Installation instructions

SANITARY FITTINGS

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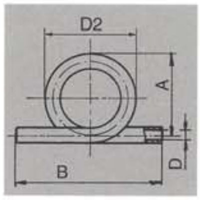
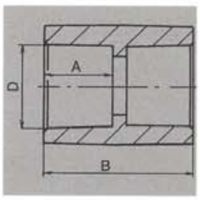
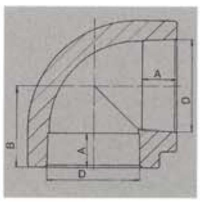
Hamburg - Germany





Installation instructions PPR System



ALMATHERM 2005-2006

CONTENTS

1. INTRODUCTION

Polypropylene piping systems are currently the most widespread type of piping for drinking water and warm water distribution systems in Czech Republic. Among their advantages is low cost, simple handling, a complete range in diameters from 16 to 110 mm, longevity and health safety.
Another indisputable advantage is the smaller inside diameter compared to metallic piping, preserving the same flow. Polypropylene piping systems can be used for central heating and floor heating as well. In this case however, the maximum permanent medium temperature is reduced to 60°C (80°C peak). Furthemore, PP piping is widely used in industrial distribution systems (i.e. for non-compressible media), where their advantage in considerable resistance to various chemicals is exploited.

NOTICE!
Proper piping dimensioning must be carried out by a qualified designer. The piping service life calculation is also a part of the project – acccording to the operating conditions and the pressure range used (appropriate wall thickness). For the piping service life calculation, standard ČSN EN 1778 is used. The assembly itself must be carried out by a qualified person (with a welding license issued by a national authority, i.e. Czech Welding Association ANB in Czech Republic.) equipped with appropriate joining instruments and recommended tools. The placement of pipes throughout the building structure as well as outside must comply with the condition described in the following document.

Test of the welded joints are caried out according to ČSN EN 12 814 d 1-8 standard and visually according to ČSN EN 13100. The allowed tolerances are stated therein.
For house pipework FV PLAST company offers pipes **made of static (random) polypropylene copolymer (PP-Type 3, PPR)**. The pipes come in gray color and in diameters of 16,20,25,32,40,50,63,75,90 and 110 mm. Pipes from PP-Type 3 are made in pressure ranges PN 20,16 and 10. For PN 20, STABI pipes are available. These pipes are mechanically reinforced by aluminum foil, thus combining the properties of metallic and plastic pipes while preserving all the advantages of all.plastic piping. Thanks to this modification they can be manufactured with a thinner wall (same as in PN 16), but with greater inner diameter resulting in greater flow.
Adapting pipes are made in PN 20.

2. RECOMMENDED USE OF PP-Type 3 MATERIAL

- Pressure range PN 10
  - cold water up to 20°C
  - floor heating up to 45°C
- Pressure range PN 16
  - cold water up to 20°C
  - warm water up to 60°C
- Pressure range PN 20
  - warm water up to 60°C
  - central heating up to 80°C (each project has to be separately assessed with respect to service life
  - dependence on pipe wall stress)

It can be generally stated that the pressure range value (PN 10, PN 16, PN 20) defines the corresponding wall thickness – a basis for the calculation of wall stress and resulting pressure resistance and service life under various conditions (see Table 1). It is important to point out that the maximum operating pressure for cold water (to 20°C) in buildings is 10 bar and 7,5 bar for warm water (max.60°C).
The assumed service life is 50 years. It is recommended to use at least PN 16 for cold water and PN 20 for warm (service) water.
When using lower pressure ranges or under modified service conditions, or for media other than pure water, it is necessary to verify the resulting service life by calculation according to ČSN EN 1778.
It is thus always necessary to take into account all relevant conditions: the result is then a compromise between following requirements: required service life, assumed temperature and pressure stress (corresponding pressure range), required water flow and costs of material.
Informative values of maximum allowed service pressure as a function of media temperature and assumed service life for PP-type 3 are shown in Table 1.

3. PIPE ROUTING

When installing plastic piping it is necessary to bear in mind that plastic has significantly different mechanical properties compared to metallic piping.
Thus, all these facts must be taken into account when mounting and installing plastic piping to rule out any possibility of failure or breakdown leading perhaps to health risk or even danger of life. The most important areas of interest are:

- The spacing of supports and various methods of fixing
- Linear expansion and contraction – methods of compensation
- Transitions between plastic and metal
- Mutual combinations of materials etc.

With respect to the fact that plastic piping is not self-supporting, it is necessary to either reinforce it or support it more often than similar piping made of iron.

The FV PLAST company delivers continuous galvanized iron supports (channels) for supporting the piping. These supports are slid onto the pipe, under its insulation (Fig.1,2). The whole assembly is then fastened using loose or fixed clamping brackets (see Chap.3-1"Pipe mounting methods"). The result is that the tubes are then optically straight (they do not deflect or sag). In places where the piping moves due to thermal expansion it is necessary to shorten the support to avoid damage of the pipe.

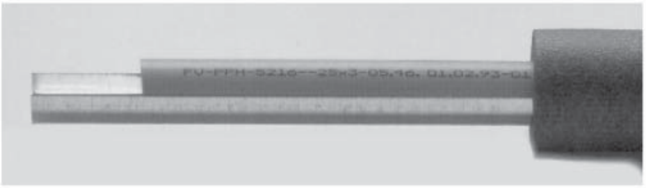


Fig.1 Example of the continuous support combined with insulation made of foamed polyethylene

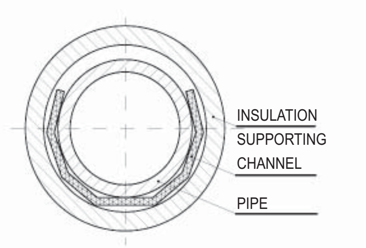


Fig.2 A cross-section of the assembly shown in Fig.1

Temperature (°C)	Service conditions of PP-Type 3 according to ISO DIS 12162			
	Service life (years)	PN 10	PN 16	PN 20
		Allowable service overpressure (bar)		
10	1	21,1	33,2	41,4
	5	19,9	31,3	39,1
	10	19,4	30,5	38,1
	25	18,7	29,5	36,8
	50	18,3	28,7	35,9
	100	17,9	28,3	35,5
20	1	18	28,3	35,3
	5	16,9	26,6	33,2
	10	16,5	25,9	32,3
	25	15,9	25,0	31,2
	50	15,5	24,3	30,4
	100	15,1	23,7	29,6
30	1	15,3	24,1	30,1
	5	14,3	22,6	28,2
	10	14,0	22,0	27,4
	25	13,5	21,2	26,4
	50	13,1	20,6	25,7
40	1	13	20,4	25,5
	5	12,1	19,1	23,9
	10	11,8	18,6	23,2
	25	11,4	17,9	22,3
	50	11,0	17,4	21,7

Temperature (°C)	Service conditions of PP-Type 3 according to ISO DIS 12162			
	Service life (years)	PN 10	PN 16	PN 20
		Allowable service overpressure (bar)		
50	1	11,0	17,3	21,6
	5	10,2	16,1	20,1
	10	9,9	15,6	19,5
	25	9,5	15,0	18,8
	50	9,3	14,6	18,2
60	1	9,3	14,6	18,2
	5	8,6	13,6	16,9
	10	8,3	13,1	16,4
	25	8,0	12,6	15,8
	50	7,8	12,2	15,3
70	1	7,8	12,3	15,3
	5	7,2	11,4	14,2
	10	7,0	11,0	13,8
	25	6,1	9,6	12,0
	30	5,2	8,1	10,1
80	1	6,5	10,3	12,8
	5	6,0	9,5	11,9
	10	4,9	7,7	9,6
	25	3,9	6,2	7,7
95	1	4,6	7,3	9,1
	5	3,1	4,9	6,2
	10	2,7	4,2	5,2

Table 1: Informative values of service conditions and respective service life of PP-Type 3 piping manufactured by the FV PLAST company. **Safety coefficient k=1,25.**

In the case this advantageous method is not used, it is necessary to thoroughly support the piping. The appropriate support distances are shown in Tables 2 and 3. The values shown are valid for horizontal piping. For a vertical direction, the distances can be increased by about 30 %.

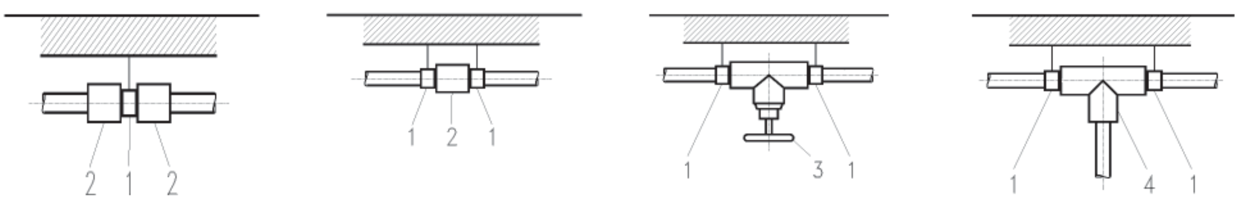
Pipe diameter (mm)	16	20	25	32	40	50	63	75	90	110
Maximum support distance (cm)	110	120	140	145	150	155	165	170	190	205

Table 2. Support distances for STABI piping.

3 – 1. Pipe mounting methods

For the purpose of mounting, two types of support can be used:

a) **in fixed point** (Fig.3.) support the piping is not permitted to dilate, i.e. no movement (slipping) at the supporting point is possible. Examples of this kind of support are at pipe bends, near fittings or water-meter installation points, or at a branch. The simplest fixed support can be established using sleeves (couplings) and brackets.



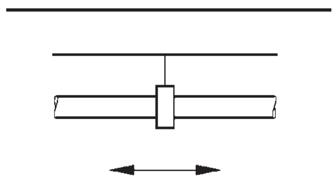
1 – bracket **2 – sleeve** **3 – cock** **4 – Tee-piece**

Fig.3. Examples of fixed support using fittings and brackets.

b) **in a loose support the piping** is not permitted to deviate from the original direction but longitudinal movement is completely free (permitting dilatation or contraction). A typical example is the so-called loose bracket (Fig.4)

Pressure range	Pipe diameter (mm)	Distance of supports (cm) as a function of media temperature					
		20 °C	30 °C	40 °C	50 °C	60 °C	80 °C
PN 20	16	90	85	85	80	80	65
	20	95	90	85	85	80	70
	25	100	100	100	95	90	85
	32	120	115	115	110	100	90
	40	130	130	125	120	115	100
	50	150	150	140	130	125	110
	63	170	160	155	150	145	125
	75	185	180	175	160	155	140
	90	200	200	185	180	175	150
	110	220	215	210	195	190	165
PN 16	16	80	75	75	70	70	60
	20	90	80	80	80	70	65
	25	95	95	95	90	80	75
	32	110	105	105	100	95	80
	40	120	120	115	110	105	95
	50	135	130	125	120	115	100
	63	155	150	145	135	130	115
	75	170	165	160	150	145	125
	90	180	180	170	165	160	135
	110	200	195	190	180	175	155
PN 10	16	75	70	70	65	65	55
	20	80	75	70	70	65	60
	25	85	85	85	80	75	70
	32	100	95	95	90	85	75
	40	110	110	105	100	95	85
	50	125	120	115	110	105	90
	63	140	135	130	125	120	105
	75	155	150	145	135	130	115
	90	165	165	155	150	154	125
	110	185	180	175	165	160	140

Table 3: Distances of supports for pipes of PP-Type 3 as a function of media temperature.



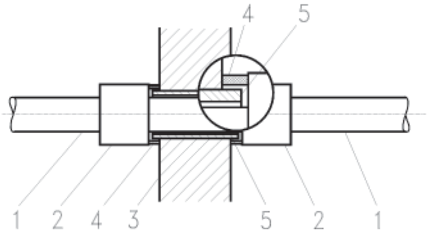
When possible, the use of the FV-plast continuous supports should be preferred (Figs. 1,2). The correct placement of fixed and free support is to a large extent a matter of understanding and gaining a feeling of the plastic piping properties under various circumstances. As a rule of thumb, it can be said that fixed support should be used for mounting of all pipe fittings, at branch-off points of smaller diameter piping (up to 2-3 range steps), etc.

