1.High Density Polyethylene. Composition and characteristics.

1.1 HDPE raw material

FILÁGUA pipes are produced with high-density polyethylene. High density polyethylene (HDPE) is a semi-crystalline thermoplastic polymer. HDPE is composed of macromolecules, formed through a polymerisation process. Polymerisation should be considered has as a chemical reaction during which a quick and successive monomers addiction leads to the formation of a macromolecule, creating long chains of simple ramifications as presented in image 2. The monomer used is ethylene, a pure hydro-carbonate, that is not easily inflammable, despite being combustible (self-ignition at high point). In the event of combustion, the products are not toxic, being even recommended by environmental organisms for facilities where the fire risk is present.

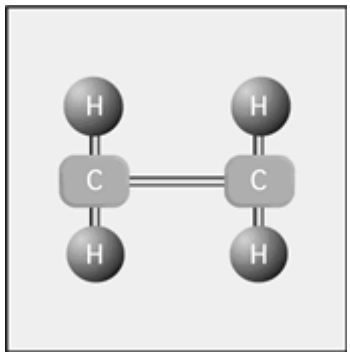


Fig. 1 - Monomer of Ethylene

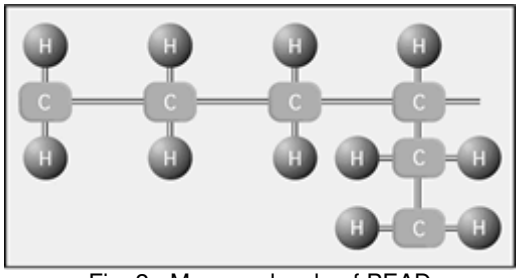
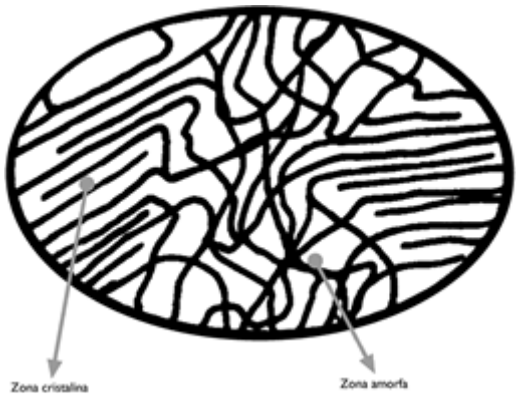


Fig. 2 - Macromolecule of PEAD

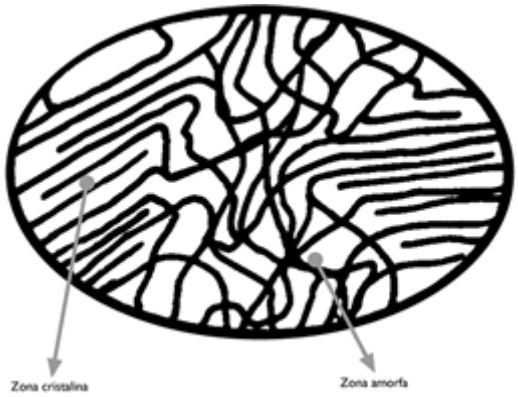
Polyethylene is a partially crystalline material, designation that comes from the fact of existing in its structure long and perfectly lined up chains whose density is higher (crystalline areas) and chains highly disordered with lower partial densities (amorphous areas). These two areas have different fusion points, near 130ºC for the amorphous areas and temperatures close to 200ºC for crystalline areas, for what it is necessary to carry out an extrusion at temperatures close to the last one so that the raw material may become fluid.



Crystalline areas allow the high density polyethylene a higher resistance, for different thermal cycles, recovering its shape and maintaining its properties along the years.

Thermoplastics of totally amorphous nature are more fragile, not supporting with the same effectiveness the variations of temperature, not presenting the resistance of high density polyethylene even with temperatures near 20ºC.

The raw material presents the following medium properties:



These properties are properly specified in standards DIN8075 and pr 12201 (FILÁGUA) and ISO 4437, standard project prEN 1555 (FILAGUA).

2. Production Range.

For the production of FILÁGUA pipes two different resins are used, classified in PE80 and PE100.

Each one of them supports a different Minimum Required Strength (MRS), 8.0 and 10.0 Mpa respectively, keeping in mind a 50 year-old durability with a working temperature of 20ºC, to which correspond tangential tensions (σ) of 6.3 and 8Mpa.

PE	MRS (MPa)	(σ) MPa
80	8,0	6,3
100	10,0	8,0

Chart 2 - MRS relation, tangential tension for resins P80 and PE100

The relation between tangential tension (σ) and MRS (minimun required strength) is verified by the following formula:

$$\sigma = \frac{MRS}{1,25^*}$$

*PE Security Coefficient

Considering the mentioned tangential tensions, the dimension of the pipes is based on the following formula:

$$PN = \frac{10 \times \sigma}{S} \quad , \quad S = \frac{SDR - 1}{2} \quad ou \quad PN = \frac{20 \times \sigma}{SDR-1}$$

Where,

PN - Nominal pressure (20ºC)

DN - Nominal diameter

S- Class or series (according to ISO 4065)

SDR - Reason between DN and nominal thickness of the pipe wall (in)

For pipes dedicated to the distribution of the water (FILÁGUA), the allowed minimum thickness is of 2.0 mm.

2.1 FILÁGUA

FILÁGUA pipes are dimensioned according to standard DIN 8074 and prEN I2201I.

The production range contemplates nominal pressures from 3.2 to 25 bar, with nominal diameters starting from 16 up to 400 mm.

All pipes are of black colour or black colour with four blue longitudinal stripes.

Through the following chart, the nominal pressure (PN), the corresponding series (S) and the type of resin to use (PE80/PE100) may be related.

		PE 80 MRS=8.0MPa C=6.3MPa	PE 100 MRS=10.0MPa C=8.0MPa
S	SDR	PN (bar)	PN (bar)
3,2	7,4	20	25
4	9	16	20
5	11	12,5	16
6,3	13,6	10	12,5
8	17	8	10
8,3	17,6	-	-
10,5	22	6	-
10	21	-	8
12,5	26	5	-
13,3	27,6	-	6
16	33	4	5
20	41	3,2	4

Chart 3 - Relationship between nominal pressure (PN), Series of pressure (S) and Class of Tension (MRS)

In chart 4, the minimum thickness is verified for each series.

