROP pipe for the transport of chemically aggressive fluids, as sour or alkaline substances, within a large spectrum of concentrations and working temperatures.

4. VICOPROP recommendations

So that VICOPROP pipes may be used with all its potentialities, must be kept in mind certain situations so they should not be damaged.

· During storage, the pipes should be correct and orderly pilled up, not exceeding the 1.5 m of storage height. They should not be stored vertically.

· VICOPROP pipes should be stored in UV rays protected sites. This caution is as important as when it is foreseen a long storage period.

· The pipes should be stored in places where they will not be in contact with combustible or highly inflammable materials. The ignition sources should always be avoided as polypropylene is also a combustible material.

· Avoid dragging the pipes through the floor or to place them in contact with sharp elements.

· With low temperatures, impacts should be avoided with the tube.

· During storage phase or pre-installation, if the pipe is damaged, it must be removed at all its length.

· The transport of the pipes should be made in vehicles with horizontal, perfectly flat booths, without elements that can damage them (e.g.: salient nails)

· The pipes should be transported in a free way, this is, without resource to currents or metallic ends. Once more, it is recommended not to store the pipes in vertical position.

· Other loads should not be placed above the VICOPROP pipes.

· The pipes should always be cut with a proper equipment, as plastic pipe scissors.

· The tubes should be correctly transported and totally leaning. Their discharge should be made in an orderly way, without impacts and violent crashes.

· During the welding phase, all the times foreseen for the same one should be respected, either in heating, contact or cooling.

· After having made the welding between the fitting and the pipe, it is possible to carry out any orientation corrections in the pipe but as long as the angle of that orientation does not overpasses the 10º so that the welding will not be damaged.

· The welding equipment, specially the socket welder heating elements, should be clean regularly and maintained under good conditions for a long duration and good welding quality.

· Do not place, under any circumstances, the flame directly in contact with the pipe, for bending. Please remember that polypropylene is combustible. A regular hot air dryer can be used in order to increase the temperature of the material and to ease up its bending.

· Expansions should be avoided in terminal areas close to equipment. For such situation, should be foreseen fixing supports for these areas, so that the welding may be kept in perfect conditions allowing the desired stanching.

· The installation of the VICOPROP pipes close to other installations that transport fluids with temperatures superior to 95ºC, as for example boilers exhaustion conduits, is undesirable. This closeness will imply a quick deterioration of the installation.

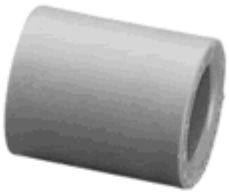
· In any case should be threaded metallic accessories directly with the VICOPROP pipes. The union will never be perfect and it will cause serious problems of stanching, instantly or in a brief working period.

· Whenever an installation is interrupted, the extremities of the VICOPROP pipes should be sealed not allowing the entrance of impurities inside the installation.

· The stanching hydraulic test should be made whenever an installation is ended, although that rehearsal should be made at least 1 hour after the last welding.

5. VICOPROP system

The VICOPROP system allows an installation of the pipe together with the fittings in PP-R. The fittings are mostly for socket welding with a socket welder machine, although existing electro-fusion fittings.



Socket

S 001	
Reference	Dimensions
S 001 020 000	20
S 001 025 000	25
S 001 032 000	32
S 001 040 000	40
S 001 050 000	50
S 001 063 000	63
S 001 075 000	75
S 001 090 000	90
S 001 110 000	110

Reducing bush

S 002	
Reference	Dimensions
S 002 025 020	*25 x 20*
S 002 032 020	*32 x 20*
S 002 032 025	*32 x 25*
S 002 040 025	*40 x 25*
S 002 040 032	*40 x 32*
S 002 050 040	*50 x 40*
S 002 063 025	*63 x 25*
S 002 063 032	*63 x 32*
S 002 063 040	*63 x 40*
S 002 063 050	*63 x 50*
S 002 075 063	*75 x 63*
S 002 090 063	*90 x 63*
S 002 090 075	*90 x 75*
S 002 110 063	*110 x 63*
S 002 110 090	*110 x 90*

Crossing bush

S 003	
Reference	Dimensions
S 003 020 000	*20*
S 003 025 000	*25*
S 003 032 000	*32*

90º elbow

S 004	
Reference	Dimensions
S 004 020 000	*20*
S 004 025 000	*25*
S 004 032 000	*32*
S 004 040 000	*40*
S 004 050 000	*50*
S 004 063 000	*63*
S 004 075 000	*75*
S 004 090 000	*90*
S 004 110 000	*110*

45º elbow

S 005	
Reference	Dimensions
S 005 020 000	*20*
S 005 025 000	*25*
S 005 032 000	*32*
S 005 032 000	*40*
S 005 050 000	*50*
S 005 063 000	*63*
S 005 075 000	*75*
S 005 090 000	*90*
S 005 110 000	*110*

Tee

S 006	
Reference	Dimensions
S 006 020 000	*20*
S 006 025 000	*25*
S 006 032 000	*32*
S 006 032 000	*40*
S 006 050 000	*50*
S 006 063 000	*63*
S 006 075 000	*75*
S 006 090 000	*90*
S 006 110 000	*110*

Reducing tee

S 007	
Reference	Dimensions
S 007 025 020	*25 x 20 x 25*
S 007 032 020	*32 x 20 x 32*
S 007 032 025	*32 x 25 x 32*
S 007 040 020	*40 x 20 x 40*
S 007 040 025	*40 x 25 x 40*
S 007 040 032	*40 x 32 x 40*
S 007 050 025	*50 x 25 x 50*
S 007 050 032	*50 x 32 x 50*
S 007 050 040	*50 x 40 x 50*
S 007 063 025	*63 x 25 x 63*
S 007 063 032	*63 x 32 x 63*
S 007 063 040	*63 x 40 x 63*
S 007 063 050	*63 x 50 x 63*

Cap

S 008	
Reference	Dimensions
S 008 020 000	20
S 008 025 000	25
S 008 032 000	32
S 008 032 000	40
S 008 050 000	50
S 008 063 000	63
S 008 075 000	75
S 008 090 000	90
S 008 110 000	110

Adapter

S 020	
Reference	Dimensions
S 020 020 000	20
S 020 025 000	25
S 020 032 000	32

Backing flange

S 021	
Reference	Dimensions
S 021 040 000	40
S 021 050 000	50
S 021 063 000	63
S 021 075 000	75
S 021 090 000	90
S 021 110 000	110