Fig.4: Sliding support – the so-called loose bracket

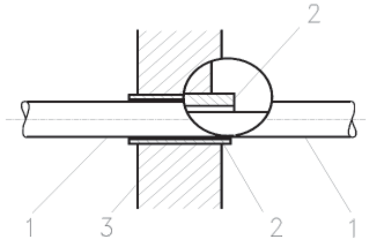
3 – 2. Plastic piping passage through walls

When passing plastic piping through a wall, care must be taken to prevent any damage. For the purpose of laying the pipes, we again consider two methods of passage:

a) **Fixed point** (Fig.5) – where the piping has no means of dilating – slipping – in the passage. The installation is similar to the regular fixed point support, where again sleeves, retaining rings and protecting tubes (usually PVC or LDPE tubes) are used.



1 – pipe 2 – pipe sleeve 3 – wall
4 – retaining ring 5 –protecting tube
Fig.5: Wall passage – fixed point



1 – pipe 2 – protecting tube 3 – wall
Fig.6: Wall passage – free point

a) **A loose support allows the pipe** to dilate in the wall passage, i.e. move or slide in the longitudinal direction of the piping and at the same time offers a protection against mechanical damage due to abrasion.

3 – 3. Linear expansion and contraction of plastic piping

The temperature difference between conditions when the piping was installed and in service, when sometimes hot water is passed through the pipes is responsible for linear dimension changes – either dilatation or contraction. In our case, these changes are substantially greater than in regular iron piping. The overall conctraction or dilatation Δl of the material depends on the coefficient of temperature expansion at [$mm.m^{-1}.°C^{-1}$] of the material used (coefficients of temperature expansion of iron is $\alpha_t = 0.012$, PP $\alpha_t = 0.15$, PP-STABI $\alpha_t = 0.05$, PE $\alpha_t = 0.2$ and PVC $\alpha_t = 0.08$), the effective piping length L [m] and temperature difference Δt [°C] ($\Delta l = \alpha_t.L.\Delta t$). Thus, when we heat or cool 1m of piping, the change in length will be 0.12 mm for steel, 1.5 mm for PP, 0.5 mm for STABI pipes, 2 mm for PE and 0.8 mm for PVC.

WARNING:
Especially dangerous is the contraction of the piping after it is filled with cold water (see Example 2). When not taken into account during installation or in the project, this contraction can eventually lead to destruction of the pipework. In this case, it is appropriate to use a compensating loop or loosening during installation.

We illustrate this topic on two examples:

Example 1: Dilatation of pipe PP-Type 3,8 m long (distance between two fixed supports) at temperature difference of 46°C, (cold water temperature 14°C, warm water temperature 60°C).

Dilatation: $\Delta l = \alpha_t.L.\Delta t = 0.15 \,.\, 8 \,.\, (60\text{-}14) = 55.2$ mm

Example 2: Contraction of PE pipe 20 m long at a temperature difference of 16°C (installation temperature 24°C, cold water temperature 8°C).

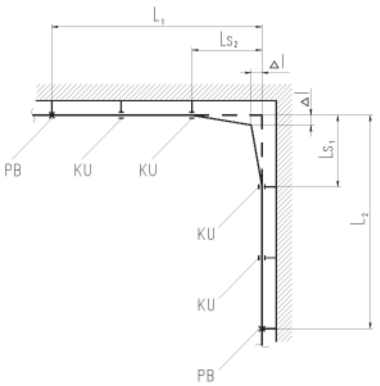
Contraction: $\Delta l = \alpha_t.L.\Delta t = 0.2 \,.\, 20 \,.\, (8\text{-}24) = -64$ mm.

As we can see, the resulting values are fairly large.

3 - 3 - 1. Regular method of plastic piping compensation

3 – 3 - 1 - 1. Compensation calculations

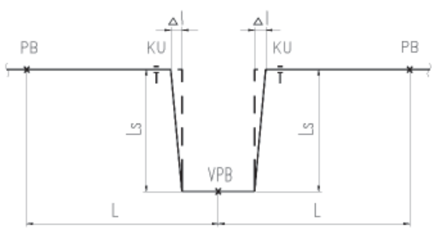
When longitudinal dilatation of piping is not appropriately compensated, i.e. the piping is not allowed to expand or contract; additional tension and pressure stress builds up in the pipe wall, consequently leading to a shorter service life. This problem, when grossly neglected can eventually lead to pipework breakdown, especialy when the piping contracts.
A suitable compensation method is to deviate the pipe in a perpendicular direction and install a loose compensating segment of length L_S. This solution ensures that no substantial additional tension and pressure stresses originate, even when the linear portion of the piping dilates (See Fig.7 and 8).



The compensating length L_S dependent on the relative dilatation or contraction Δl of the segment, on the pipe material and diameter used. It can be obtained using a graph in the following manner (we will use values from Examples 1, Chapter 3-3 for simplicity):
We first determine the relative dilatation Δl [mm] as a function of the pipe length L [m] (distance of two fixed points) and temperature difference Δt [°C] with the help Graph 1.

PB – Fixed point
KU – Free support
L – Pipe length
L_S – Free compensation length
Δl – Calculated pipe dilatation

Fig.7: Warm water piping compensation in a piping bend

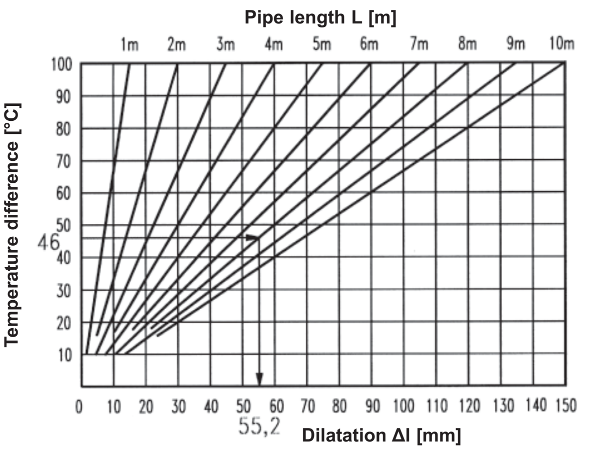


PB – Fixed point
KU – Free support
VPB – Offset fixed point
L – Pipe length
L_S – Free compensation length
Δl – Calculated pipe dilatation

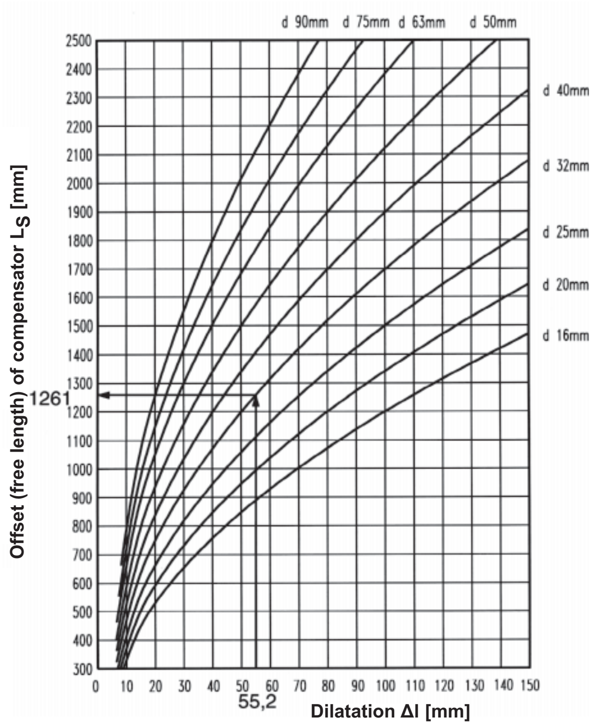
Fig.8: A U-compensator for warm water piping in a straight portion of the piping

The obtained value will be then used for the final determination of the free compensation length L_S [mm], dependent on the pipe material (for polypropylene, k = 30), the pipe outer diameter d [mm] ($L_S = k.(d.\Delta l)^{1/2}$) either computationally or with the help of Graph.2.

It is assumed that within the free compensating length L_S, no supports or suspensions are necessary. The free compensating length should, however, not exceed the maximum support distance according to piping material and diameter (see Table 3).



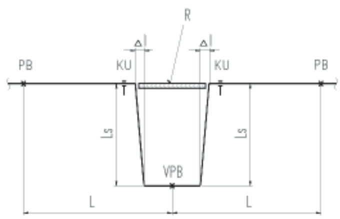
*Graph 1: Dilatation **Δl** of polypropylene piping as a function of temperature difference **Δt** of the transported medium and pipe length **L**.*



*Graph 2: Free compensation length **L_S** for polypropylene piping as a function of dilatation **Δl** and pipe diameter **d***

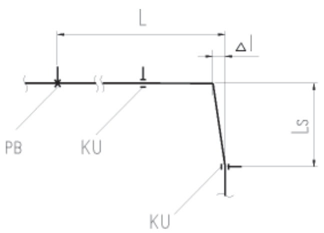
3 – 3 – 1 – 2. Compensator design

When designing compensators it is necessary to decide whether the piping will dilate (distribution of warm service water or water for heating) or contract (distribution of cold water in high ambient temperature – see Example 2, Chapter 3-3).
The more dangerous process is contractions, because in dilation the piping has the possibility to bend out from original position (Fig.16). In contraction dangerous additional pressure stress arises, as already mentioned above.**To compensate dilation we must create sufficient prestress in the piping.** The mechanical properties of plastic allow the compensator to compress only to a limited degree (valid especially for loop compensators). It is therefore necessary to ensure that the compensator stretches the dilating pipe.
The simplest way to do this is by prestressing the legs of the U-compensator using a suitably dimensioned crossbar (Fig.9) before welding the compensator into the piping. The process is similar when compensating for pipe dilatation in a bend (Fig.10).



R – crossbar
PB – fixed point
KU – loose support
VPB – offset fixed point
L – pipe length
L_S – free compensating length
Δl – calculated pipe dilatation

Fig.9: creating of prestress in warm water piping using a U-compresator



PB – fixed point
KU – loose support
L – pipe length
L_S – free compensating length
Δl – calculated pipe dilatation

Fig.10: creating of prestress in warm water piping in a piping bend

Generally, from the point of view of plastic piping dilatation compensation, the more perpendicular bends in the route, the better (Fig.11).

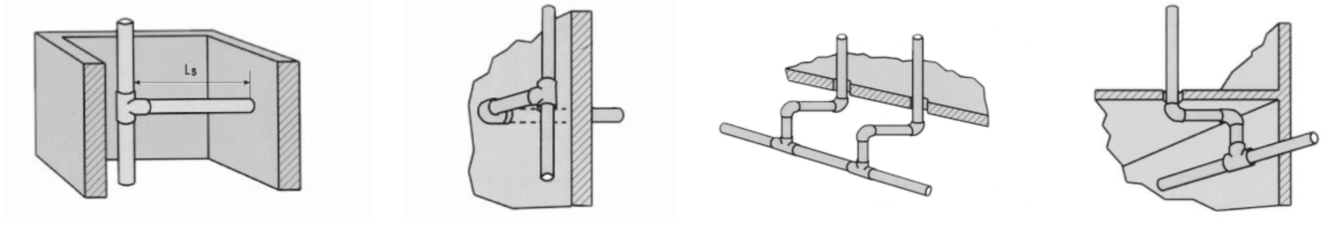


Fig.11: Common methods of plastic piping dilatation compensation

NOTE
For compensating pipes of 40 mm diameter, **loop compensators** are used as well. However, basing on own experience, the FV PLAST does not recommended their usage for compensating of warm water piping. Nevertheless, they are still offered due to existing customer demand. the maximum values of L_S that the loop compensator is capable to absorb are listed in the following table. Here too, it is necessary to build sufficient prestress for warm water piping by appropriately compressing the compensator before welding into the piping (Fig.12).

L_S (mm)	∅ (mm)
80	20
65–70	25
55	32
45	40

Table 4. Maximum values of L_S that the loop compensator can absorb

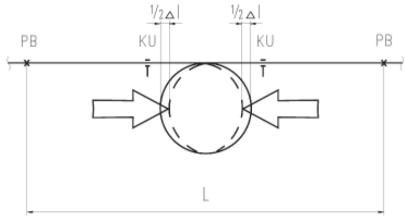


Fig.12: Building of prestress in warm water piping using a loop compensator

3 – 3 - 2. The FV-plast method of compensating plastic piping

Based on own extensive hands-on experience the FV PLAST company has devised its own simple method of compensating plastic piping, based on the above mentioned general rules and at the same time taking into account the specific demands of installation of inner piping, especially in high-rise buildings.