D	S 3.2 SDR 7.4	S 4 SDR 9	S 5 SDR 11	S 6.3 SDR 13.6	S 8 SDR 17	S 8.3 SDR 17.6	S 10 SDR 21	S 10.5 SDR 22	S 12.5 SDR 26	S 16 SDR 33	S 20 SDR 41
16	2,3	2,0	-	-	-	-	-	-	-	-	-
20	3,0	2,3	2,0	-	-	-	-	-	-	-	-
25	3,5	3,0	2,3	2,0	-	-	-	-	-	-	-
32	4,4	3,6	3,0	2,4	2,0	2,0	-	-	-	-	-
40	5,5	4,5	3,7	3,0	2,4	2,3	2,0	2,0	-	-	-
50	6,9	5,6	4,6	3,7	3,0	2,9	2,4	2,3	2,0	-	-
63	8,6	7,1	5,8	4,7	3,8	3,6	3,0	2,9	2,5	-	-
75	10,3	8,4	6,8	5,6	4,5	4,3	3,6	3,5	2,9	-	-
90	12,3	10,1	8,2	6,7	5,4	5,1	4,3	4,1	3,5	-	-
110	15,1	12,3	10	8,1	6,6	6,3	5,3	5,0	4,2	-	-
125	17,1	14,0	11,4	9,2	7,4	7,1	6,0	5,7	4,8	-	-
140	19,2	15,7	12,7	10,3	8,3	8,0	6,7	6,4	5,4	-	-
160	21,9	17,9	14,6	11,8	9,5	9,1	7,7	7,3	6,2	-	-
180	24,6	20,1	16,4	13,3	10,7	10,2	8,6	8,2	6,9	-	-
200	27,4	22,4	18,2	14,7	11,9	11,4	9,6	9,1	7,7	-	-
225	30,8	25,2	20,5	16,6	13,4	12,8	10,8	10,3	8,6	-	-
250	34,2	27,9	22,7	18,4	14,8	14,2	11,9	11,4	9,6	-	-
280	38,3	31,3	25,4	20,6	16,6	15,9	13,4	12,8	10,7	-	-
315	43,1	35,2	28,6	23,2	18,7	17,9	15	14,4	12,1	9,7	7,7
355	48,5	39,7	32,2	26,1	21,1	20,1	16,9	16,2	13,6	10,9	8,7
400	54,7	44,7	36,3	29,4	23,7	22,7	19,1	18,2	15,3	12,3	9,8

Chart 4 - minimum wall Thickness for the different series of pipes

The existent marking in the external surface of the pipe FILÁGUA is according to standards, indicating:

• Manufacturer • Reference to standard(s) • Order of production • Security Tension • Metric branding • Date • Operator • Reference to Homologation • Class of pressure • Commercial designation • External Diameter • abbrev. PEAD

Example:

DUOFIL • FILÁGUA • PEAD • 63X3.8 • certification LNEC DH 652 • s=6.3 Mpa • MRS=8.0 Mpa • OP 71–22:33:12 • 12/09/02 • PEA 1017/01 • 12mt.

Pipes are supplied in coils for diameters 20 up to 110 mm inclusive, being properly tied-up and with covered extremities.

Straight bars for diameters 110 up to 400 mm.

Diameter (mm)	Quantity	Layers	Height (mm)	Width (mm)
110	43	5	600	1060
125	38	5	670	1070
140	33	5	735	1050
160	17	3	545	1030
180	14	3	600	970
200	14	3	655	1070
225	11	3	725	970
250	11	3	795	1070
280	8	3	875	910
315	6	2	735	1015
355	4	2	815	780
400	4	2	905	800

Chart 6 - (Identical Value for 6 and 12 meters bars)

2.2 Stokage

For FILÁGUA pipes supply in pallets the quantities are as follows:

Diameter (mm)	Quantity	Layers	Height (mm)	Width (mm)
110	43	5	600	1060
125	38	5	670	1070
140	33	5	735	1050
160	17	3	545	1030
180	14	3	600	970
200	14	3	655	1070
225	11	3	725	970
250	11	3	795	1070
280	8	3	875	910
315	6	2	735	1015
355	4	2	815	780
400	4	2	905	800

Chart 6 - (Identical Value for 6 and 12 meters bars)

3. Durability.

The durability of FILÁGUA pipes is sustained by the valid standards. Keeping in mind the maximum service pressure specified for each one of the pipe series, considering a 20ºC temperature, a 50 year duration is expected.

The behaviour of the high density polyethylene pipes for different temperatures may be analysed in the following charts:

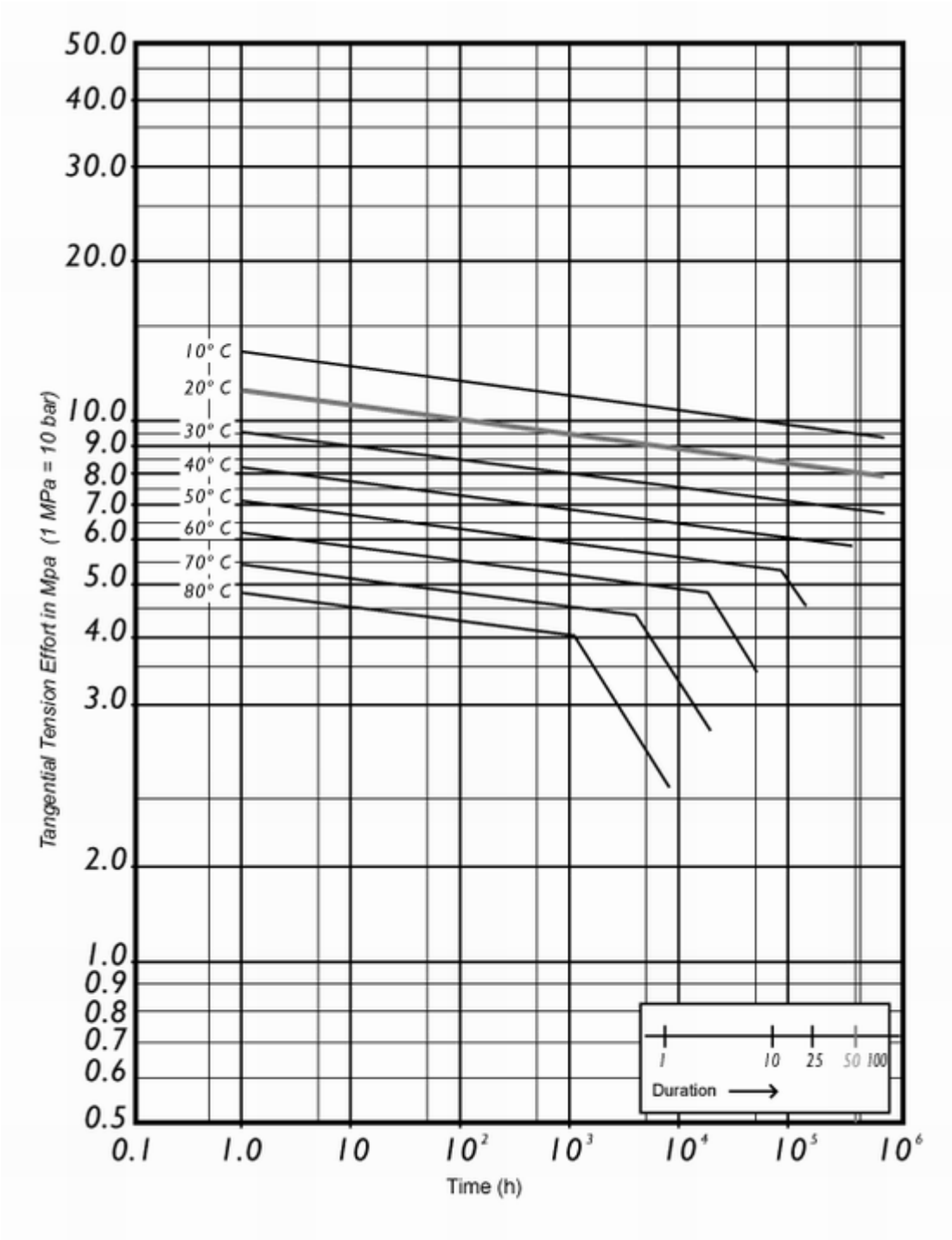


Fig. 3 - Regression curves PE80 (Source DIN 8074)

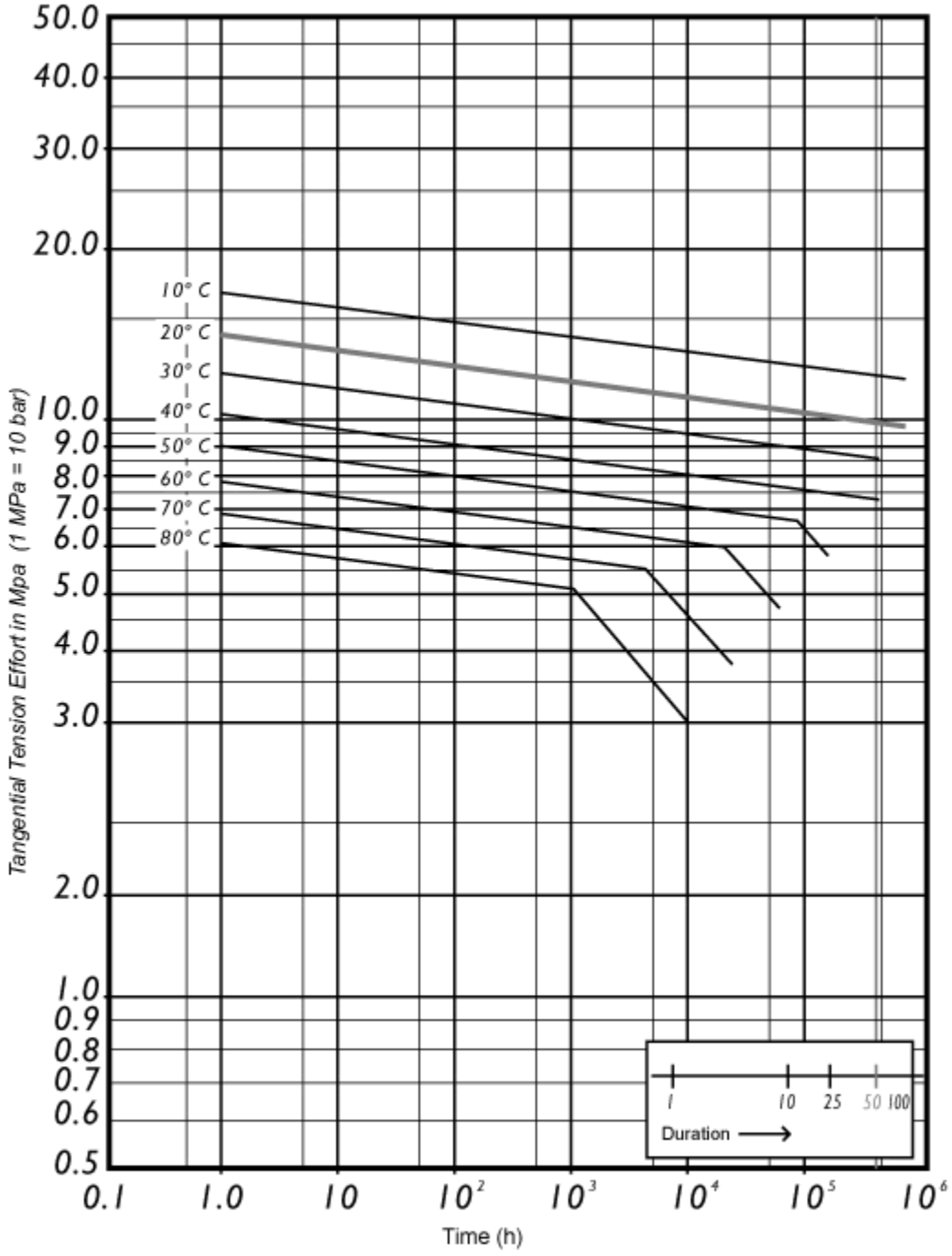


Fig. 4 - Regression curves PE100 (Source DIN 8074)

In the following chart (according to standard DIN 8074) are described the allowed working pressure values for different working conditions (temperature and duration). These values are only valid for water.