Sphere valve

S 025	
Reference	Dimensions
S 025 020 000	20
S 025 025 000	25
S 025 032 000	32

Female transition socket

S 030	
Reference	Dimensions
S 030 020 000	20
S 030 025 000	25
S 030 032 000	32
S 030 032 000	40
S 030 050 000	50
S 030 063 000	63
S 030 075 000	75
S 030 090 000	90
S 030 110 000	110

Male transition socket

S 031	
Reference	Dimensions
S 031 025 012	25 x 1/2"
S 031 025 034	25 x 3/4"
S 031 032 034	32 x 3/4"
S 031 032 100	32 x 1"
S 031 040 100	40 x 1"
S 031 040 114	40 x 1 1/4"
S 031 050 114	50 x 1 1/4"
S 031 063 200	63 x 2"

90º female transition elbow

S 032	
Reference	Dimensions
S 032 020 012	20 x 1/2"
S 032 020 034	20 x 3/4"
S 032 025 034	25 x 1/2"
S 032 025 034	25 x 3/4"
S 032 032 012	32 x 1/2"
S 032 032 034	32 x 3/4"
S 032 032 100	32 x 1"
S 032 040 034	40 x 3/4"
S 032 040 100	40 x 1"

90º male transition elbow

S 033	
Reference	Dimensions
S 033 020 012	20 x 1/2"
S 033 025 012	25 x 1/2"
S 033 025 034	25 x 3/4"
S 033 032 012	32 x 1/2"
S 033 032 034	32 x 3/4"
S 033 032 100	32 x 1"
S 033 040 034	40 x 3/4"
S 033 040 100	40 x 1"

Female transition tee

S 034	
Reference	Dimensions
S 034 020 012	20 x 1/2"
S 034 025 012	25 x 1/2"
S 034 025 034	25 x 3/4"
S 034 032 012	32 x 1/2"
S 034 032 034	32 x 3/4"
S 034 032 100	32 x 1"
S 034 040 034	40 x 3/4"
S 034 040 100	40 x 1"

Heating elements for socket welder

S 201	
Reference	Dimensions
S 201 020 000	20
S 201 025 000	25
S 201 032 000	32
S 201 040 000	40
S 201 050 000	50
S 201 063 000	63
S 201 075 000	75
S 201 090 000	90

Male transition tee

S 035	
Reference	Dimensions
S 035 020 012	20 x 1/2"
S 035 025 012	25 x 1/2"
S 035 025 034	25 x 3/4"
S 035 032 034	32 x 3/4"
S 035 032 100	32 x 1"
S 035 040 034	40 x 3/4"
S 035 040 100	40 x 1"

Loose end female transition socket

S 036	
Reference	Dimensions
S 036 020 034	20 x 3/4"
S 036 025 034	25 x 3/4"
S 036 025 100	25 x 1"
S 036 032 034	32 x 3/4"
S 036 032 100	32 x 1"
S 036 032 114	32 x 1 1/4"
S 036 040 100	40 x 1"
S 036 040 114	40 x 1 1/4"

Female transition elbow

S 037	
Reference	Dimensions
S 037 020 034	20 x 3/4"
S 037 025 034	25 x 3/4"
S 037 025 100	25 x 1"
S 037 032 034	32 x 3/4"
S 037 032 100	32 x 1"
S 037 032 114	32 x 1 1/4"
S 037 040 100	40 x 1"
S 037 040 114	40 x 1 1/4"

Female back support transition elbow

S 038	
Reference	Dimensions
S 038 020 012	*20 x 1/2"*

S 151

Cap fittings for hydraulic testing

Electrofusion socket

S 101	
Reference	Dimensions
S 101 020 000	20
S 101 025 000	25
S 101 032 000	32
S 101 040 000	40
S 101 050 000	50
S 101 063 000	63
S 101 075 000	75
S 101 090 000	90
S 101 110 000	110

S 150

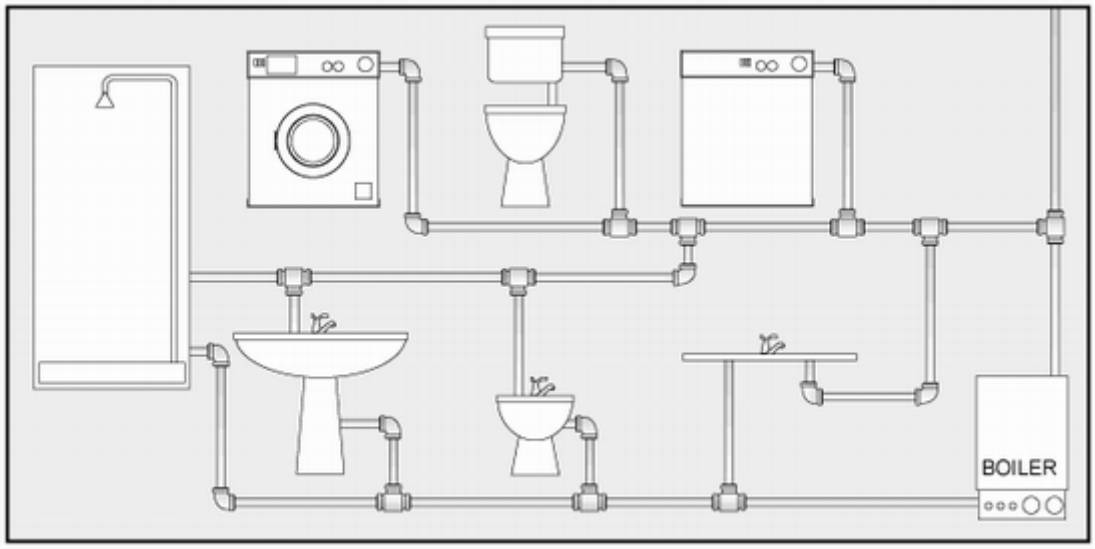
Scissor

S 200

-Kit for socket welding with:

. Socket welder
. 3 heating elements (Ø20- Ø 25- Ø32)
. Suitcase

In the following figure, there is an application example of water distribution using the VICOPROP system.



6. Charge losses

VICOPROP pipes are characterised by introducing very reduced charge losses to the wanted systems. However, it is necessary to quantify those values. The verifications of the charge losses introduced by the system are very relevant, either for the dimensioning of the pumping system or to verify if the upstream available pressure (barometrical height) is enough to avoid the introduction of a pumping group for the circulation of the fluid.