3 - 3 - 2 - 1. Horizontal piping

Normally, the compensation elements are installed perpendicularly to the route between two fixed points, i.e. between branches to the vertical (rising) piping. This solution is spatially demanding due to the placement of the compensating loops (Fig.13).

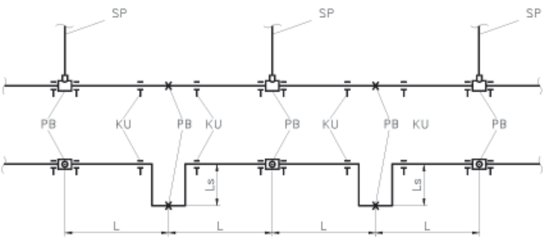


Fig.13: Conventional method of compensating of horizontal piping

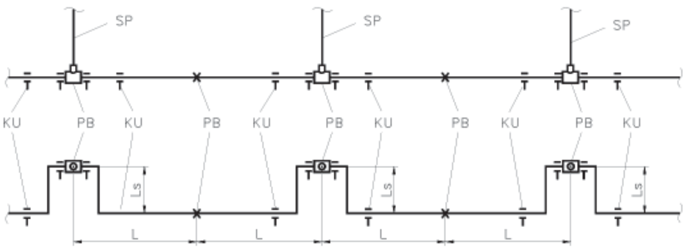
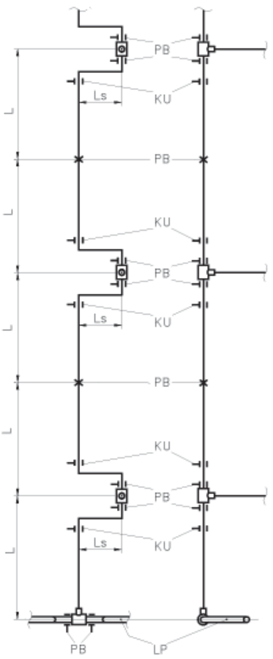


Fig.14: The FV PLAST method of compensating of horizontal piping

The FV-plast method is basen on installing compensation elements directly at the branches to the rising piping (Fig.14). The pipe route between these points is direct and due to the common distances between rising pipes, support in between is not necessary, provided the horizontal route is held in place by the FV-plast galvanized supports. This method is thus satisfactory not only from the spatial, but from the aesthetical point of view as well.

3 – 3 – 2 – 2. Vertical (rising) piping

The FV-plast method can be used with an advantage in vertical piping as well. Contrary to horizontal piping, **the vertical piping must always be firmly anchored between individual storeys with a fixed support.**
If the FV-plast galvanized supports are not used the distance between individual rising pipe supports can be increased by a factor of 1.3 compared to values in Table 3 (for horizontal piping).
The compensators are installed directly at the branches to individual apartments (Fig.15).



Symbols:
PB – fixed point
KU – loose support
L_S – free compensating length

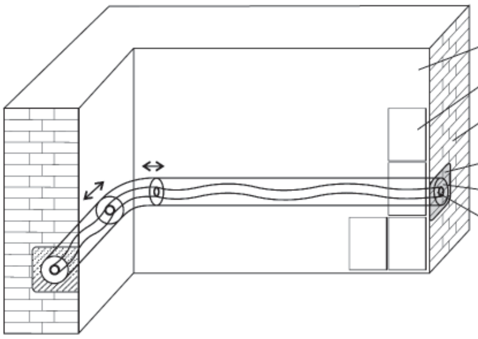
< Fig.15: The FV-plast method of compensating of rising piping

Fig.16: An example of uncompensated piping before and after heating >

When using the FV-plast compensation method a sufficient thermal compensation in standard buildings is ensured without the need of complicated calculations and bulky compensation loops. This results in a reduction of labour and material savings (especially elbows).

3 – 3 – 3. Compensation of plastic piping in plaster

When the piping leads in plaster the basis is the same as with piping leading in a canal. It is necessary to ensure sufficient space for the movement of the pipe and at the same time prevent mechanical damage due to abrasion. For the insulation of the piping PE foam or micro-porous rubber of sufficient wall thickness is considered as the most suitable solution.



Compensation of the linear expansion takes place in bends and by bending-out in straight sections.

Fig.17: Compensation of plastic piping in plaster

WARNING
It is necessary to insulate all fittings as well, not only the pipes.

FINAL NOTICE
The compensation of linear expansion of plastic piping **is necessary when its contraction during service is anticipated,** as in installation of cold water piping in high ambient temperature (e.g. installation in summer – see Example 2, Chapter 3-3), when the use of a loop compensator is recommended (Table 4). Compensation of linear expansion of plastic piping in the case when dilatation during service is anticipated and the piping can bend out (as in plastic continuous supports) is required only due to aesthetical reasons (see Fig.16). To ensure the effectiveness of this kind of compensation, it is necessary to build sufficient pre-stress, so that the compensating element stretches the dilating pipe (see Chap. 3-3-1-2).

4. APARTMENT CONNECTION

The apartment connections are usually made using pipes of 20 mm diameter. Piping installed in a raggle in masonry must be thoroughly insulated. The purpose of this insulation is not to only prevent thermal loss (in warm water piping) but to prevent water condensation (in cold water distribution) and protect the piping against mechanical damage as well as provide for linear expansion.

WARNING: In no case is it recommended to insulate with only one layer of felt lining, as this has not sufficient compressibility to absorb piping dilatation.

The pipe in the raggle must be duly anchored before completing masonry! (with supports, plaster, screws, etc.)

5. MATERIALS COMBINATIONS

The combination of individual components of different materials using mechanical joints or metal-plastic reducers (Fig.18,19, or threaded joints – Fig.22,23,24) is straightforward provided suitability of the components for the particular purpose is observed.

Materials of PP-Type 3 may not be welded with materials of other groups, e.g. PE, PB, etc!

The weldability of various plastic materials is assessed by the welding class. Only plastics in one welding class can be welded together without risk. This class is defined by the index of granulate flow (ITT). The manufacturer of the plastic material guarantees this value (within certain tolerance limits). The accompanying delivery documents serve as evidence. We also test the compatibility in our own test laboratory. For this reason, the parameters of the material itself are decisive, not the manufacturer alone.

6. INSTALLATION TEMPERATURE

The ambient temperature when installing plastic piping must not fall below +5°C. It is recommended that the contractor incorporates this condition into the contract. The minimum temperature is a requirement of the plastic material on one hand, on the other hand at lower temperatures the welding instruments cool too fast.

7. BENDING OF PIPES

Cold bending of pipes is carried out at temperatures higher than +15°C.

Generally, for the bending of pipes up to the diameter of 32 mm, the allowed bending radius is:

$r=12 \cdot d$ (mm)

8. INSTALLATION OF REDUCERS WITH OUTER OR INNER THREADS

Reducers with outer or inner threads are used for the changeover between plastic and metal, especially for the connection of metallic fittings, washstands, etc.

FV PLAST delivers three types of these reducers (see our catalogue):
● **Reducers with plastic outer threads**
● **Reducers with fused metallic inner or outer threads** (these parts are made of nickel-plated brass and are fitted with cylindrical inner or outer threads)
● **Dismountable joints** (based on a special plastic fitting, equipped with a cap sleeve of nickel-plated brass with inner or outer cylindrical thread).

FV PLAST gives the guarantee to the full extent, i.e. for the period of 10 years, detriment up to the amount of 2,000.000 CZK and declared service life of 50 years of the abovementioned reducers only when the following principles and installation procedures will be adhered to:

8 - 1. Installation process

8 - 1 – 1. Reducers with external plastic thread

1) Check that the inner thread of the counter piece is longer than 2/3 of the reducer plastic thread. If not, it is necessary to use a reducer with external metallic fused thread.
2) Coarsen the reducer thread (with a metal saw) so that the hemp wrapped in the thread later on does not slip. Apply a sufficient amount, so that the joint is leak-proof even before completely tightened.
3) It is necessary to grease the hemp with a suitable lubricant (do not use varnish oil, as this leads eventually to permanent joint)-best results are with Indulona (Hand care cream).
4) Screw the fitting into the metallic thread of the counter piece while observing whether the hemp does not slip.
5) If the hemp lips, it is necessary to repeat steps 3 to 5.

WARNING
Reducers with plastic outer thread cannot be used when the length of the inner thread of the counter piece is less than 2/3 of the reducer plastic thread.

8 - 1 - 2. Reducers with external plastic thread

This type of fitting is a combination of a metallic thread with a plastic termination enabling a polyfusion joint with piping of the same material.

Strong and leak-proof joints between plastic and metal (usually nickel-plated brass) fused fittings are achieved thanks to its special shape – a combination of grooves that help to transfer the torque as well in smaller fittings.

NOTICE:
Reducers with fused metal threads may not be used for media that degrade the metal (nickel-plated brass) parts by corrosion, as is the case in filter systems for chlorinated water in swimming pools, etc. In these cases, all-plastic fittings are recommended.

Fig.18: Cross-section of a reducer with outer plastic thread with a cast brass bushing.

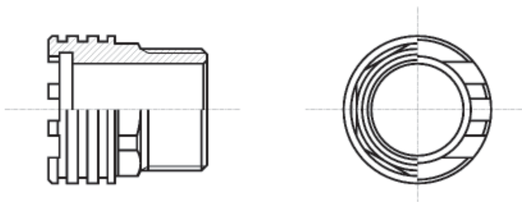


Fig.19: Outer metallic thread

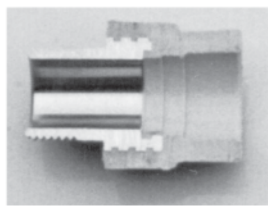


Fig.20: Cross-section of a reducer with outer metallic thread.

It is thus clear from the above mentioned that the installation procedure is important here as well.

1) If a fitting manufactured by another company is to be used (determined by the manufacturer’s sign) we must check whether the metal part is not made of steel (e.g.with the help of a magnet). If it does contain steel, it must be instantly discarded!!!
2) Even when the metal part is made of brass, a written permission of the FV PLAST company is required to ensure the validity of the guarantee (10 years and damage up to 2 million CZK) – see Section 3 of the Conditions of Guarantee.
3) We apply sealing into the fitting thread. For outer or inner metal threads only Teflon band or sealing putty can be used! When tightening the reducer into the corresponding counter piece care must be taken not to rip off the metal thread from the plastic part. We suggest using a special tightening wrench with a strap, especially for fittings of smaller demensions (Fig.21). This tool enclasps the fitting along the whole circumference, unlike pipe wrench or adjustable wrench, so the joint is not stressed so much. This wrench can be obtained from FV PLAST.

For the tightening of fitting into to corresponding counter piece common pipe wrench or adjustable wrench should not be used!

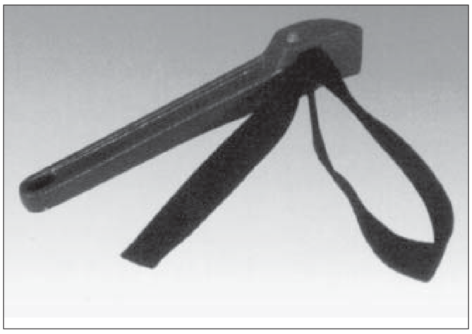


Fig.21: Tightening wrench with strap

<u>Notice!</u>
Claims for ripped inner fused threads into which the counterpart with conical metallic thread was installed, or sealed with other material than Teflon band or sealing compound (e.g.hemp) will not be recognized. Similarly, clams for untight reducers with cast metal threads carrying evidence of tightening with tools which do not comply with Section 3 of installation procedure, will not be recognized either.

8 - 2. Dismountable joints

These joints fully replace commonly used reducers with outer or inner metal thread (Figs.19,20), offering a possibility of repeatable and easy dismantling and reassembly.

Fig.22: An example of a joint between PE and PPR using a removable joint

Fig.23: Various combinations of plastic reducers with cap nuts fully replacing reducers with fused inner thread.

This feature can be used with advantege for installing elements of shorter service life compared to the plastic piping itself (e.g. valves, water-meters, etc.,Fig.24). Another great advantage is the possibility to combine a great variety of pipe materials and dimensions (PE,PP,PPR,steel,brass) and elements (Figs. 22,23,24).