		PE 80			PE 100		
Temperature (° C)	Duration (years)	SDR 22 S 10,5	SDR 17 S 8	SDR 13,6 S 6,3	SDR 21 S 10	SDR 17 S 8	SDR 11 S 5
10	5	7,5	10,1	12,6	10,1	12,6	20,2
	10	7,4	9,9	12,4	9,9	12,4	19,8
	25	7,2	9,7	12,1	9,6	12,1	19,3
	50	7,1	9,5	11,9	9,5	11,9	19,0
	100	7,0	9,3	11,6	9,3	11,6	18,7
20	5	6,3	8,5	10,6	8,4	10,6	16,9
	10	6,2	8,3	10,4	8,3	10,4	16,6
	25	6,1	8,1	10,1	8,1	10,1	16,2
	50	6,0	8,0	10,0	8,0	10,0	16,0
	100	5,8	7,8	9,8	7,8	9,8	15,7

Chart 7 - Maximum working pressures

Note: In the ducts with fittings or welded points, it is advisable to consider a security additional factor (fs=0,8xbar).

4. FILÁGUA characteristics.

• Long durability, keeping their properties throughout the years.

• Good physiologic behaviour, as polyethylene pipes do not change the characteristics of drinking water.

• Non toxic in case of fire.

• Great chemical resistance to chemical agents and aggressive soils.

• Excellent welding possibility, an inherent characteristic of thermoplastics.

• Reduced weight, for an easier handling and transport.

• Low coefficient of interior rugosity. Its inner surface, almost flat, allows the execution of systems with reduced charge loss, compared with another type of pipes.

• Good resistance to abrasion, due to the tenacity of the materials.

• Good flexibility. The pipes in polyethylene are easily bended, easing up their installation in layouts with curves and also allowing a good behaviour with low temperatures.

• Excellent resistance to ultraviolet rays, when pigmented with black colour (through the addition of black smoke).

• Low thermal conductivity.

• Low electric conductivity.

• More ecological than metals - less quantities of raw material and of energy necessary to produce the same quantity of finished product. It is a product easily re-used either for the production of other products or for combustion (ex: thermal energy)

5. Recomendations.

5.1 Handling

Cables, metallic accessories or any other type of equipment which may somehow damage the product can not be used, being obligatory the use of appropriate waistbands.

5.2 Storage

During the storage you should not:

• place the pipes in contact with any solvent.

• pile loose pipes with a height superior to 1m.

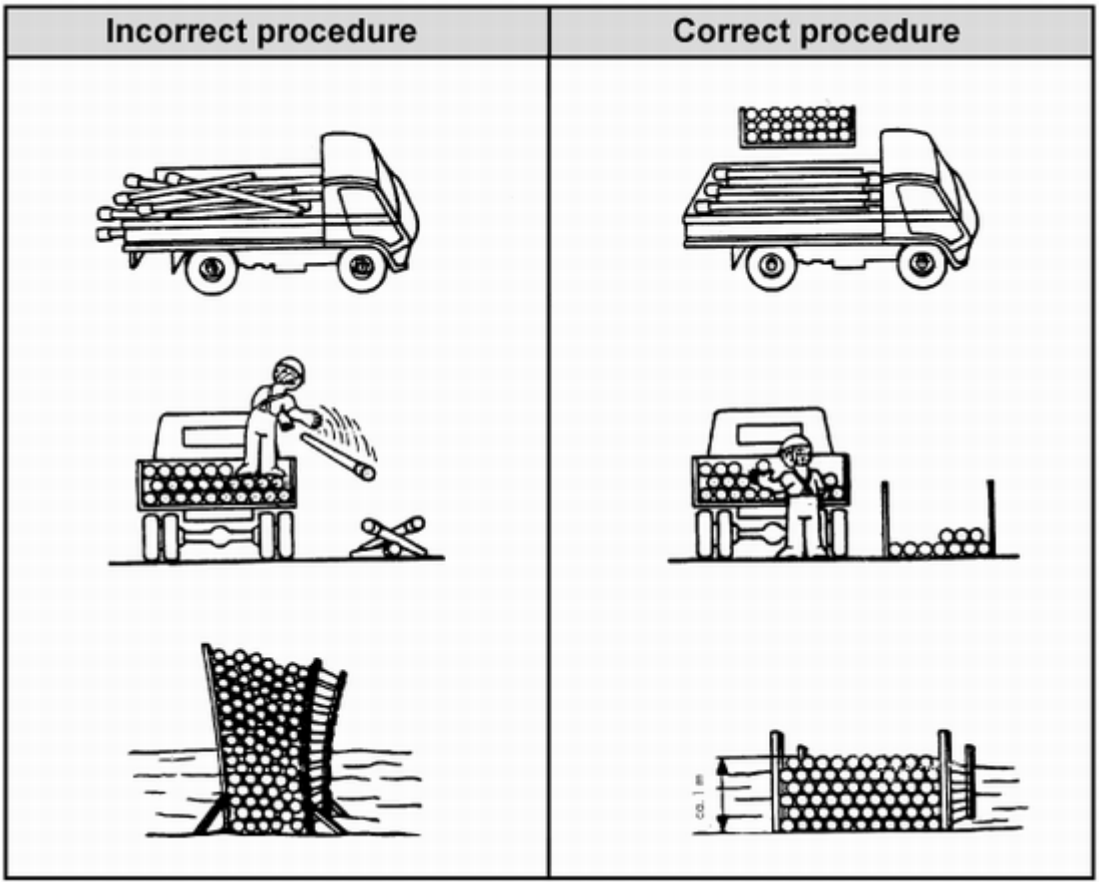
• pile more than 3 pallets of pipes.

• subject the pipes to a temperature superior to 40ºC.

• the pipes, when stored in coils, should maintain the extremities tied and covered.

5.3. Transport

During the load, the transfer of product should be soft, with no stretching, blows or dragging so that damages in the material are avoided. The pipes should be held in at all their length.



6.Application Fields.

6.1 FILÁGUA

FILÁGUA pipes, due to their properties, have several applications:

Water supply ducts:

Industrial applications:

7. FILÁGUA systems.

FILÁGUA systems are used with two types of fittings: butt-fusion and e-fusion fittings.