The charge losses in an installation depend on a large number of factors: transported fluid; circulation flow, pipes section, flow temperature; pipe inside surface rugosity, flow regimen, among others.

The several resistance ways imposed to the circulation of the fluid inside the installation may be divided as follows:

· **Apf: Charge loss due to friction.**

Charge losses due to the existent attrite between the contact of the inside surface of the VICOPROP pipe and the circulating fluid. Please note that this parcel only contemplates the charge losses resulting from the circulation of the fluid inside a tube with a constant section and with a well defined length.

· **Apl: Located charge loss**

Charge losses resulting from the introduction of fittings which, due to their configuration, introduce a resistance to the passage of the fluid. Let us take as an example the introduction of an elbow in the installation. This elbow will originate a change of direction in the fluid circulation and in this spot (local) the loss of charge will be lightly superior to the value that would present if there were no direction change.

Sometimes this parcel is more important than the previous one for the quantity of direction changes or valves that exist in the installation.

· **Ape: Charge loss in the connection:**

This parcel has a similar base to the introduction of a reducing fitting. If the welding is perfect, in this spot we will have material continuity and a consequent continuity of passage section. But in the case of not existing such perfection, there is a reduction or increase of the passage section of the fluid located in the welding, which introduce additional charge losses. These load losses are of difficult theoretical quantification as it is not possible to verify the passage section in the place of the welding. The degree of impossibility increases when it is verified that the probability of being executed a welding 100 % perfect, that is, in which the passage section unaffected, is very reduced. All previously described is also valid for the situations of flangeable connections.

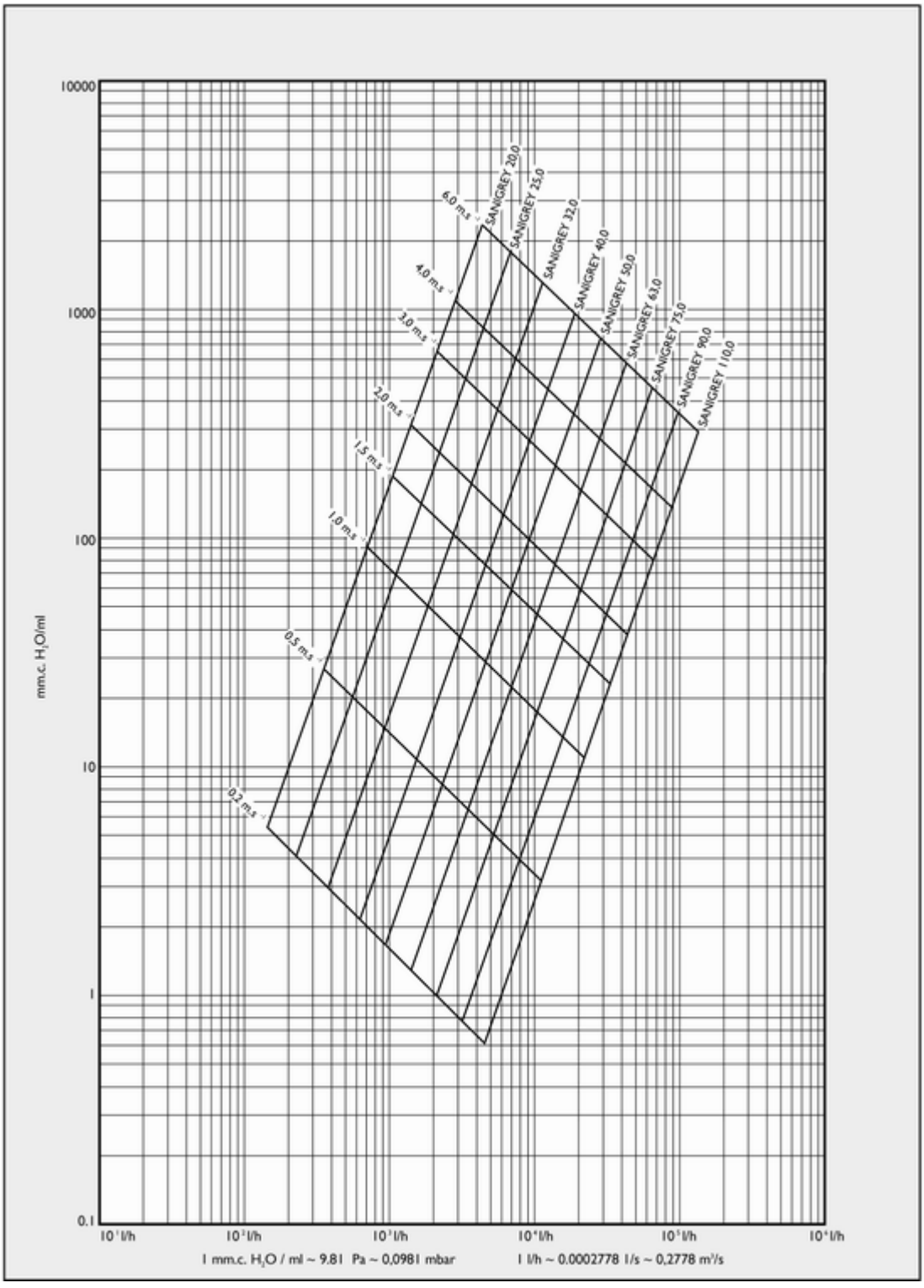
Is advised the use of a security final coefficient that introduces this type of charge losses.