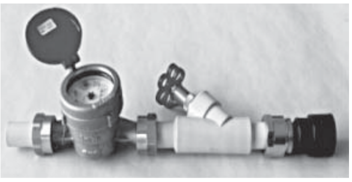


Fig.24: A working example of removable joints application – the connection of family house (or apartment) water piping of polypropylene, type 3 (water-meter valve with check valve) with central distribution made of LDPE.

9. PLASTIC PIPING INSULATION

Although the thermal conductivity of plastic piping is more than an order of magnitude smaller compared to pipes made of steel, it is nevertheless obvious that high quality insulation is very important here as well. In Table 5 the theoretical cost savings for various types of insulation are given. This table shows that saving on insulation does not pay off, because **the investment into quality insulation returns as soon as in the first heating season.**

Insulation type	Energy loss (W.h/m)	Energy saving (W.h/m)	Service costs saving (EUR/year.m)	Insulation cost (EUR/m)
None	432	0	0	0
Felt	180	252	38,19	0,13
Polystyrene foam	113	319	48,35	0,32
PE foam – MIRELON	**28**	**404**	**61,22**	**1,19**

Table 5: Service costs saving and insulation cost recalculated from the Czech market conditions. Comparison of energy saving and service costs as a function of insulation method for vertical PP-Type 3 piping with 40 mm diameter, PN 16 under normal conditions (water flow 0,7 m³/hr, heating price 150,- CZK/GJ i.e. 4,838 EUR/GJ) at water temperature 55°C and ambient temperature 18°C.

For polypropylene water piping the foamed polyethylene roll-on tubes are currently the optimal insulation solution from the quality, ease of installation and handling point of view (Fig.25).

WARNING:
In places where the insulated piping leads in wet surroundings the use of insulation materials with unsoakable surface (e.g.with outer protective foil) is necessary, in order to prevent soaking of the material with water or moisture.

This type of insulation, besides superior insulation properties offers sufficient room for pipe dilatation as well when used in mansonry (Fig.17).

The FV PLAST company supplies insulation made of foamed polyethylene in the range of pipe diameters 16 to 110 mm with wallthickness from 6 to 20 mm.

The thermal stability of this material allows use in the temperature range -65°C to 95°C, or even -75 °C to +105°C short-term.
Thermal conductivity 0.04 W/m °C
Specific weight 18-28 kg/m³ (depending on the amount and type of additives)
Minimum service life is 50 years, when protected from direct influence of weather.

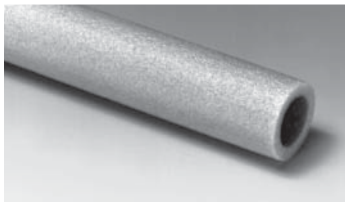


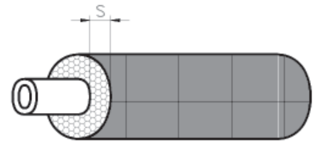
Fig.25: Insulation made of foamed polyethylene

9 – 1. Application of roll-on tubes

This is a very simple operation. The tubes are slid directly onto the plastic pipe and butt-fixed in place using a special cement based on chloroprene rubber or polyacrylate.
If, for some reason, it is not possible to roll-on the tube it is possible to cut it longitudinally first, then put it in place and finally fix in place with cement. **The use of various mechanical joints or staples is not recommended,** as the isolating tube then breaks open in places where it is not cemented, due to the higher temperature expandability of plastic piping. This leads to thermal losses and the insulation consequently loses its purpose.
Besides pipes it is also necessary to insulate the fittings, to prevent thermal losses in these places. This can be done with the help of a special adhesive tape made of the same material as the insulation tube or with the insulation tube itself. We then use a larger diameter, cut it lengthwise, put in place and finally secure with cement.

9 – 2. The insulation of cold water piping

Cold water piping is insulated not only to reduce heat exchange between the delivered medium and surrounding environment but to prevent dewing as well. The recommended insulation thickness for pipes of PN 20 range is shown in the following set of tables, where



s = recommended insulation thickness in mm (for thermal conductivity 0.04 W/m °C)
T_e = ambient temperature in °C
T_i = temperature of the delivered medium (water) in °C
At relative air humidity 60 or 80%

pipe ∅ 20 x 3,4 mm

T_i \ T_e	26	27	28	29	30	31	32	33	34	humidity
5	3,7	3,9	4,1	4,3	4,6	4,8	5,0	5,3	5,5	60 %
7	3,0	3,3	3,5	3,8	4,0	4,2	4,5	4,7	5,0	
9	2,4	2,7	2,9	3,2	3,4	3,7	3,9	4,2	4,4	
5	10,5	10,9	11,3	11,7	12,1	12,4	12,8	13,2	13,6	80 %
7	9,5	9,9	10,3	10,7	11,1	11,5	11,9	12,3	12,7	
9	8,4	8,8	9,2	9,6	10,0	10,5	10,9	11,3	11,7	

pipe ∅ 20 x 3,4 mm

T_i \ T_e	26	27	28	29	30	31	32	33	34	humidity
5	3,6	3,8	4,1	4,3	4,6	4,8	5,1	5,3	5,6	60 %
7	3,0	3,2	3,5	3,7	4,0	4,2	4,5	4,8	5,0	
9	2,3	2,6	2,9	3,1	3,4	3,7	3,9	4,2	4,4	
5	10,9	11,3	11,7	12,1	12,5	12,9	13,3	13,7	14,1	80 %
7	9,7	10,2	10,6	11,0	11,4	11,9	12,3	12,7	13,1	
9	8,6	9,0	9,5	9,9	10,3	10,8	11,2	11,7	12,1	

pipe ∅ 32 x 5,4 mm

T_i \ T_e	26	27	28	29	30	31	32	33	34	humidity
5	3,5	3,8	4,0	4,3	4,5	4,8	5,0	5,3	5,5	60 %
7	2,9	3,1	3,4	3,6	3,9	4,2	4,4	4,7	5,0	
9	2,2	2,5	2,7	3,0	3,3	3,6	3,8	4,1	4,4	
5	11,1	11,6	12,0	12,4	12,9	13,3	13,7	14,1	14,6	80 %
7	10,0	10,4	10,9	11,3	11,8	12,2	12,7	13,1	13,5	
9	8,7	9,2	9,7	10,1	10,6	11,1	11,6	12,0	12,5	

pipe ∅ 40 x 6,7 mm

T_i \ T_e	26	27	28	29	30	31	32	33	34	humidity
5	3,4	3,6	3,9	4,2	4,4	4,7	4,9	5,2	5,5	60 %
7	2,7	3,0	3,2	3,5	3,8	4,1	4,3	4,6	4,9	
9	2,0	2,3	2,6	2,8	3,1	3,4	3,7	4,0	4,3	
5	11,3	11,8	12,3	12,8	13,2	13,6	14,1	14,5	15,0	80 %
7	10,1	10,6	11,0	11,5	12,0	12,5	12,9	13,4	13,9	
9	8,8	9,3	9,8	10,3	10,8	11,3	11,8	12,3	12,8	

pipe ∅ 50 x 8,4 mm

T_i \ T_e	26	27	28	29	30	31	32	33	34	humidity
5	3,1	3,4	3,7	4,0	4,2	4,5	4,8	5,0	5,3	60 %
7	2,4	2,7	3,0	3,3	3,6	3,8	4,1	4,4	4,7	
9	1,7	2,0	2,3	2,6	2,9	3,2	3,5	3,8	4,1	
5	11,5	11,9	12,4	12,9	13,4	13,8	14,3	14,8	15,3	80 %
7	10,1	10,6	11,1	11,6	12,1	12,6	13,1	13,6	14,1	
9	8,8	9,3	9,8	10,4	10,9	11,4	11,9	12,4	13,0	

pipe ∅ 63 x 10,5 mm

T_i \ T_e	26	27	28	29	30	31	32	33	34	humidity
5	2,8	3,1	3,4	3,7	4,0	4,2	4,5	4,8	5,1	60 %
7	2,1	2,4	2,7	3,0	3,3	3,6	3,8	4,1	4,4	
9	1,4	1,7	2,0	2,3	2,6	2,9	3,2	3,5	3,8	
5	11,5	12,0	12,5	13,0	13,5	14,0	14,5	15,0	15,5	80 %
7	10,1	10,6	11,2	11,7	12,2	12,7	13,2	13,8	14,3	
9	8,7	9,2	9,8	10,3	10,9	11,4	12,0	12,5	13,1	

pipe ∅ 75 x 12,5 mm										
T_i \ T_e	26	27	28	29	30	31	32	33	34	hu-midity
5	2,5	2,8	3,1	3,4	3,7	3,9	4,2	4,5	4,8	60 %
7	1,8	2,1	2,4	2,7	3,0	3,3	3,5	3,8	4,1	
9	1,0	1,3	1,6	1,9	2,2	2,6	2,9	3,2	3,5	
5	11,4	11,9	12,4	13,0	13,5	14,0	14,5	15,0	15,6	80 %
7	10,0	10,5	11,1	11,6	12,1	12,7	13,2	13,8	14,3	
9	8,5	9,1	9,7	10,2	10,8	11,3	11,9	12,5	13,0	

NOTICE:
Experience shows that improperly insulated cold water piping can threaten steel supporting building structures due to dewing as a consequence of cooling be the medium.

9 – 3. Insulation of warm water piping

Warm water piping must be insulated to prevent thermal losses (Table 5)
The recommended thickness of foamed PE is at least 9 – 13 mm. Generally, the thicker the thicker the insulation, the better.

10. METHODS OF CONNECTING PLASTIC PIPES

Methods of connecting plastic pipes can be divided into two basic groups:
- **connecting by mechanical joints**
- **joining**

10 – 1. Connecting by mechanical joints

For the connection of polypropylene piping PP-type 3 used in FV-plast floor heating system, dismountable brass joints can be used.

10 – 2. Joining (welding)

The FV-plast fittings made of PP-type 3 are suitable for connecting by joining. This type of connecting can be divided into three groups:
- **polyfusion joining**
- **butt joining**
- **joining using electrofittings**

WARNING:
Joining of PP-type 3 with materials from other groups, e.g. PE,PB, etc. is not allowed.

10 – 2 – 1. Polyfusion joining

The pipes and fittings coming from FV PLAST are connected preferably by polyfusion joining.
In this process, the outer heated end of the pipe is connected with the inner surface of the fitting sleeve (Fig.38). The partially melted surfaces come into contact and a homogenous and a very rigid joint arises after cooling.
Polyfusion joining is subject to German regulations DVS 2207 d.

10 – 2 - 1 – 1. Required tools

1) Polyfusion joining machine
2) Adapters for polyfusion joining
3) Contact thermometer
4) Special shears or cutter (jaws with cutting wheel)
5) Small sharp knife with a short blade
6) Rag from non-synthetic textile
7) Tangit (cleaner for PP and PE from Henkel), isopropyl alcohol or ethyl alcohol for degreasing
8) Meter, market
9) For diameters greater than 50 mm a hand scaper or trimming knife and a welding fixture
10) Pipe cutter for FV-STABI pipes

10 – 2 - 1 – 1 – 1. Polyfusion joining machine with adapters

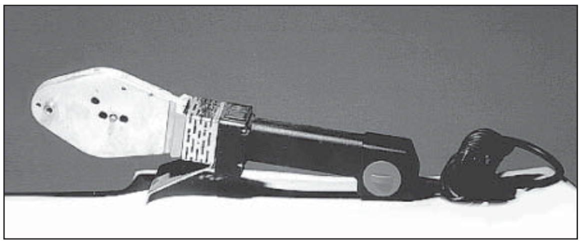


Fig.26: Flat polyfusion joining machine

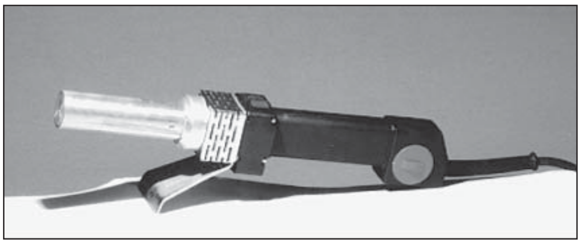


Fig.27: Polyfusion joining machine with bushings

For polyfusion joining **the electric polyfusion joining machine** (Figs.26,27) **with polyfusion adapters** (Fig.28) for individual profiles of pipes and fittings is used.