7.1 Butt-fusion fittings

Long elbow 90º PE 80 S5–SDR 11	
Reference	Dimensions
AP.001.020000.2000	20
AP.001.025000.2300	25
AP.001.032000.3000	32
AP.001.040000.3700	40
AP.001.050000.4600	50
AP.001.063000.5800	63
AP.001.075000.6800	75
AP.001.090000.8200	90
AP.001.110000.1000	110
AP.001.125000.1100	125
AP.001.140000.1200	140
AP.001.160000.1400	160
AP.001.180000.1600	180
AP.001.200000.1800	200

Long elbow 45º PE 80 S5–SDR 11	
Reference	Dimensions
AP.002.020000.2000	20
AP.002.025000.2300	25
AP.002.032000.3000	32
AP.002.040000.3700	40
AP.002.050000.4600	50
AP.002.063000.5800	63
AP.002.075000.6800	75
AP.002.090000.8200	90
AP.002.110000.1000	110
AP.002.125000.1100	125
AP.002.140000.1200	140
AP.002.160000.1400	160
AP.002.180000.1600	180
AP.002.200000.1800	200

Long Tee PE 80 S5–SDR 11	
Reference	Dimensions
AP.003.020000.2000	20
AP.003.025000.2300	25
Ap.003.032000.3000	32
AP.003.040000.3700	40
AP.003.050000.4600	50
AP.003.063000.5800	63
AP.003.075000.6800	75
AP.003.090000.8200	90
AP.003.110000.1000	110
AP.003.125000.1100	125
AP.003.140000.1200	140
AP.003.160000.1400	160
AP.003.180000.1600	180
AP.003.200000.1800	200

Cap PE 80 S5–SDR 11	
Reference	Dimensions
AP.011.020000.2000	20
AP.011.025000.2300	25
AP.011.032000.3000	32
AP.011.040000.3700	40
AP.011.050000.4600	50
AP.011.063000.5800	63
AP.011.090000.6800	75
AP.011.090000.8200	90
AP.011.110000.1000	110
AP.011.125000.1100	125
AP.011.140000.1200	140
AP.011.160000.1400	160
AP.011.180000.1600	180
AP.011.200000.1800	200

Reducing bush PE 80 S5–SDR 11	
Reference	Dimensions
AP.005.025020.2320	25/20
AP.005.032020.3020	32/20
AP.005.032025.3023	32/25
AP.005.040020.3720	40/20
AP.005.040025.3723	40/25
AP.005.040032.3730	40/32
AP.005.050025.4623	50/25
AP.005.050032.4630	50/32
AP.005.050040.4637	50/40
AP.005.063032.5830	63/32
AP.005.063040.5837	63/40
AP.005.063050.6346	63/50
AP.005.075050.6846	75/50
AP.005.075063.6858	75/63
AP.005.090063.8258	90/63
AP.005.090075.8268	90/75
AP.005.110063.1058	110/63
AP.005.110090.1082	110/90
AP.005.125063.1158	125/63
AP.005.125090.1182	125/90
AP.005.125110.1110	125/110
AP.005.140125.1211	140/125
AP.005.160090.1482	160/90
AP.005.160110.1410	160/110
AP.005.160125.1411	160/125
AP.005.160140.1412	160/140
AP.005.180125.1611	180/125
AP.005.180160.1614	180/160

Eccentric bush PE 80 S5–SDR 11	
Reference	Dimensions
AP.006.025020.2320	25/20
AP.006.032025.3023	32/25
AP.006.040025.3723	40/25
AP.006.040032.3730	40/32
AP.006.050032.4630	50/32
AP.006.050040.437	50/40
AP.006.063032.5830	63/32
AP.006.063040.5837	63/40
AP.006.063050.5846	63/50
AP.006.075050.6846	75/50
AP.006.075063.6858	75/63
AP.006.090063.8258	90/63
AP.006.090075.8268	90/75
AP.006.110063.1058	110/63
AP.006.110090.1082	110/90
AP.006.125063.158	125/63
AP.006.125090.1182	125/90
AP.006.125110.1110	125/110
AP.006.140125.1211	140/125
AP.006.160090.1482	160/90
AP.006.160110.1410	160/110
AP.006.160125.1411	160/125
AP.006.160140.1412	160/140
AP.006.180090.1682	180/90
AP.006.180125.1611	180/125
AP.006.180160.1614	180/160
AP.006.200160.1814	200/160
AP.006.200180.1816	200/180

Long reducing Tee PE 80 S5–SDR 11	
Reference	Dimensions
AP.004.063050.5846	63/50
AP.004.075032.6830	75/32
AP.004.075050.6846	75/50
AP.004.075063.6858	75/63
AP.004.090063.8258	90/63
AP.004.090075.8268	90/75
AP.004.110063.1058	110/63
AP.004.110075.1068	110/75
AP.004.110090.1082	110/90
AP.004.125090.1182	125/90
AP.004.125110.1110	125/110
AP.004.160063.1458	160/63
AP.004.160075.1468	160/75
AP.004.160090.1482	160/90
AP.004.160110.1410	160/110
AP.004.180090.1682	180/90
AP.004.180110.1610	180/110
AP.004.180160.1614	180/160

Stub end PE 80 S5–SDR 11	
Reference	Dimensions
AP.007.020000.2000	20
AP.007.025000.2300	25
AP.007.032000.3000	32
AP.007.040000.3700	40
AP.007.050000.4600	50
AP.007.063000.5800	63
AP.007.075000.6800	75
AP.007.090000.8200	90
AP.007.110000.1000	110
AP.007.125000.1100	125
AP.007.140000.1200	140
AP.007.160000.1400	160
AP.007.180000.1600	180
AP.007.200000.1800	200

Blind flange PE 80 S5–SDR 11	
Reference	Dimensions
AV.208.020000.0016	20
AV.208.025000.0016	25
AV.208.032000.0016	32
AV.208.040000.0016	40
AV.208.050000.0016	50
AV.208.063000.0016	63
AV.208.075000.0016	75
AV.208.090000.0016	90
AV.208.110000.0016	110
AV.208.125000.0016	125
AV.208.140000.0016	140
AV.208.160000.0016	160
AV.208.180000.0016	180
AV.208.200000.0016	200

Backing Flange PE 80 S5–SDR 11	
Reference	Dimensions
AV.209.020000.0016	20
AV.209.025000.0016	25
AV.209.032000.0016	32
AV.209.040000.0016	40
AV.209.050000.0016	50
AV.209.063000.0016	63
AV.209.075000.0016	75
AV.209.090000.0016	90
AV.209.110000.0016	110
AV.209.125000.0016	125
AV.209.140000.0016	140
AV.209.160000.0016	160
AV.209.180000.0016	180
AV.209.200000.0016	200

7.2 E-fusion fittings

Socket PE 100 S5–SDR 11	
Reference	Dimensions
AP.101.020000.0010	20
AP.101.025000.0010	25
AP.101.032000.0010	32
AP.101.040000.0010	40
AP.101.050000.0010	50
AP.101.063000.0010	63
AP.101.075000.0010	75
AP.101.090000.0010	90
AP.101.110000.0010	110
AP.101.125000.0010	125
AP.101.140000.0010	140
AP.101.160000.0010	160
AP.101.180000.0010	180
AP.101.200000.0010	200