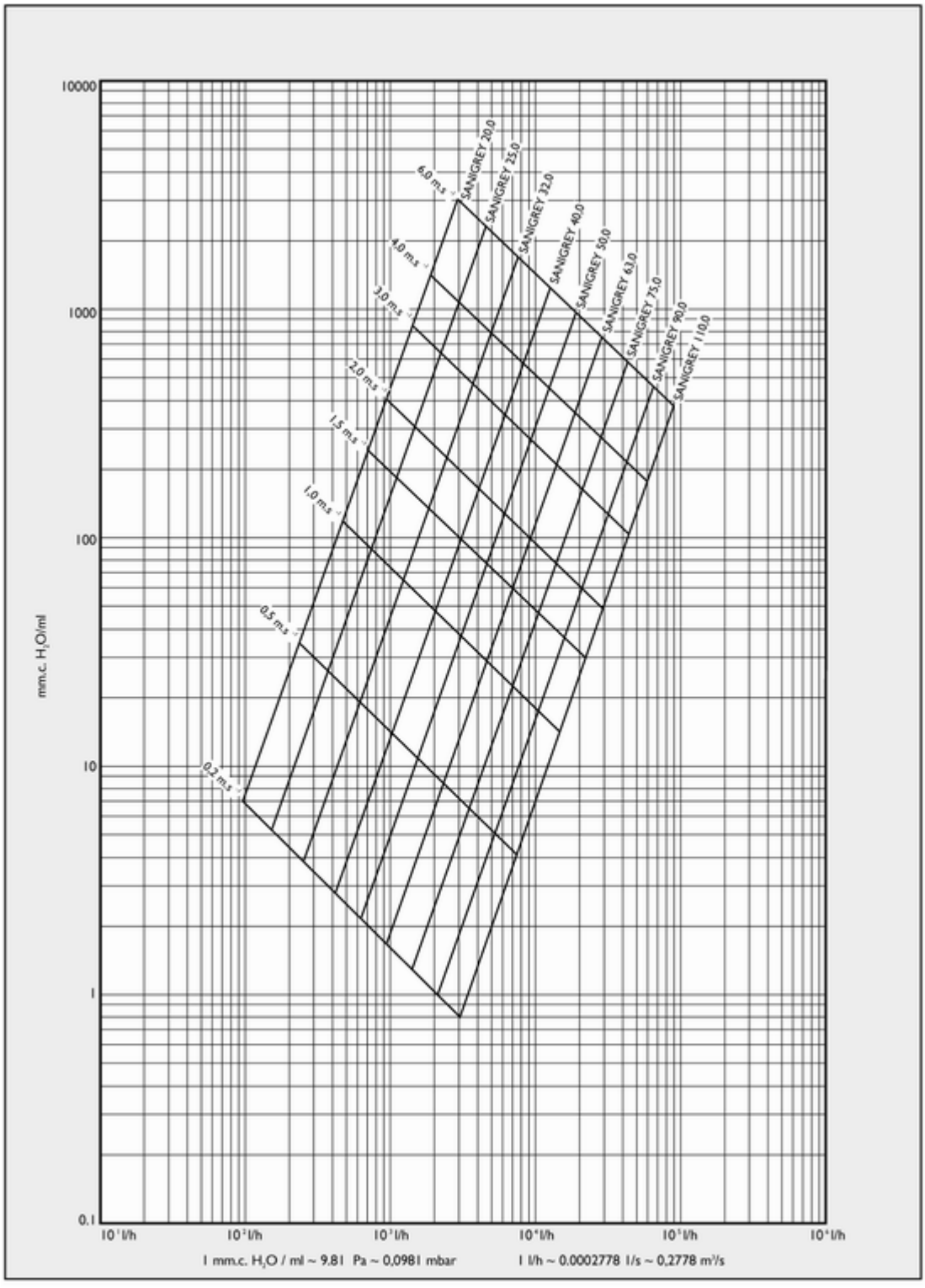
The complete charge loss of the installed system will be the sum of the partial losses above mentioned,

$$\Delta p_{total} \cong \Delta p_{fricção} + \Delta p_{localizadas} + \Delta p_{conexão} \cong u_x (\Delta p_{localizadas} + \Delta p_{fricção})$$

Graphics 1 and 2 situated in the following pages show the charge losses per friction (Apf) introduced by the VICOPROP pipes for nominal pressures of 10 Bar and 20Bar, respectively. These charge losses are for linear meter of installed pipe and are valid for the circulation of water at 20ºC.

Obviously, the values provided in the graphics previously mentioned are **not** invalid when it is necessary to quantify the charge losses introduced in a system when the fluid, not being water, circulating in the interior of the installation or the temperature of the water is not of 20ºC.


10000
1000
100
10
1
0.1
mm.c. H2O/ml
6,0 m.s⁻¹
4,0 m.s⁻¹
3,0 m.s⁻¹
2,0 m.s⁻¹
1,5 m.s⁻¹
1,0 m.s⁻¹
0,5 m.s⁻¹
0,2 m.s⁻¹
SANIGREY 20,0
SANIGREY 25,0
SANIGREY 32,0
SANIGREY 40,0
SANIGREY 50,0
SANIGREY 63,0
SANIGREY 75,0
SANIGREY 90,0
SANIGREY 110,0
10¹ l/h
10² l/h
10³ l/h
10⁴ l/h
10⁵ l/h
10⁶ l/h
1 mm.c. H2O / ml ~ 9.81 Pa ~ 0,0981 mbar
1 l/h ~ 0.0002778 l/s ~ 0,2778 m³/s



Therefore, for the same conditions of transport (water flow) and for the same pipe diameter, the value of the charge loss in the system may be calculated when changing the transport temperature of the fluid or replacing the transported fluid.

Chart 4 indicates which are the coefficient values for each case.

Chart 4-KVT and KVF coefficients

Please consider that the correction of charge loss for another transported fluid is not a direct operation as in the case of the temperature variation of the transported water. In the case of the fluid, the characteristic coefficient of the fluid should be determined (CFluid) indicated in chart 4. This coefficient is not more than the reason between the volume mass of the transported fluid and its dynamic viscosity, that is to say, the viscosity kinematics of the fluid.

$$C_{fluido}\ [^{s}/_{m^2}] = \frac{\rho_{fluido}\left[^{Kg}/_{m^3}\right]}{\mu_{fluido}\left[^{Ns}/_{m^2}\right]}$$

Chart 5 presents some values of compatible fluids for the transport with VICOPROP pipes.

For other values of temperature or characteristic coefficient of the fluid, interpolations can be made. However, this variation is not linear as quickly is verified. The extrapolations are not advised for other values of C_{fluid}. Please consider that the values of mercury and glycerine coefficient are outside of the range of believable interpolation.

For the determination of the corrected load loss, is used the following formula,

$$\left[^{h_f}/_{L}\right]_{T^{\circ}C\ Water\_fluido} = \left[K_{VT} \text{v} K_{VF}\right] \cdot \left[^{h_f}/_{L}\right]_{20^{\circ}C\ H_2O}$$

Chart 5 - Proprieties of other compatible fluids with VICOPROP pipe

Graphics 3 and 4 indicated below clear up which are the advantages of the VICOPROP pipes when compared with the pipes in steel. The reduction of the energy invoice inherent to the circulation of the fluids is a reality.