WARNING:
Socket fittings for polyfusion joining are manufactured as the A-type according to DVS 2207, Part II (see Fig.29). Before using a particular welding adapter it is important to check whether it is suitable for this type of fitting.
NOTICE:
Welding adapters for a number of other types of sockets can be seen on the Czech market, leading to frequent confusion. Among these types are adapters for TYPE B sockets, a special type for elements made by PLASTIKA NITRA, etc.

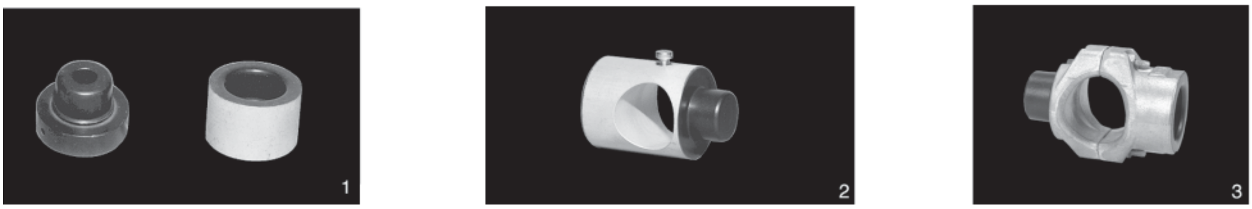


Fig.28: Polyfusion adapters 1) Pair-type 2) with bushings 3) for clamp-bushigs

The dimensions of polyfusion adapters are subject to DIN regulations.

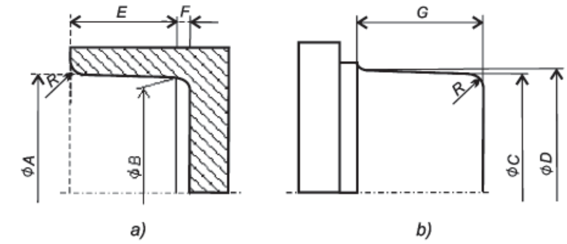


Fig.29: Polyfusion adapters of A-type (dimensions in Table 6)

Pipe diameter	A 1)	B 1)	C 1)	D 1)	E	G	R
20	20,15	19,94	19,40	19,65	12,0	14	2,5
25	25,15	24,92	24,37	24,65	13,0	15	2,5
32	32,15	31,90	31,34	31,65	14,5	16,5	3
40	40,15	39,88	39,31	39,65	16,0	18	3
50	50,20	49,84	49,27	49,65	18,0	20	3
63	63,20	62,78	62,22	62,70	24,0	24	4
75	75,25	74,57	73,67	74,98	26,0	26	4
90	90,30	89,54	88,61	90,05	29,0	29	4
110	110,30	109,45	108,48	110,10	32,5	32,5	4

1) valid for 260 ±°C

Table 6: Dimensions (in mm) of polyfusion adapters, A-type

The heated surfaces of polyfusion adapters are coated with Teflon. It is necessary to clean these surfaces thoroughly before and during welding. **Also, before first use of a new polyfusion adapter it is necessary to polish the Teflon surface** (e.g. using a rag from nonsynthetic material, preferably flannel).

10 – 2 – 1 – 1 – 2. FV-STABI pipe cutter

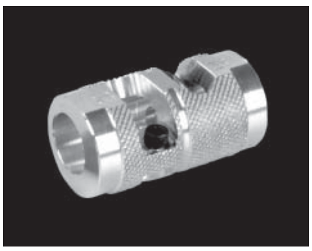


Fig.30: FV-STABI pipe cutter

For the removal of the surface layer of FV-STABI pipes a special cutter is used. This tool is in stock, and serves for the removal of the surface layer while preserving the diameters required for a high quality polyfusion joint.
NOTICE:
The cutting blade in the cutter is replaceable and adjustable. The blade must be adjusted before first use. This is best done using a normal plastic pipe of the corresponding diameter. After the test cut, the resulting pipe diameter is measured. This diameter must be the same as in the all-plastic pipe of the corresponding diameter.

10 – 2 – 1 – 2. The fusion process

Preparing the tools
1) Firmly screw the welding adapters onto the joining machine
1 – welder element
2 – welding adapter
3 – threaded brass quick-coupler

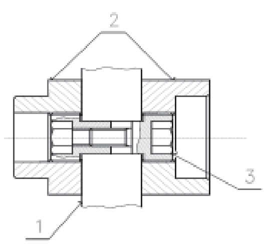


Fig.31: Fastening the pair welding adapters using the threaded brass quick-coupler

2) Using the temperature regulator (or switch) set the welding tenmperature (240 – 260 °C ±5 °C) and connect the joining machine into mains. The heat-up time depends on the ambient temperature. Let the machine regulator turn-on and turn-off several times, so the adapters thoroughly warm-up.

NOTICE:
The required temperature is reached only after several successive cycles of the electronic or thermostatic temperature regulator. The warm-up times of the pipes and fittings (assuming the welding adapter temperature is 260 °C), the possible correction time and time required for cooling of the joint, during which the joint must not be stressed are stated in the table below:

Outer pipe diameter (mm)	**Warm-up time (s)**	**Correction time (s)**	**Cooling time (min)**
16	5	4	2
20	5	4	2
25	7	4	3
32	8	4	4
40	12	4	4
50	18	4	5
63	24	4	6
75	30	5	7
90	40	8	8
110	50	10	9

Table 7: Process times of polyfusion joining as a function of pipe (fitting) diameter at adapter temperature 260 °C.

3) Clean the welder heating elements using a rag from non-synthetic material (preferably flannel).
4) The welder is prepared to work only after the LED indicates it is sufficiently heated-up.
5) Using the contact thermometer check the surface temperature of the adaptors.

NOTICE: Each worker should be equipped with a contact thermometer to check the true temperature of the adapters. The temperature indication on the joining machine is only informative!
6) With one or two test cuts of a test pipe check the correct function of the special shears or cutting wheel. In this test **no deformation of the test pipe is allowed to occur.** If this happens, it is necessary to adjust the tool (evt.sharpen it).

Preparing the installation material

All parts should be thoroughly checked before commencing work.

Material with significant defects (e.g. sinks, bulges, foreign particles, etc.) must be discarded!!! Similarly, reducers with steel fused threads must be discarded as well!!!

Thoroughly clean the material from grease and dirt!!! This applies especially to the inner sides of fittings and pipes to be joined.

The joining process

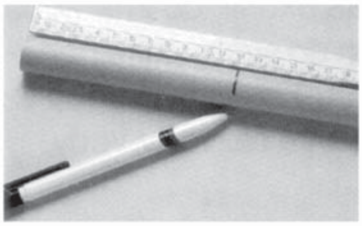


Fig.32: Measure and mark the required length of the pipe (do not forgot to add the length which will be slid into the fitting during welding)
We recommend marking the point where the pipe will emerge from the fitting. It is necessary to bear in mind that the pipe end must not be pressed right to the edge in the fitting sleeve, but a clearance of cca 2 mm must be preserved (see Fig.38).

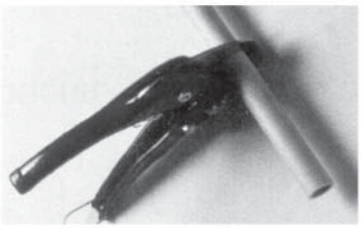


Fig.33: Cut the pipe accordigly, preferably with pipe shears or a pipe cutter.

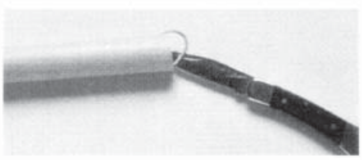


Fig.34: Remove eventual chips.

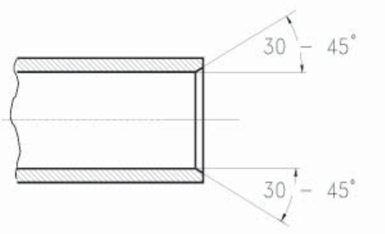


Fig.35: Using a knife or a special tool cut out the inner edge of the pipe to be heated at an angle of 30-45°. This should be done especially with pipes of larger diameters, i.e. from 40 mm diameter and more. This prevents bulging of material when sliding into the fitting.

Fig.36: With a special cutter remove the surface plastic and aluminium layer in STABI pipes. Using this process a pipe with a smooth surface and diameter required for polyfusion joining is made.

Before we begin the heating process it is necessary to **thoroughly clean both ends** to be joined from grease using a special agent Tangit, with isopropyl alcohol or ethyl alcohol (benzine, tetrachlorethylene, acetone, etc are not allowed).

WARNING!
Scratches caused by improper storage or handling can lead to brittle fractures!
After checking the temperature of the welding adapters using a contact thermometer we can begin the joining itself.

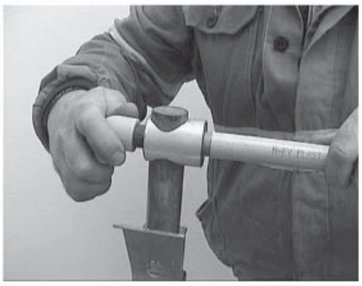


Fig.37: The inner surface of the fitting and the outer surface of the pipe are heated by sliding the fitting and the pipe onto the bushings. Notice whether both parts are not too loose.

If the fitting is loose, discard it !!! The same applies for the pipe.
The heating times for individual pipe diameters are shown in Table 7.

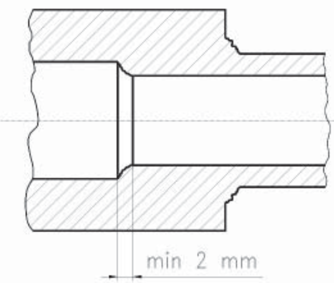


Fig.38: After expiration of the heating time we pull out the fitting and pipe and connect them by slowly and evenly sliding the pipe axially and without rotation into the fitting sleeve.

After the parts are in place check whether both parts are coaxial.
A fresh joint must be fixed for the first 20-30 seconds to enable a partial cooling which prevents further motion of both joined parts.

CAUTION

● For polyfusion joining of pipes and fittings **adaptors of type A** must be used (Fig.29, Table 6). Should other adapters be used no claims on untight joints will be accepted. When pressing the pipe into the fitting and during cooling no rotation or turning is allowed!

● The fitting or pipe should not be turned during heating on the joining machine either. When we do decide to slightly rotate the parts to prevent burning-in of older bushings, we must do it slowly.

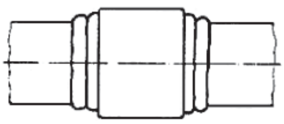
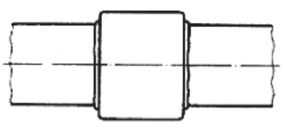
● During the cooling period accordingly to Table 7 the joint must not be mechanically stressed. Total cooling occurs after cca. 30 minutes. Only after this period can the joint be fully stressed.

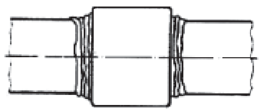
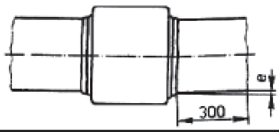
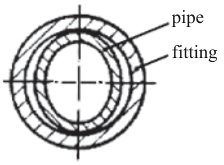
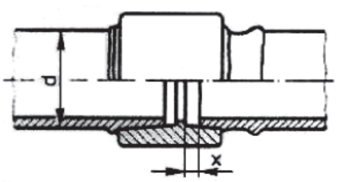
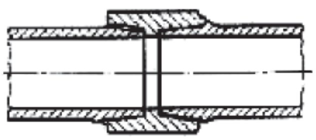
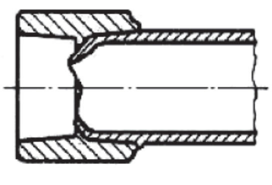
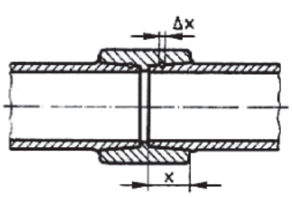
● When operating the joining machine security guidelines for operating electrical hand tools must be adhered to.