Elbow 90º PE 100 S5–SDR 11	
Reference	Dimensions
AP.102.020000.0010	20
AP.102.025000.0010	25
AP.102.032000.0010	32
AP.102.040000.0010	40
AP.102.050000.0010	50
AP.102.063000.0010	63
AP.102.075000.0010	90
AP.102.090000.0010	110
AP.102.110000.0010	125
AP.102.160000.0010	160

Elbow 45º PE 100 S5–SDR 11	
Reference	Dimensions
AP.103.020000.0010	20
AP.103.025000.0010	25
AP.103.032000.0010	32
AP.103.040000.0010	40
AP.103.050000.0010	50
AP.103.063000.0010	63
AP.103.075000.0010	75
AP.103.090000.0010	90
AP.103.110000.0010	110
AP.103.125000.0010	125
AP.103.160000.0010	160

Tee PE 100 S5–SDR 11	
Reference	Dimensions
AP.104.020000.0010	20
AP.104.025000.0010	25
AP.104.032000.0010	32
AP.104.040000.0010	40
AP.104.050000.0010	50
AP.104.063000.0010	63
AP.104.075000.0010	75
AP.104.090000.0010	90
AP.104.110000.0010	110
AP.104.125000.0010	125
AP.104.160000.0010	160

Cap PE 100 S5–SDR 11	
Reference	Dimensions
AP.107.020000.0010	20
AP.107.025000.0010	25
AP.107.032000.0010	32
AP.107.040000.0010	40
AP.107.050000.0010	50
AP.107.063000.0010	63
AP.107.075000.0010	75
AP.107.090000.0010	90
AP.107.110000.0010	110
AP.107.125000.0010	125
AP.107.140000.0010	140
AP.107.160000.0010	160
AP.107.180000.0010	180
AP.107.200000.0010	200

Reducing bush PE 100 S5–SDR 11	
Reference	Dimensions
AP.106.025020.0010	25/20
AP.106.032020.0010	32/20
AP.106.032025.0010	32/25
AP.106.040020.0010	40/20
AP.106.040025.0010	40/25
AP.106.040032.0010	40/32
AP.106.050025.0010	50/25
AP.106.050032.0010	50/32
AP.106.050040.0010	50/40
AP.106.063032.0010	63/32
AP.106.063040.0010	63/40
AP.106.063050.0010	63/50
AP.106.075050.0010	75/50
AP.106.075063.0010	75/63
AP.106.090063.0010	90/63
AP.106.110063.0010	110/63
AP.106.110090.0010	110/90
AP.106.160090.0010	160/90
AP.106.160110.0010	160/110

Spigot saddle with incorporated valve PE 100 S5–SDR 11	
Reference	Dimensions
AP.302.063032.0058	63/32
AP.302.090032.0058	90/32
AP.302.110063.0058	110/63
AP.302.125063.0058	125/63
AP.302.140063.0058	140/63
AP.302.160063.0058	160/63
AP.302.180063.0058	180/63
AP.302.200063.0058	200/63

Tapping saddle PE 100 S5–SDR 11	
Reference	Dimensions
AP.201.063020.0030	63/20
AP.201.063025.0030	63/25
AP.201.063032.0030	63/32
AP.201.063040.0037	63/40
AP.201.063063.0058	63/63
AP.201.090020.0030	90/20
AP.201.090025.0030	90/25
AP.201.090032.0030	90/32
AP.201.090040.0037	90/40
AP.201.090050.0046	90/50
AP.201.090063.0058	90/63
AP.201.110020.0030	110/20
AP.201.110025.0030	110/25
AP.201.110032.0030	110/32
AP.201.110040.0037	110/40
AP.201.110050.0046	110/50
AP.201.110063.0058	110/63
AP.201.125020.0030	125/20
AP.201.125025.0030	125/25
AP.201.125032.0030	125/32
AP.201.125040.0037	125/40
AP.201.125050.0046	125/50
AP.201.125063.0058	125/63
AP.201.160020.0030	160/20
AP.201.160025.0030	160/25
AP.201.160032.0030	160/32
AP.201.160040.0037	160/40
AP.201.160050.0046	160/50

PE ball valve PE 80 S5–SDR 11	
Reference	Dimensions
AP.301.020000.0008	20
AP.301.025000.0008	25
AP.301.032000.0008	32
AP.301.040000.0008	40
AP.301.050000.0008	50
AP.301.063000.0008	63
AP.301.075000.0008	75
AP.301.090000.0008	90
AP.301.110000.0008	110
AP.301.125000.0008	125
AP.301.140000.0008	140
AP.301.160000.0008	160
AP.301.180000.0008	180
AP.301.200000.0008	200

Coupling PE-steel PE 80 S5–SDR 11	
Referencia	Dimensions
AP.012.020012.20PO	20x1/2"
AP.012.025034.23PO	25x3/4"
AP.012.032100.30PO	32x1"
AP.012.040114.37PO	40x1 1/4"
AP.012.050112.46PO	50x1 1/2"
AP.012.063200.58PO	63x2"
AP.012.075300.68PO	90x3"

8. Assembly instructions.

8.1 Welding general instructions

a) The fluidity index of pipes and/or fittings is variable according to the raw material that composes it, an important aspect when proceeding to a welding. However, a gap between 0.2 and 1.3 g/10 min (190º1 5Kg) may be admitted.

b) The welding area should be protected from unfavourable weather conditions (humidity, wind, intensive UV radiation, temperatures inferior to 5ºC), using an appropriate tent or awning. The acceptable temperatures for welding are between 5ºC and 40ºC.

c) Please keep in mind the following information when welding:

• E-fusion weldings may be made used for all diameters.

• The flanged sockets should be as reduced as possible.

• Quick coupling system is only possible for water distribution installations, never for gas.

8.2 E-fusion welding

During e-fusion welding, pipes and fittings are welded through electrical resistances incorporated in the fitting which, when heated up by the induced tension, weld the material in an uniform way.

8.2.1. E-fusion procedures

1) Cut the pipe perpendicularly to the radial axis, with the respective cutting tools. Mark the introduction length in the accessory.

2) Scrap the pipe in the axial direction using a proper scraper in order to eliminate the oxide layer coming from atmospheric influences, particularly UV rays. If the object to weld is a fitting, it should be preceded by the same operation.