Graphics 3 and 4 - Percentual increase of the loss of load due to friction when using a steel pipe, geometrically similar when comparing with the VICOPROP installation

The above graphics show which is the percentual increase of the load loss for the same transport conditions (water flow, 20ºC, interior diameter of the pipe) when it is used a steel pipe instead of a PP-R pipe. Obviously, as the power absorbed by the pumping group is directly proportional to the load loss, or better, to the manometric necessary height for the circulation of the fluid under the intended conditions, it may be concluded that the energy invoice is substantially reduced when using VICOPROP pipe.

As stated in the beginning of this chapter, the fittings introduce local passage section changes that cause local variations of charge loss. As theoretical hypothesis, if the introduction of a fitting in the installation would produce a geometrical and dimensional continuity passage section, there would also exist a continuity in the determination of the charge loss, considering the graphics 1 and 2. However each fitting introduces a loss of local load inherent to its own geometry. Therefore, they have associated a coefficient of load loss indicated in chart 6.

The determination of the charge loss obeys to the following formula,

$$h_1 = \sum_{i=1}^{u} K_{Local} \cdot \frac{V_i^2}{2g}$$ onde n é o número de acessórios.

Where n is the number of fittings

Chart 6 - Coefficient of located loss charge

In order to determine the necessary manometric height to process the transport of fluid inside the pipe, is carried out the algebraical sum of the previously defined parcels.

$$H_{total} = \left[{}^{h_f}/_{L} \right] \cdot L + h_l$$

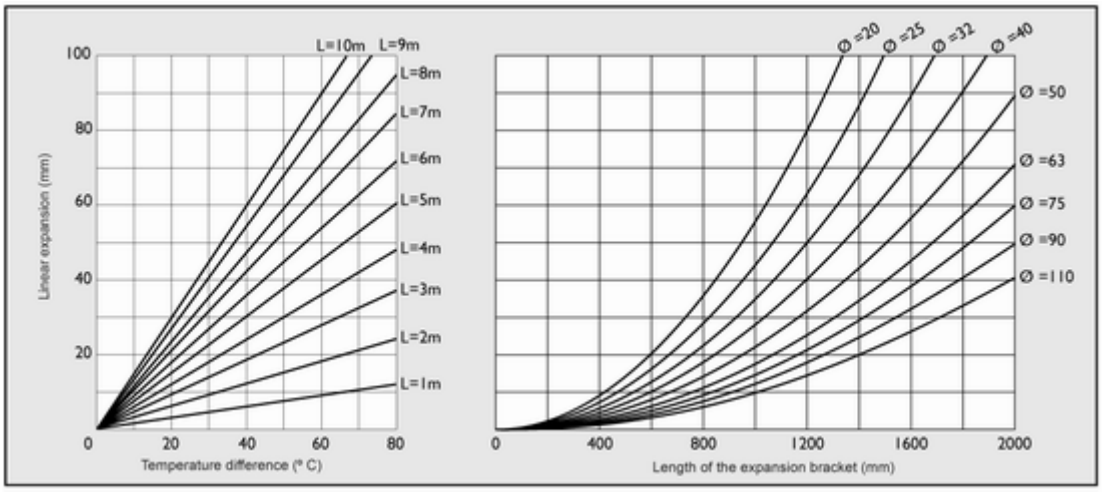
where L is the length of the installed.

Finally, please consider that for the definition of a pumping group a security coefficient must be added to the previous formula, keeping in mind other factors that contribute for the outlet pressure fall, but whose calculation is practically impossible, as the welding of the pipes.

7. Thermal expansions

The thermal expansions, a phenomenon which occurs due to the temperature variation of the PP-R pipe in a three-dimensional way but being more pronounced in the longitudinal direction of the pipe, must also be considered in an installation. The coefficient of expansion of the VICOPROP pipe, as indicated in chart I, is of 0.15 mm/ºK.

The correct definition of the linear expansion will allow locating the fixation points to give the necessary mobility to the pipes preventing the appearance of ruptures.



Graph 5 - Linear expansions and expansion brackets for VICOPROP installations.

Graph 5 allows to see which is the dilation that certain VICOPROP pipe will suffer when subject to a variation of temperature and, in a continuous way, to determine which is the necessary dilation bracket to absorb that dilation. This dilation may be absorbed using dilation lyres or foreseeing the necessary distance for the installation of a fixation point after a direction change (image 3).

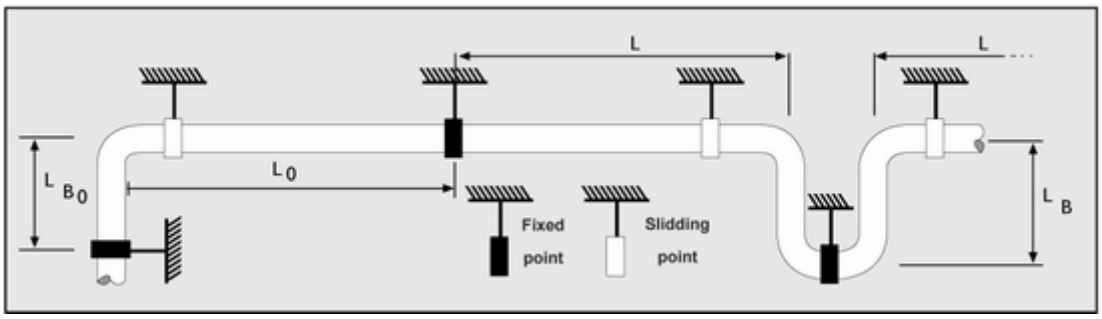


Image 3 - Examples of placement of supports for absorption of dilations

The importance of the linear dilations, as observed, is strongly related with the placement of the supports of the pipe in an installation. The contraction phenomenon is considered similar to the dilation one, therefore the calculation formula to be considered is the same.

8. VICOPROP support points

VICOPROP pipes may be installed in two different ways: inside the walls or at sight with UV ray protection, when necessary.

In the inside installations it is the land or wall itself which allows the support of the pipe. Expansion points should be foreseen, as explained previously.