● Before commencing work with the joining machine the operating guidelines and instructions for use must be thoroughly read

Recommendation
Hand joining is possible for diameters up to 40 mm. For greater diameters machine joining units or welding jigs must be used to ensure the required pressure during joining and final coaxiality of the joint.

10 – 2 – 1 – 2 – 1. Examples of improper joints

1	Defect	Description	Tolerance group	
			Water	Acceptable
	Improper joint collar (ring) 	Unsymmetrical collar or nonexistent collar on one or both sides of the joint (partially or on the whole perimeter) due to: - excessive temperature of polyfusion adapters - excessive length of polyfusion adapters - exceeded tolerances		
		Unsymmetrical collar or nonexistent collar on one or both sides of the joint (partially or on the whole perimeter) due to: - too short heating interval - too low temperature of polyfusion adapters - exceeded tolerances		

1	Defect	Description	Tolerance group	
			Water	Acceptable
		Unsymmetrical collar or nonexistent collar on one or both sides of the joint (partially or on the whole perimeter) due to: - untreated contact surfaces - contamination of contract surfaces - excessive temperature of polyfusion adapters		
	Angular deflection (deformation) 	Aslant fused pipe on one or both sides of fitting	Accetable dif $e \leq 1$ mm	Acceptable if $e \leq 2$ mm
	Improper joint due to deformation 	Deformation or oval shape of pipe or fitting end due to - improper warehousing of pipe and/or fitting - improper clamping unit	Acceptable difference from the mean outer diameter: 1,5%, 1,5 mm max.	Acceptable difference from the mean outer diameter: 2%, 2 mm max.
	Improper joint due to incomplete pipe penetration 	Insufficient joint length due to improper or only partial melting of contact surfaces due to e.g.: - too short interval of heating - the pipe ends are not perpendicular - insufficient temperature of heating element - axial movement of the parts during cooling - too long interval of ?correlation? (Table 7)	Acceptable for minute shortening of the required joint length and completely formed collar without cuts up to $x \leq 0{,}05$ d $x \leq 0{,}1$ fitting neck	Acceptable for $x \leq 0{,}1$ d $x \leq 0{,}5$ fitting neck
	Improper joint due to insufficient mechanical contact 	Occurence of a local, planar or circumferential ca-nal due to e.g. - scratches on the pipe surface - exceeding tolerances of the pipe or fitting diameter - improper mechanical workmanship - the pipe is not fused axially		
	Improper joint due to insufficient seal	Incomplete joint of a local or planar nature with dis-continuity in milled edge plane due to e.g. - thermal damage - contamination of contact surfaces - improper joint - residual material on the polyfusion adapters		
	Reduction of pipe diameter 	Excessive pipe penetration during heating or joining due to e.g. - excessive pressure during joining - welding of thin-wall pipes - excessive interval of heating - excessive welding temperature		
	Porosity due to foreign material impurities 	Individually distributed or locally accumulated pores or impurities due to e.g. - development of vapor during welding (water, thinner) - contamination of polyfusion adapters	Small individual pores acceptable if $\Delta x \leq 0{,}05$ x	Individual or accumulated pores acceptable if $\Delta x \leq 0{,}1$ x

10 – 2 – 2. Butt fusion

This type of fusion is suitable especially for pipes of larger diameter. Using this method pipes and fittings of polypropylene and polyethylene for butt fusion can be welded together.
The basic technical principles for butt fusion are stated in DVS 2207, Part II.
The welding apparatus for buttt fusion is composed of a clamping and pressur unit with guideway, heating welding plate and test and control units. The working surfaces of heating plate must be smooth, polished and preferably coated with Teflon. The plate surface temperature must be adjustable (normally 190 – 210 ºC ±5 ºC) and is checked using a precise contact thermometer.

Preparation for welding:
- *clamping the pipes and leveling the end surfaces (in order to obtain a high guality joint the contact surfaces must be mechanically cleared of burrs and contaminants*
- *checking and securing axial position (the allowed misalignment is max. 10% of pipe wall thickness).*

The joining process

Every butt joint is made in 4 steps:

I. **Leveling phase** – leveling of the contact surfaces using the heated area of the welding plate (under pressure)
II. **Heating phase** – thorough heating the material under reduced pressure
III. **Joining phase** – joining of the contact surfaces under pressure after removal of welding plate
IV. **Cooling phase** – cooling of the joint with applied pressure

The welding parameters for individual pipe material are supplied by the respective pipe manufacturers.

The joined part must be pressed together using a pressure given by the welding unit manufacturer. If this pressure is exceeded, the melted material will be forced out and a cold joint will result.

In butt fusion, two parts of unequal wall thickness must not be welded together.

10 – 2 – 3. Electrofitting welding

This method is suitable for welding in inaccessible or poorly accessible places.The higher price of the electrofittings is a disadvantage.

11. WAREHOUSING AND TRANSPORTATION

The most important principles of warehousing and transportation of FV-plast components

- The products must be protected from mechanical damage, thermal stress, direct sunlight, organic solvents, etc.,
- The warehouses must be dark (if the components are not kept in opaque packing), free of dust and dry,
- The products may not be exposed to direct radiating heat (the distance to heating elements and pipes should be at least 1 m).
- Permanent asymmetric load, bending and storage in excessive thickness is not allowed,
- The storage place must be level and the pipes must be stored in whole lenght,
- If the pipes are stored coiled, the coils must be laid and the maximum layer can be 1.2 m,
- All components must be kept clean for the whole period of storage
- Pulling or throwing of pipes is not allowed,
- The pipes and fittings are transported using common transportation means
- During transportation of pipes care must be taken to stow them in whole length on the loading space and care must be taken to prevent contact with sharp objects, possibly leading to damage or deformation of pipes,
- When handling products in ambient temperature less than 5 °C extra care must be taken.

CAUTION!
Scratches caused by inadequate storage or handling can lead to brittle fractures!

12. DESIGNING THE PIPEWORK

When designing the pipework the following three regulations must be obeyed:
- ČSN 73 66 60 dealing with the desing and technical conditions of piping for cold water, warm (service) water distribution and circulation
- ČSN 73 66 55 describing the calculation procedure for dimensioning of the piping
- ČSN 06 03 20 dealing with the desing of water heating facilities and determining the power requirements for heating

12 – 1. Comparison of the required inner cross-section of the piping for inner water distribution lines

The basic equation for the calculation of flow through the pipe when the velocity and inner cross-section are known:

$$\mathbf{Q = S \cdot v}$$

Where **Q** is the flow ($m3s^{-1}$)
S is the area of the cross-section (m^2)

For **S** the following is true:

$$\mathbf{S = \frac{\pi \cdot d^2}{4}}$$

Where **d** is the inner diameter of the pipe (m)

Generally, it is true that:

$$\mathbf{Q = 0{,}25 \cdot \pi \cdot d^2 \cdot v}$$

Where **d** is the inner diameter of the pipe (m)
v is the velocity of water in the pipe ($m \cdot s^{-1}$)

It can thus be seen that **the water flow in the pipe is for constant pipe diameter directly proportional to the velocity of the flowing water.** The maximum allowed velocities for individual types of material are shown in Table 9.

Material	Maximum allowed velocity of lowing water ($m \cdot s^{-1}$)
Copper	**1,2 (at higher velocities piping corrosion can occur)**
Steel	**1,6 (at higher velocities piping becomes too noisy)**
Plastic	**3,0**

Table 8. Maximum allowed velocities of water flowing in piping of various materials.

Example 3: A comparison of inner diameters of polypropylene, copper and steel pipes for the same flow of water Q.

Solution: Let us designate the corresponding diameters and velocities with indexes (copper – d_m, v_m; steel – d_o, v_o; plastic – d_p, v_p) and substitute into the equation:

$$Q = 0{,}25 \cdot \pi \cdot d_p^2 \cdot v_p = 0{,}25 \cdot \pi \cdot d_m^2 \cdot v_m = 0{,}25 \cdot \pi \cdot d_o^2 \cdot v_o$$

$$d_p^2 \cdot 3 = d_m^2 \cdot 1{,}2 = d_o^2 \cdot 1{,}6$$

$$\mathbf{d_p = 0{,}63 \cdot d_m = 0{,}73 \cdot d_o}$$

If we wanted to replace (preserving the same flow) e.g. plastic piping of outer diameter 32 mm in the pressure range PN 16 (inner diameter 23) with piping of another material, the copper piping would have had the inner diameter = 36,5mm and steel piping "only" d = 32,5mm.

When we consider the fact that when dimensioning steel piping from the service life point of view (the influence of rust grow-up) the resulting diameter must be augmented by one dimension grade (at least), we see that the benefit of using plastic piping is even more significant.

12 – 2. The calculation of hydraulic losses

A pressure loss occurs in water flowing in pipes due to resistances. This loss depends primarily on the velocity of the flowing water (see Chapter 12–2–2), more specifically on the square of the velocity, e.g. when the velocity of flow increases two times, the pressure loss increases 4 times. **However, when the velocity of flow increases by a factor of 3, the pressure loss is already 9 times so great!!**

For this reason we will deal in this chapter with the task of calculating hydraulic losses in piping with respect to pipe dimensioning in somewhat more detail. We would like to draw your attention to the complexity and laboriousness of such calculation and **emphasize the importance of a high quality project, especially for more complicated pipeworks.**

Commonly is this topic unjustly underestimated, especially by smaller installation companies.

The correct calculation is nevertheless important not only from the appropriate functional point of view, so that even in the farthest point (the highest floor, the last draining fixture) the prescribed values of flow and water pressure are maintained, bud the economical aspect is important as well. An optimally designed system needs not to be overdimensioned, **what often leads to substantial reduction in costs and material.**

12 – 2 – 1. Conventional calculation of hydraulic losses

This calculation serves today only for an approximate assessment of the suitability of design of individual pipework branches (or their functionality) due to its complexity and small effectiveness. For optimizing the pipework from the economical point of view (when minimizing the pipe diameters) it is unbearably time-consuming. For this purpose computer programs are used today (Chapter 12–2–2).

When water flows in the pipe a pressure loss p_Z . occurs due to resistances. This loss can be generally expressed as

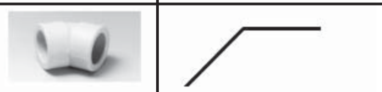
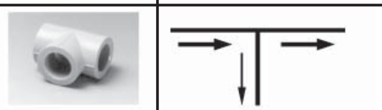
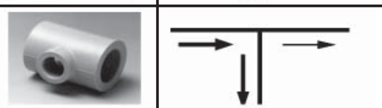
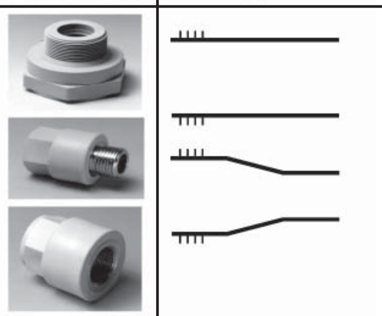
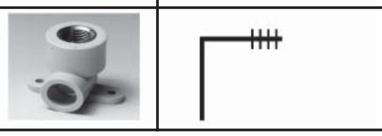
$$\mathbf{p_Z = p_L + p_T} \quad \mathbf{(Pa)}$$

Where **p_L** is pressure loss arising from laminar flow,i.e. caused by friction of water at the tube wall (Pa)
p_T is pressure loss arising from water turbulence,e.g. at draining fixtures and other installation elements. Further on, at places of irregularities of the inner pipe surface, at abrupt changes of pipe diameter or flow direction change,i.e. particularly at pipe joints (Pa).

The magnitude of pressure loss **p_T** is given by

$$P_T = \sum \xi \cdot \frac{V_d^{\,2}}{2}$$

Where ξ are resistivity coefficients dependent on the variation in the pipe crosssection or flow direction change (see Table 10)
v_d velocity of water flow (m . s^{-1})

Fitting	Local resistivity	the resistivity coefficient ξ (Pa . s^2 . m^{-2})
	Pipe sleeve (coupling)	0,2
	Reducer (2 steps) Reducer (3 steps)	0,6 0,9
	90° elbow	2,0
	45° elbow	0,6
	T – tee through – unique reduced	1,1
	T – tee branch – unique reduced	1,5 4,3
	adapter adapter with reducer	0,4 0,9
	90° threaded elbow	2,2

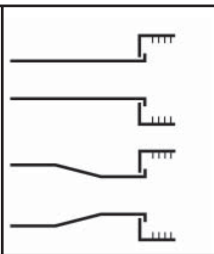
Fitting		**Local resistivity**	**the resistivity coefficient** **ξ (Pa . s^2 . m^{-2})**
		threaded joint	1,5
		threaded joint with reducer	8,3
		cross-over	0,8

Table 9: The coefficient of resistivity ξ for some fittings

The total coefficient of resistivity $\sum \xi$ can be influenced to a limited extent only, as the piping route and number of draining fixtures and other fittings is given by the project.