3) Clean up pipes and fittings. Do not weld pipes or fittings that may not be properly cleaned up and entirely dried up, being advisable the use of a solvent (nail polish remover, alcohol...) and a soft paper.

4) Introduce the pipes in the fitting and verify if the marks are placed at the fitting's end. The length of the marks introduced in the pipes should correspond to halfway the length of the fitting.

5) Tighten up both pipes through an aligning clamp or another aligning equipment.

6) Place the fitting's wire clamps up.

7) Place the machine's cables so that their weight does not cause the rotation of the fitting.

8) Introduce the welding data in the machine through the reading of the code bar existing in the fitting or card. Some equipments allow the manual introduction of the welding code.

9) Proceed to the welding respecting the working instructions.

10) Respect the minimum cooling time, facilitating the solidification of the welding, fundamental aspect to guarantee the quality of the welding.

11) Whenever the e-fusion process is interrupted (electric power lack....), the same fitting can not be re-used.

8.3 Butt-fusion welding

Butt-fusion welding is characterised by three phases:

1) Preparation of the welding - line up pipe/fitting endings to be weld through the facer tool and align the pipes.

2) Pre-heating - the pipe and/or fittings endings to be welded are pressed (at low pressure) against the heating plate until the welding temperature is reached.

3) Connection and cooling – The heated parts are linked, under pressure, after having withdrawn the heating element, during the necessary time to cool down both parts.

8.3.1 Welding parameters

To proceed to the welding, it is necessary to specify the necessary parameters so that it is made correctly. The following chart exemplifies time and pressure necessary for different thickness.

Wall thickness (mm)	Height of the neck (mm)	Pre-heating time (Seg.)	Adjustment time (Seg.)	Application time for the union pressure	Cooling time (min.)
	P = 0.15(N/mm²)	P = (0.02/N/mm²)		P = 0.15(N/mm²)	
2.0 – 4.5	0.5	45	5	5	6
4.5 – 7.0	1.0	45 – 70	5 – 6	5 – 6	6 – 10
7.0 – 12.0	1.5	70 – 120	6 – 8	6 – 8	10 – 16
12.0 – 19.0	2.0	120 – 190	8 – 10	8 – 11	16 – 24
19.0 – 26.0	2.5	190 – 260	10 – 12	11 – 14	24 – 32
26.0 – 37.0	3.0	260 – 370	12 – 16	14 – 19	32 – 45
37.0 – 50.0	3.5	370 – 500	16 – 20	19 – 25	45 – 60
50.0 – 70.0	4.0	500 – 700	20 – 25	25 – 35	60 – 80

Chart 8 - Reference values for butt fusion welding of PE80 pipes and fittings at 20ºC and belowthe air speed level

8.3.2 Procedures for butt-fusion welding

1) Prepare the welding place, in the event of needing to work under a tent or appropriate awning.

2) Read the machine's manual, verifying the correct operation of all its components.

3) Place the pipe and/or fittings with the respective areas to weld in a parallel level, assuring the possibility of longitudinal movements.

4) Align the faces to weld (phase 1), clean any borders or other resulting particles from the rectification process.

5) Clean up the inside and outside of the pipe and/or fitting, using a cleaning agent.

6) Verify if the pipes and/or fittings are properly placed in the welding machine, leaning them against each other.

7) Seal the opposite part of the pipe so that a quick cooling of the interior temperature is avoided, in case of being detected the existence of air currents.

8) Determine the dragging pressure, which depends on the thickness and of the weight of the pipe to be dragged (pressure that will be added to the welding pressure).

9) Verify the temperature of the heating plate (it is advisable to clean before each welding).

10) Insert the heating plate, leaning both ends against each other, imposing the determined pressure and time, so that a barb is created. The adjustment pressure should then be reduced and wait for the pre-heating time to be completed (phase 2).

11) Remove the heating plate and to unite both ends, slowly increasing the adjustment pressure during the time of fusion until the required value is attained. Maintain the adjustment pressure during the necessary time for the cooling.

12) Completed the welding, there must be a barb around the whole circumference with the following characteristics:

• Identical size of the two parts that compose the barb.

• Soft neck surface.

8.4. Buried pipe systems

8.4.1 FILÁGUA

This point explains the procedures to follow according to the *General Regulation of Public Systems of Distribution and Drainage of Residual Waters*.

• The minimum depth for burying the pipes should not be inferior to 80 cm, measured between the upper part of the pipe and the pavement level, being possible to reduce to 50 cm when it is a connection branch in areas not subject to vehicles traffic.

• The width of the gutter for depths inferior to 3m, should have a minimum dimension defined by the following formulas:

- L=D+0.5 for ducts with a diameter non superior to 0.50m.

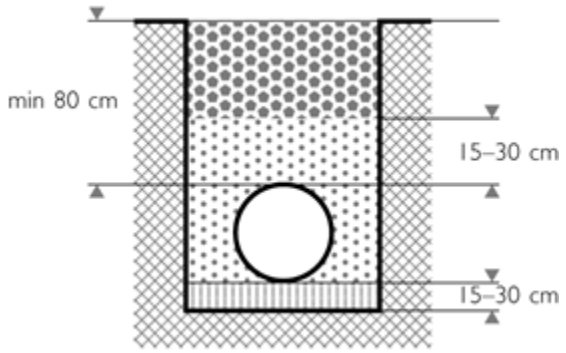
- L=D+0,70 for ducts with a diameter superior to 0.50 m.

Where L is the width of the gutter (m) and D the diameter of the pipe (m)

• The ducts should fulfil the following requirements:

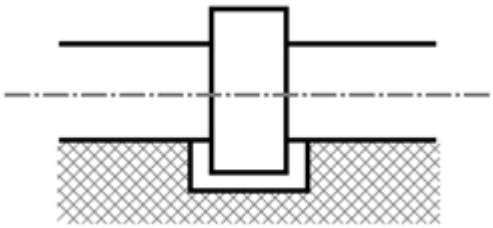
- The pipes should be settled so that each one of them leans on continuously and directly soils with the same resistance.

- If the ducts are settled in rocky soils, the pipes should lay, in all their extension, on an uniform pre-prepared layer with 0.15m to 0.30m of thickness of sand or another uniform material whose bigger dimension does not exceed 20 mm.



- When, for its nature, the soil does not assure the necessary conditions of stability of the pipes or fittings, they should be replaced by more resistant materials.