In the at sight installations, these supports are not continuous visible, existing rules which define the maximum distances between support points, and not fixation points. These values are calculated keeping in mind the weight of the pipe, of the fluid that runs inside, as well as its temperature and, sometimes, include security coefficients which consider “forces” from natural phenomena as winds or earthquakes, for installations which transport fluids considered of high risk. Please consider that the disposition of the supports does not allow a pronounced bending of the pipe.

In chart 7 are indicated the distances to consider between supports of pipes horizontally installed.

Nominal Diameter	Temperature							
	20° C	30° C	40° C	50° C	60° C	70° C	80° C	95° C
20	0,70	0,70	0,70	0,65	0,65	0,60	0,60	0,55
25	0,85	0,80	0,80	0,75	0,75	0,70	0,70	0,60
32	0,95	0,95	0,90	0,90	0,85	0,80	0,80	0,70
40	1,20	1,15	1,10	1,05	1,00	0,95	0,90	0,80
50	1,40	1,35	1,30	1,30	1,20	1,15	1,10	1,00
63	1,50	1,45	1,40	1,40	1,35	1,35	1,30	1,20
75	1,75	1,70	1,70	1,60	1,60	1,50	1,40	1,30
90	1,90	1,85	1,80	1,70	1,70	1,60	1,50	1,40
110	2,20	2,15	2,10	2,00	1,80	1,75	1,70	1,60

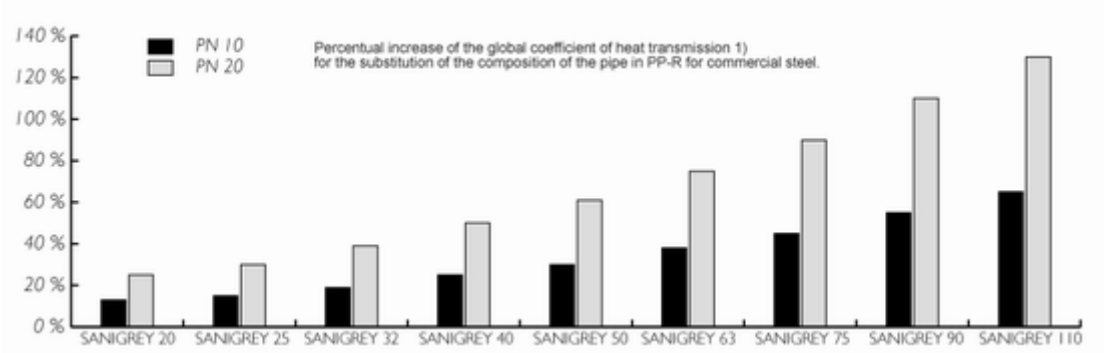
Chart 7-Distance in meters, between supports for VICOPROP PN20 pipes, being water the transport fluid.

As it has been mentioned, the distances presented in chart 7 are related with pipe supports horizontally installed.

For lines of vertical transport it will be considered a multiplication factor of C=13. Please note that in the changes of direction horizontal/vertical, a support close to this direction change should be foreseen, as this is the element of support of the whole vertical column. The supports placed along this vertical column will work as a guide of the pipe not allowing bendings.

9. Thermal behaviour

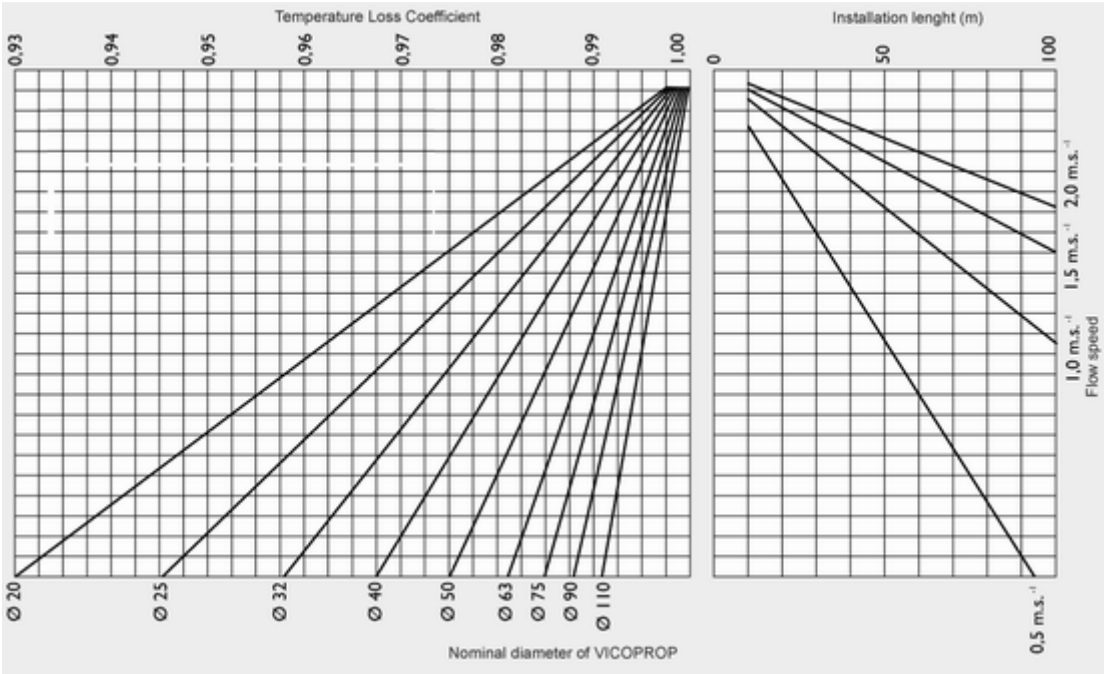
When comparing the conductivity coefficients, are easily understandable all the advantages of the installations made with VICOPROP when compared with steel pipes.



Graph 6-Comparison of the global coefficient of transfer of heat 1) considering the composition of a pipe geometrically and dimensionally similar to the VICOPROP pipe, but composed by commercial steel.

1) The determination of the heat transfer and of the limit condensation temperature global coefficient was made appealing to some suppositions and simplifications. It was considered that being the interior convection coefficient usually high, the temperature of the external wall was similar to the temperature of the transported fluid. The value of the coefficient of external convection was supposed of 10W/m^2.º K.

In sanitary systems, for example, it is necessary to guarantee that the thermal losses are small in order to maximise the profit of the installation, i.e., not to waste the energy that is transported as hot water. In graph 7, it can be analysed that for traditional systems and for the speed range imposed by law, the losses of water temperature are insignificant.