The crucial parameter is thus the pressure loss $\mathbf{p_L}$, which is given by

$$\mathbf{p_L} = \sum \mathbf{R \cdot L}$$

Where **L** are the lengths of individual pipe segments (m)
R are longitudinal pressure losses arising from friction for the pipe diameters and flows used (kPa . m^{-1})

Q		**16 x 2,0**	**20 x 2,0**	**25 x 2,3**	**32 x 3,0**	**40 x 3,7**	**50 x 4,6**	**63 x 5,8**	**75 x 6,9**	**90 x 8,2**
0,01	**R**	0,019	0,005							
	v	0,09	0,05							
0,02	**R**	0,065	0,017	0,005						
	v	0,18	0,10	0,06						
0,03	**R**	0,133	0,034	0,011	0,003					
	v	0,27	0,19	0,09	0,06					
0,04	**R**	0,221	0,056	0,016	0,006					
	v	0,36	0,19	0,12	0,08					
0,05	**R**	0,327	0,083	0,026	0,008	0,003				
	v	0,44	0,24	0,15	0,09	0,06				
0,06	**R**	0,451	0,114	0,036	0,011	0,004				
	v	0,53	0,29	0,18	0,11	0,07				
0,07	**R**	0,592	0,150	0,047	0,015	0,005	0,002			
	v	0,62	0,34	0,21	0,13	0,08	0,05			
0,08	**R**	0,749	0,190	0,059	0,019	0,006	0,002			
	v	0,71	0,39	0,24	0,15	0,10	0,06			
0,09	**R**	0,923	0,233	0,073	0,023	0,008	0,003			
	v	0,80	0,44	0,28	0,17	0,11	0,07			
0,10	**R**	1,112	0,281	0,087	0,028	0,009	0,003			
	v	0,88	0,49	0,31	0,19	0,12	0,08			
0,12	**R**	1,537	0,387	0,121	0,038	0,013	0,004	0,001		
	v	1,06	0,58	0,37	0,23	0,14	0,09	0,06		
0,14	**R**	2,022	0,509	0,159	0,049	0,017	0,006	0,002	0,001	
	v	1,24	0,68	0,43	0,26	0,17	0,11	0,07	0,05	
0,16	**R**	2,566	0,644	0,202	0,062	0,022	0,007	0,002	0,001	0,001
	v	1,41	0,78	0,49	0,30	0,19	0,12	0,08	0,05	0,04
0,18	**R**	3,167	0,794	0,246	0,076	0,027	0,009	0,003	0,001	0,001
	v	1,59	0,87	0,55	0,34	0,22	0,14	0,09	0,06	0,04
0,20	**R**	3,824	0,957	0,299	0,094	0,032	0,011	0,004	0,002	0,001
	v	1,77	0,97	0,61	0,38	0,24	0,15	0,10	0,07	0,05
0,30	**R**	7,932	1,971	0,613	0,192	0,063	0,022	0,007	0,003	0,001
	v	2,65	1,46	0,92	0,57	0,36	0,23	0,14	0,10	0,07
0,40	**R**	13,37	3,300	1,022	0,319	0,108	0,037	0,012	0,005	0,002
	v	3,54	1,94	1,22	0,75	0,48	0,31	0,19	0,14	0,09
0,50	**R**		4,932	1,522	0,474	0,160	0,055	0,018	0,008	0,003
	v		2,43	1,53	0,94	0,60	0,38	0,24	0,17	0,12
0,60	**R**		6,861	2,110	0,655	0,221	0,076	0,025	0,011	0,004
	v		2,91	1,84	1,13	0,72	0,46	0,29	0,20	0,14
0,70	**R**		9,080	2,784	0,863	0,291	0,099	0,033	0,014	0,006
	v		3,40	2,14	1,32	0,84	0,54	0,34	0,24	0,16
0,80	**R**			3,542	1,095	0,369	0,126	0,042	0,017	0,007
	v			2,45	1,51	0,96	0,61	0,39	0,27	0,19
0,90	**R**			4,384	1,352	0,455	0,155	0,051	0,021	0,009
	v			2,75	1,7	1,08	0,69	0,43	0,31	0,21

Q		16 x 2,0	20 x 2,0	25 x 2,3	32 x 3,0	40 x 3,7	50 x 4,6	63 x 5,8	75 x 6,9	90 x 8,2
1,00	**R**			5,306	1,634	0,549	0,187	0,062	0,026	0,011
	v			3,06	1,88	1,20	0,76	0,48	0,34	0,24
1,20	**R**				2,269	0,760	0,258	0,085	0,036	0,015
	v				2,26	1,44	0,92	0,58	0,41	0,28
1,40	**R**				2,998	1,001	0,340	0,112	0,047	0,019
	v				2,64	1,68	1,07	0,67	0,48	0,33
1,60	**R**				3,819	1,273	0,431	0,142	0,059	0,025
	v				3,01	1,92	1,22	0,77	0,54	0,38
1,80	**R**					1,574	0,532	0,175	0,073	0,030
	v					2,16	1,38	0,87	0,61	0,42
2,00	**R**					1,903	0,642	0,211	0,088	0,036
	v					2,40	1,53	0,96	0,68	0,47
2,20	**R**					2,262	0,762	0,250	0,104	0,043
	v					2,64	1,68	1,06	0,75	0,52
2,40	**R**					2,649	0,891	0,292	0,122	0,050
	v					2,88	1,84	1,16	0,82	0,56
2,60	**R**					3,064	1,029	0,337	0,140	0,058
	v					3,11	1,99	1,25	,88	0,61
2,80	**R**						1,176	0,385	0,160	0,066
	v						2,14	1,35	0,95	0,66
3,00	**R**						1,332	0,436	0,181	0,075
	v						2,29	1,45	1,02	0,71
3,20	**R**						1,497	0,489	0,204	0,084
	v						2,45	1,54	1,09	0,75
3,40	**R**						1,671	0,545	0,227	0,093
	v						2,60	1,64	1,16	0,80
3,60	**R**						1,854	0,604	0,252	0,104
	v						2,75	1,73	1,22	0,85
3,80	**R**						2,045	0,666	0,277	0,114
	v						2,91	1,83	1,29	0,89
4,00	**R**						2,246	0,731	0,304	0,125
	v						3,06	1,93	1,36	0,94
4,20	**R**							0,798	0,332	0,136
	v							2,02	1,43	0,99
4,40	**R**							0,868	0,361	0,148
	v							2,12	1,50	1,03
4,60	**R**							0,940	0,391	0,161
	v							2,22	1,56	1,08
4,80	**R**							1,016	0,423	0,173
	v							2,31	1,63	1,13
5,00	**R**							1,093	0,455	0,187
	v							2,41	1,70	1,18
5,20	**R**							1,138	0,488	0,200
	v							2,51	1,77	1,22
5,40	**R**							1,219	0,523	0,214
	v							2,60	1,84	1,27
5,60	**R**							1,303	0,559	0,229
	v							2,70	1,90	1,32
5,80	**R**							1,389	0,595	0,244
	v							2,80	1,97	1,36
6,00	**R**							1,477	0,633	0,259
	v							2,89	2,04	1,41
6,20	**R**							1,569	0,672	0,275
	v							2,99	2,11	1,46
6,40	**R**							1,662	0,712	0,291
	v							3,08	2,18	1,50
6,60	**R**								0,753	0,308
	v								2,24	1,55
6,80	**R**								0,795	0,325
	v								2,31	1,60
7,00	**R**								0,838	0,343
	v								2,38	1,65
7,50	**R**								0,950	0,388
	v								2,55	1,76
8,00	**R**								1,069	0,437
	v								2,72	1,88
9,00	**R**								1,326	0,541
	v								3,06	2,12
10,0	**R**									0,655
	v									2,35

Table 10: Values of longitudinal loss R (kPa.m^{-1}) and flow velocity (m.s^{-1}) for pipes of PP (the hydraulic roughness of the inner wall surface k=0,01 mm) of the pressure range PN 10 as a function of water flow Q (l.s^{-1}) at a temperature of 10°C.

Q		16 x 2,3	20 x 2,8	25 x 3,5	32 x 4,5	40 x 5,6	50 x 6,9	63 x 8,7		
0,01	R	0,025	0,008							
	v	0,10	0,06							
0,02	R	0,083	0,027	0,009						
	v	0,20	0,12	0,08						
0,03	R	0,170	0,056	0,019	0,006					
	v	0,29	0,18	0,12	0,07					
0,04	R	0,282	0,093	0,032	0,010	0,003				
	v	0,39	0,25	0,16	0,10	0,06				
0,05	R	0,418	0,137	0,047	0,015	0,005				
	v	0,49	0,31	0,20	0,12	0,08				
0,06	R	0,576	0,189	0,065	0,020	0,007	0,002			
	v	0,59	0,37	0,24	0,14	0,09	0,06			
0,07	R	0,756	0,248	0,085	0,027	0,009	0,003			
	v	0,69	0,43	0,28	0,17	0,11	0,07			
0,08	R	0,998	0,313	0,108	0,034	0,012	0,004			
	v	0,78	0,49	0,31	0,19	0,12	0,08			
0,09	R	1,180	0,386	0,133	0,041	0,014	0,005	0,002		
	v	0,88	0,55	0,35	0,22	0,14	0,09	0,06		
0,10	R	1,422	0,465	0,160	0,050	0,017	0,006	0,002		
	v	0,98	0,61	0,39	0,24	0,15	0,10	0,06		
0,12	R	1,967	0,641	0,221	0,069	0,023	0,008	0,003		
	v	1,18	0,74	0,47	0,29	0,18	0,12	0,07		
0,14	R	2,588	0,843	0,290	0,090	0,031	0,010	0,003		
	v	1,37	0,86	0,55	0,34	0,21	0,14	0,09		
0,16	R	3,285	1,068	0,367	0,114	0,039	0,013	0,004		
	v	1,57	0,98	0,63	0,39	0,25	0,16	0,10		
0,18	R	4,056	1,316	0,452	0,140	0,048	0,016	0,005		
	v	1,76	1,11	0,71	0,43	0,28	0,17	0,11		
0,20	R	4,900	1,588	0,544	0,168	0,058	0,019	0,006		
	v	1,96	1,23	0,79	0,48	0,31	0,19	0,12		
0,30	R	10,182	3,277	1,118	0,345	0,118	0,040	0,013		
	v	2,94	1,84	1,18	0,72	0,46	0,29	0,18		
0,40	R		5,499	1,868	0,574	0,196	0,066	0,022		
	v		2,46	1,57	0,96	0,61	0,39	0,245		
0,50	R		8,236	2,786	0,854	0,290	0,097	0,032		
	v		3,07	1,96	1,20	0,77	0,49	0,31		
0,60	R			3,869	1,183	0,401	0,134	0,045		
	v			2,36	1,44	0,92	0,58	0,37		
0,70	R			5,112	1,558	0,528	0,176	0,058		
	v			2,75	1,68	1,07	0,68	0,43		
0,80	R			6,513	1,980	0,669	0,223	0,074		
	v			3,14	1,93	1,23	0,78	0,49		
0,90	R				2,448	0,826	0,275	0,091		
	v				2,17	1,38	0,87	0,55		
1,00	R				2,960	0,997	0,332	0,110		
	v				2,41	1,54	0,97	0,61		
1,20	R				4,117	1,382	0,459	0,152		
	v				2,89	1,84	1,17	0,73		
1,40	R				5,449	1,824	0,604	0,199		
	v				3,37	2,15	1,36	0,86		
1,60	R					2,322	0,767	0,253		
	v					2,46	1,55	0,98		
1,80	R					2,874	0,948	0,311		
	v					2,76	1,75	1,10		
2,00	R					3,480	1,145	0,376		
	v					3,07	1,94	1,22		
2,20	R						1,360	0,446		
	v						2,14	1,35		
2,40	R						1,591	0,521		
	v						2,33	1,47		
2,60	R						1,839	0,601		
	v						2,53	1,59		
2,80	R						2,104	0,686		
	v						2,72	1,71		
3,00	R						2,385	0,777		
	v						2,91	1,84		
3,20	R						2,682	0,873		
	v						3,11	1,96		

Q		16 x 2,3	20 x 2,8	25 x 3,5	32 x 4,5	40 x 5,6	50 x 6,9	63 x 8,7		
3,40	**R** **v**							0,974 2,08		
3,60	**R** **v**							1,080 2,20		
3,80	**R** **v**							1,190 2,33		
4,00	**R** **v**							1,306 2,45		
4,20	**R** **v**							1,427 2,57		
4,40	**R** **v**							1,554 2,69		
4,60	**R** **v**							1,683 2,82		
4,80	**R** **v**							1,819 2,94		
5,00	**R** **v**							1,959 3,06		

Table 11: Values of longitudinal pressure loss R (kPa.m-1) and flow velocity (m.s-1) for pipes of PP (the hydraulic roughness of the inner wall surface k=0,01 mm) of the pressure range PN 16 as a function of water flow Q (l.s-1) at a temperature of 10°C.