• In the welded unions, it should be guaranteed that the flat part of the pipe rests on all its length.



• The embankment of gutters should be made from 0.15 m to 0.30 m above the pipes with materials whose dimensions do not exceed the 20mm. The embankment of the material should be carefully made so that the pipes are not damaged.

• FILÁGUA pipes, thanks to their flexibility, allow the realisation of large bends or detours without being necessary to use connection fittings. The reference values for the radius of the minimum bend are as follows:

- Installation temperature more than 20ºC minimum radius bend = 20 x exterior diameter.

- Installation temperature more than 10ºC minimum radius bend = 35 x exterior diameter.

- Installation temperature more than 5ºC minimum radius bend = 50 x exterior diameter.

Note: when making a curve that does not complete the mentioned radius bend above mentioned, a fitting should be used (ex: 45º or 90º elbow).

8.5 - Pressure essays

All the pipes, before being used, should be subjected, in all their length, for a single time or per short periods, to the established rehearsals:

• The rehearsal of the pipes to be placed inside sleeves should be made separately with the pipe outside them, before the assembly in site, being also necessary the final essay to the complete net.

• The rehearsal pressure should be, at least, 1.5 times the working pressure of the pipe, but never inferior to 1 bar.

• For the execution of the essays, a continuous measurement of the pressures and temperatures should be made, with the help of registration devices and of a pressure gauge, accompanied by the calibration certificate.

• The pressure values should be corrected having in mind the temperature variations of the fluid used in the essay, of the pipe wall, of the soil or of the ambient and elastic behaviour of the material.

• The result will be satisfactory if, after the stabilization of the rehearsal conditions, the pressure stays constant in the following six hours, with an eventual correction according to the temperature variation.

9. High density polyethylene FILÁGUA pipes. Load losses.

To exemplify the calculation in the easiest way, we can use the Manning formula:

$$V = \frac{10^{-3}}{n} R^{2/3} J^{1/2} \text{ (m/s)}$$

Where:

V- Water speed m/sg.

DI- Pipe's inner diameter (mm)

R - Hydraulic radius equal to Di/4 (mm)

J - Load loss in m.c.a. / 100 m

N - 0.007 or 0.008 (for PE)

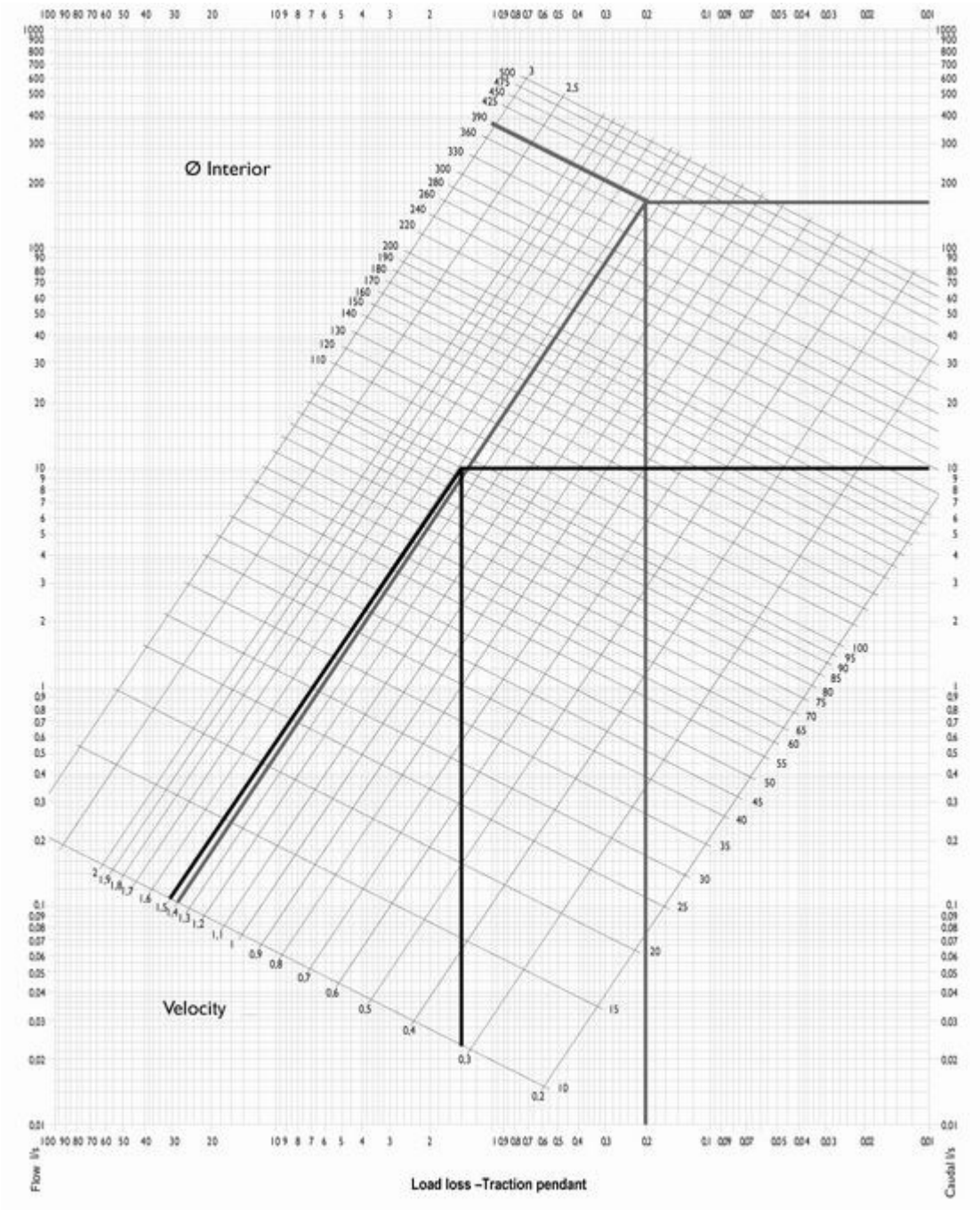
The flow that circulates for the pipe will be:

$$Q = V.S = 0{,}785\ V.Di^2 \times 10^{-3}\ l/s$$

9.1 FILÁGUA pipes load losses graphic

According to Manning formula

$$V = \frac{10^{-3}}{n} R^{2/3} J^{1/2} \text{ (m/s)}$$



Load loss –Traction pendant