Graph 7 - VICOPROP PN10 temperature losses coefficient (water transport temperature of 50ºC and external temperature of 20ºC)

The possibility of installing the pipe with thermal isolation will prevent the excessive heating of the external surface of the pipe.

On the other hand, and in the possibility of using the VICOPROP pipe in situations of ice cold water transport, (the pipe supports chemically the transport of antifreezes like glicol or glicol water), this necessity of exterior thermal isolation is more relevant, in order to prevent the formation of condensations in the external surface of the pipe.

Temperature condensation limit			External air temperature													
			20° C			25° C			30° C			35° C			40° C		
			Relative external humidity													
Nominal diameter I		Thickness	40%	60%	80%	40%	60%	80%	40%	60%	80%	40%	60%	80%	40%	60%	80%
20		1,9	4,0	10,8	16,0	8,5	15,6	20,9	13,1	20,4	25,7	17,7	25,1	30,6	21,9	29,6	35,3
		3,4	2,3	9,8	15,5	6,7	14,6	20,4	11,3	19,4	25,3	15,8	24,0	30,1	20,0	28,5	34,8
25		2,3	3,6	10,6	15,9	8,1	15,4	20,8	12,7	20,2	25,6	17,3	24,9	30,5	21,5	29,4	35,2
		4,2	1,5	9,3	15,3	5,9	14,2	20,2	10,4	18,9	25,1	14,9	23,5	29,9	19,1	28,0	34,6
32		3,0	3,0	10,2	15,7	7,4	15,0	20,6	12,0	19,8	25,5	16,5	24,5	30,3	20,8	29,0	35,0
		5,4	0,2	8,6	15,0	4,6	13,4	19,9	9,1	18,2	24,7	13,6	22,8	29,5	17,7	27,2	34,3
40		3,7	2,3	9,8	15,5	6,7	14,7	20,4	11,3	19,4	25,3	15,9	24,1	30,1	20,0	28,5	34,9
		6,7	-1,1	7,8	14,7	3,2	12,7	19,6	7,7	17,4	24,4	12,2	21,9	29,1	16,2	26,3	33,9
50		4,6	1,5	9,3	15,3	5,9	14,2	20,2	10,5	18,9	25,1	15,0	23,5	29,9	19,1	28,0	34,6
		8,4	-2,8	6,8	14,2	1,4	11,7	19,1	5,9	16,3	23,9	10,3	20,9	28,7	14,2	25,2	33,4
63		5,8	0,4	8,7	15,0	4,7	13,5	19,9	9,3	18,2	24,8	13,7	22,9	29,6	17,8	27,3	34,3
		10,5	-5,0	5,6	13,7	-0,8	10,4	18,6	3,6	15,0	23,4	8,0	19,6	28,1	11,8	23,8	32,7
75		6,9	-0,6	8,1	14,8	3,7	12,9	19,7	8,2	17,6	24,5	12,6	22,2	29,3	16,7	26,6	34,0
		12,5	-7,0	4,4	13,2	-2,9	9,2	18,0	1,5	13,8	22,8	5,8	18,3	27,5	9,5	22,5	32,2
90		8,2	1,8	7,4	14,5	2,5	12,2	19,4	6,9	16,9	24,2	11,3	21,5	28,9	15,3	25,8	33,7
		15,0	-9,6	3,0	12,5	-5,5	7,7	17,4	-1,2	12,3	22,1	3,0	16,7	26,8	6,6	20,8	31,4
110		10,0	-3,5	6,5	14,1	0,7	11,3	18,9	5,2	15,9	23,8	9,5	20,5	28,5	13,5	24,8	33,2
		18,4	-13,0	1,0	11,7	-9,1	5,7	16,5	-4,9	10,2	21,2	-0,8	14,6	25,8	2,7	18,6	30,4

Chart 8-Limit condensation temperatures, starting from which it is necessary to isolate VICOPROP pipe, for ice cold water transport.

As it can be observed in chart 8, according to the air conditions where the VICOPROP pipe is installed (temperature and relative humidity of the air), the limit condensation temperature indicates the minimum values of the temperature of the water at which it may be transported inside the pipe, without creating condensation drops in its external surface. For transport values inferior to the limit condensation temperature, the thickness of the isolation pipe to be installed should be calculated depending on its thermic characteristic (isolation pipe thermic conductivity).

10. Application examples

Please consider the example represented in image 4 that schematically presents a typical sanitary installation.

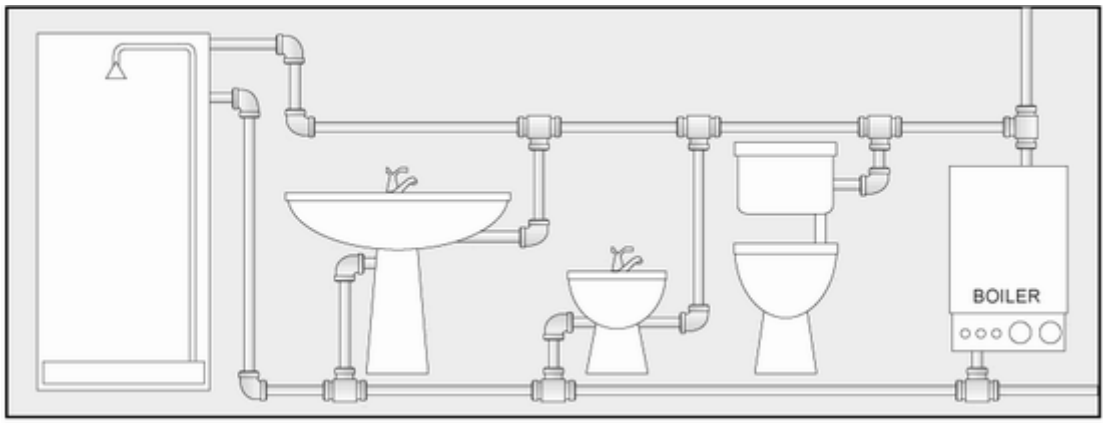


Fig. 4- Sanitary installation with VICOPROP system

According to the General System of the Public and Predial Systems of Water Distribution and Drainage of Residual Waters, in particular with respect to the water distribution predial systems chapter, for the dimension of the distribution lines should be considered the defined values of the minimum water flows, as in chart nº9.