Q		16 x 2,7	20 x 3,4	25 x 4,2	32 x 5,4	40 x 6,7	50 x 8,4	63 x 10,5	75 x 12,5	
0,01	**R** **v**	0,034 0,11	0,013 0,07							
0,02	**R** **v**	0,117 0,23	0,044 0,15	0,015 0,09	0,004 0,06					
0,03	**R** **v**	0,240 0,34	0,088 0,22	0,029 0,14	0,008 0,08	0,003 0,05				
0,04	**R** **v**	0,400 0,45	0,144 0,29	0,47 0,18	0,014 0,11	0,005 0,07				
0,05	**R** **v**	0,594 0,57	0,211 0,37	0,069 0,23	0,020 0,14	0,007 0,09	0,002 0,06			
0,06	**R** **v**	0,821 0,68	0,288 0,44	0,094 0,28	0,027 0,17	0,01 0,11	0,003 0,07			
0,07	**R** **v**	1,080 0,79	0,375 0,52	0,122 0,323	0,035 0,20	0,013 0,12	0,004 0,08	0,002 0,05		
0,08	**R** **v**	1,368 0,91	0,472 0,58	0,153 0,37	0,044 0,23	0,016 0,14	0,05 0,09	0,002 0,06		
0,09	**R** **v**	1,686 1,02	0,576,8 0,66	0,188 0,42	0,054 0,25	0,020 0,16	0,006 0,10	0,003 0,06		
0,10	**R** **v**	2,032 1,13	0,691 0,73	0,224 0,46	0,065 0,28	0,024 0,18	0,007 0,12	0,003 0,07		
0,12	**R** **v**	2,808 1,36	0,943 0,88	0,306 0,55	0,89 0,34	0,033 0,22	0,010 0,14	0,004 0,09		
0,14	**R** **v**	3,690 1,59	1,228 1,02	0,398 0,65	0,115 0,40	0,042 0,25	0,013 0,16	0,005 0,1		
0,16	**R** **v**	4,676 1,81	1,543 1,17	0,499 0,74	0,144 0,45	0,053 0,29	0,016 0,18	0,007 0,12		
0,18	**R** **v**	5,762 2,04	1,888 1,32	0,609 0,83	0,176 0,51	0,065 0,32	0,020 0,21	0,008 0,13		
0,20	**R** **v**	6,954 2,27	2,260 1,46	0,728 0,92	0,211 0,57	0,078 0,36	0,024 0,23	0,010 0,14		
0,30	**R** **v**	14,254 3,40	4,523 2,19	1,451 1,39	0,420 0,85	0,154 0,54	0,049 0,35	0,019 0,22		
0,40	**R** **v**		7,398 2,92	2,366 1,85	0,685 1,13	0,252 0,72	0,080 0,46	0,031 0,29	0,013 0,20	
0,50	**R** **v**		10,836 3,65	3,457 2,31	1,001 1,42	0,368 0,90	0,116 0,58	0,044 0,36	0,019 0,25	
0,60	**R** **v**			4,712 2,77	1,365 1,70	0,501 1,08	0,159 0,69	0,060 0,43	0,024 0,31	
0,70	**R** **v**			6,123 3,23	1,774 1,98	0,652 1,26	0,207 0,81	0,077 0,51	0,030 0,36	
0,80	**R** **v**				2,226 2,27	0,818 1,44	0,260 0,92	0,096 0,58	0,039 0,41	

Q		16 x 2,7	20 x 3,4	25 x 4,2	32 x 5,4	40 x 6,7	50 x 8,4	63 x 10,5	75 x 12,5	
0,90	**R**				2,719	0,999	0,318	0,117	0,048	
	v				2,55	1,62	1,04	0,65	0,46	
1,00	**R**				3,253	0,381	0,381	0,139	0,059	
	v				2,83	1,80	1,16	0,72	0,51	
1,20	**R**				4,435	1,629	0,520	0,188	0,070	
	v				3,40	2,16	1,39	0,87	0,61	
1,40	**R**					2,117	0,676	0,243	0,088	
	v					2,52	1,62	1,01	0,71	
1,60	**R**					2,657	0,850	0,303	0,112	
	v					2,88	1,85	1,15	0,81	
1,80	**R**					3,246	1,040	0,367	0,138	
	v					3,24	2,08	1,30	0,92	
2,00	**R**						1,244	0,437	0,186	
	v						2,31	1,44	1,02	
2,20	**R**						1,465	0,512	0,193	
	v						2,54	1,59	1,12	
2,40	**R**						1,700	0,591	0,225	
	v						2,77	1,73	1,22	
2,60	**R**						1,949	0,674	0,268	
	v						3,00	1,88	1,32	
2,80	**R**							0,762	0,300	
	v							2,02	1,43	
3,00	**R**							0,854	0,343	
	v							2,17	1,53	
3,20	**R**							0,950	0,390	
	v							2,31	1,63	
3,40	**R**							1,050	0,423	
	v							2,45	1,73	
3,60	**R**							1,154	0,476	
	v							2,60	1,83	
3,80	**R**							1,262	0,514	
	v							2,74	1,94	
4,00	**R**							1,373	0,536	
	v							2,89	2,04	
4,20	**R**							1,488	0,566	
	v							3,03	2,14	
4,40	**R**								0,609	
	v								2,24	
4,60	**R**								0,655	
	v								2,34	
4,80	**R**								0,705	
	v								2,44	
5,00	**R**								0,765	
	v								2,55	
5,20	**R**								0,816	
	v								2,65	
5,40	**R**								0,847	
	v								2,75	
5,60	**R**								0,904	
	v								2,85	
5,80	**R**								0,951	
	v								2,95	
6,00	**R**								1,030	
	v								3,06	

Table 12: Values of longitudinal pressure loss R (kPa.m^{-1}) and flow velocity (m.s^{-1}) for pipes of PP (the hydraulic roughness of the inner wall surface k=0,01 mm) of the pressure range PN 20 as a function of water flow Q (l.s^{-1}) at a temperature of 10°C.

NOTICE

The values of longitudinal loss R shown in the table above are valid for cold water. The respective values for warm water are slightly lower (see Notice 2), so when calculating the piping for cold water we are well on the secure side.

If can happen that values stated in other sources may differ from the values herein. This is due to the fact that when calculating R different empirical formulas are used (see Notice 2), leading consequently to different value of flow Q.

NOTICE 2
Only for the sake of completeness we mention the process of calculating the longitudinal pressure loss due to friction

$$\mathbf{R} = \frac{\lambda}{d} \cdot \frac{v_d^2}{2}$$

Where **d** is the inner pipe diameter (m)
vd flow velocity ($m.s^{-1}$)
λ is the coefficient of friction pressure
For the calculation of 1 several empirical formulas are available, one of them follows:

$$\lambda = \left[\frac{1}{\left(1{,}13874^{-2} \log \frac{k}{d}\right)^8} + \frac{0{,}01}{Re} \right]^{0{,}25}$$

Where **Re** is the Reynolds number ($re = v_d \cdot d \cdot \nu^{-1}$)
d is the inner pipe diameter (m)
k is the hydraulic coarseness of the inner pipe surface (pro PP k = 0,01 mm)
$\mathbf{v_d}$ is the flow velocity ($m \cdot s^{-1}$)
ν is the kinematic viscosity ($m^2 \cdot s^{-1}$)

The kinematical viscosity depends on water temperature (e.g.for 10°C it is $1.306.10^{-6}$ m^2s^{-1} and for 50°C $0.556.10^{-6}$ m^2s^{-1}). The influence on the longitudinal pressure loss due to friction is relatively small (e.g. for diameter of pipe 25 mm in the pressure range PN 16 at flow Q = 0.5 $l.s^{-1}$, for water temperature 10°C the R_{10}=2.786 $Pa.m^{-1}$ and for water temperature 50°C R_{50}= 2.376 $Pa.m^{-1}$).

12 – 2 - 2. Calculation of hydraulic losses and optimization of the pipework using a computer

In the preceding section we have shown how the conventional calculation of hydraulic losses in plastic piping is elaborate and time consuming.

At present there is a lot of programs for PC enabling a quick calculation and immediate optimization of all important parameters of the designed pipework, available for water, sewarage and gas.

13. PRESSURE CHECK

During installation of any plastic pipework the supplier is obliged to carry out a pressure check in accordance with ČSN 73 66 60 as possibly ČSN 73 66 11.
The pipework can be filled with water for the purpose of stabilization not sooner than after two hours after the last joining. In the following 12 hours the pipework must be stabilized using water from the distribution line. Only then can be the pressure test itself be commenced

WARNING
As the abovementioned standards assume the use of steel piping, the pressure checks for pipes of PP are to be done under the following conditions:
● Test presure: 1,5 Mpa
● Beginning of test: at least 1 hour after deareation of the system
● Test duration: stress with the prescribed pressure for 60 minutes
● Maximum pressure drop: 0.02 Mpa
● Visual check: even the slightest leaks must be remedied

The pressure test must be documented using the following test protocol:

Test protocol

Pipework description

Site: Building:

Pipe length (m)			
∅ l6 mm		∅ 50 mm	
∅ 20 mm		∅ 63 mm	
∅ 25 mm		∅ 75 mm	
∅ 32 mm		∅ 90 mm	
∅ 40 mm		∅ 110 mm	

Highest drain point: m above pressure gauge

Pressure test

Operating pressure:	bar
Pressure after 1 hour:	bar (starting testing)
Pressure decrease:	bar (max. 0,2 bar)

Test results

Beginning of test	End of test	Test duration

Customer
Supplier

Place: Date: Signature:

14. POSSIBLE MISTAKES IN INSTALLATION OF PIPEWORK AND THEIR CONSEQUENCES:

1) Neglecting the thermal expandability of plastic and failing carry out the appropriate compensations leads to significant build-up of stresses in the pipe wall leading to a substantial shortening of the pipework service length.
2) Incorrect distances of piping supports. For greater than optimal separation of supports, sagging of the pipework occurs with similar consequences as mentioned above.
3) The fixing of pipes in wall passages with concrete. The pipes must be left free to move due to thermal dilatation, i.e. the pipes must be furnished with insulation or „pipe guards“ and only then fixed with concrete.
4) Failure to insulate cold water piping against dew build-up and warming and warm water against thermal losses.
5) Failure to observe appropriate conditions in joining (cleanliness, temperature, warm-up and cooling intervals, etc.) leads to substantional decrease in joining quality leading possibly to subsequent leakages.
6) The use of unsuitable sealing materials. Hemp may be used for sealing plastic threading. For the sealing of inner or outer metal pressed thread **only Teflon band or sealing putty may be used.**
7) Inappropriate tightening of metal threaded reducer into the counter-piece (using a pipe wrench or adjustable wrench), ripping the threading from the plastic.
8) Inadequate pressure tests can lead to the concealment of poor joins resulting in consequent leakages.
9) Unsuitable conditions during warehousing and transportation.
10) Failure to secure sufficient pressure and temperature control of the medium in the pipework (i.e. excessive heating and pressurization of water) leads to the infringement of the operating conditions of the plastic material resulting possibly in system breakdown.

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