Devices	Minimum water flow
Mechanism with toilet discharge	0,1 l/s
Bidet	0,1 l/s
Individual washbasin	0,1 l/s
Individual shower	0,15 l/s

Chart 9 - Minimum flows of the devices

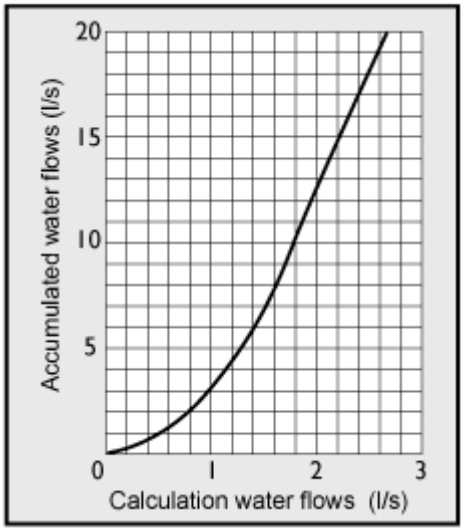
Chart 11 presents the dimensioning of the whole installation appealing to this specification.

However, please note that in this dimensioning were considered the minimum water flows as operating simultaneously in all the devices. Such situation is not realistic. The application of coefficients of simultaneity as indicated by the mentioned regulation should be made in the distribution lines.

Following up, are indicated the calculation values defined by the above mentioned regulation.

Devices	Minimum water flow
Individual washbasin	0,10 l /s
Collective washbasin (per gutter pipe)	0,05 l/s
Bidet	0,10 l/s
Bathtub	0,25 l/s
Individual shower	0,15 l/s
Mechanism of toilet discharge	0,10 l/s
Individual urinal	0,15 l/s
Kitchen sink	0,20 l/s
Drinking fountain	0,10 l/s
Dishwasher machine	0,15 l/s
Laundry machine or tank	0,20 l/s

Chart 10-Project minimum values for domestic devices



Graph 8-Calculation water flows in function of the water flows accumulated for a level of medium comfort

Therefore, the distribution lines may be dimensioned the following way:

Q total = 0.8 l/s

Q cold water = 0.45 l/s

Q hot water = 0.35 l/s

According to the mentioned standard, the distribution speed should be maintained between 0.5 and 2 m/s^{-1}.

Devices	Diameter	Speed
Line of general distribution	Ø 32	1,5
Line of cold water distribution	Ø 25	1,4
Line of hot water distribution	Ø 25	1,1
Mechanism with toilet discharge	Ø 20	0,5
Bidet	Ø 20	0,5
Individual laundry	Ø 20	0,5
Individual shower	Ø 20	0,5

Chart 11 - Dimension of the pipes VICOPROP PN10

11. Installation. Procedure and assembly

Before carrying out any welding, and after the definition of the layout to be executed, the VICOPROP pipe should be cut, using a specific tool. This cut should be made perpendicularly to the geriatric of the pipe (image 5)

The surface of the pipe that will be in contact in the welding must be clean off all the dust for a better quality of the welding (Image 6).

Next will be described the different welding procedures in a VICOPROP installation.

Image 5 - VICOPROP pipe cutting

Image 6 - Cleaning off the dust from the surface of the pipe

11.1- Socket welding installation

Socket welding process is related with the socket fusion equipment and respective heating elements.

Above are described the stages of this process:

Image 7 - Connection of the socket welder

Image 8 - Heating

1. Place the socket welder and respective heating elements to be used (image 7). Wait until the temperature of the heating elements reaches a value close to 270ºC (±15ºC) (Image 7).

2. Place the fitting in the male heating element and the VICOPROP pipe into the female heating element, waiting the necessary heating time so that the welding occurs (Image 8).

Image 9 - Connection fitting / pipe

3. Withdraw the fitting and the pipe simultaneously from the heating elements, and immediately proceed to their connection introducing the pipe in the fitting. The time of welding indicates the maximum time in stand-by for the realisation of the contact, after the withdrawal from the heating elements (Image 9).

4. After the connection, the necessary time for cooling should be respected so that the welding may take place. Any adjustment or alignment between the pipe and the fitting must be made at the beginning of this period, as after cooling it is no longer possible to make any operation damaging the welding.

Chart 11 indicates the relative times to the welding process that should be respected for a good quality welding.

	Nominal diameter (mm)								
	20	25	32	40	50	63	75	90	110
	Time (s)								
Heating [1]	5	7	8	12	18	24	30	40	50
Welding [2]	4	4	6	6	6	8	8	8	10
Cooling [1]	120	120	240	240	240	360	360	360	480

Chart 12 - Times for socket welding procedures

11.2 Butt-fusion installation.

The butt-fusion technique does not require any linking fitting. The welding takes place, as indicated by its name, by the contact of both ends of the pipes, previously heated. The ends of the two pipes are heated when placed against a heating plate kept in a high temperature, keeping the pipe pressed

against it.

Also in this case, it is important to respect the times of the process, as described in Chart 13, so that the welding is well done.

To add to this welding process, there is the possibility of carrying out bends in cold in VICOPROP pipes, as long as the bend minimum radius are respected. These minimum values are near 8 times the nominal diameter of the pipe to be bended.

Thickness of the pipe	Heating period		Time	
	With pressure	Without pressure	Welding	Cooling
(mm)	(s)	(s)	(s)	(s)
2,1 a 5	30	90	4 a 8	240 a 480
5,1 a 10	60	180	5 a 10	600 a 900
10,1 a 20	180	300	10 a 15	900 a 1500
20,1 a 30	300	420	15 a 20	1500 a 2700
	0,01 a 0,02 N/mm^2		0,01 a 0,15 N/mm^2	

Chart 13 - Butt-fusion times, external temperature of 20ºC and moderated air movement.

11.3-Electronic fusion installation

E-fusion and e-fusion socket (SO38) are a solution to consider when the welding, for reasons of accessibility, is not possible. There are some situations of installation as repairs when the resource to this welding method is quite effective. The replacement of a damaged part of the pipe made with the mentioned fitting and with resource to a special e-fusion equipment can be made quite quickly.

12. Chemical resistance

As it has already often been indicated, VICOPROP pipe has a high chemical resistance to a wide number of aggressive fluids. A compatibility list of VICOPROP with the fluid to be transported is presented below.

In the following chart the chemical resistance of VICOPROP pipe when used in the food industry is presented: