

1. General information

Progressing development of civilization results in people aspiration for the better living standards. We can meet this needs by using new materials in building industry rigid, better and more aesthetic than the traditional ones like iron or copper. Such progress can be observed best in the sanitary installations which are fully integrated with each new or existing building.

Modern water installations improve standard of each building where they're installed, especially in the residential, office and public use buildings by assuring corrosion free high quality water delivery lines, thus providing residents with good and clean water supply.

One of most popular materials used in European cold and hot water supply installations are polypropylene pipes and fittings.

Polypropylene appears to be one of the best choices when taking into consideration material and long term usage properties. At the same time, during the years of tests it was possible to improve the technology of designing modern welding tools and thermostats. They assure the correct and constant temperature when the used during installation which is one of the basic conditions to assure durability and long lasting usage of PP water sanitary installations.

The advantages of polypropylene are as follows :

- corrosion resistance for 50 years of life without any need for change,
- high chemical resistance,
- neutrality in contact with potable water,
- low material weight making easier transport and assembly easy and efficient,
- low labor consumption during assembly,
- low thermal conductivity that makes possible to limit the necessity of insulation,
- high smoothness giving good hydraulic conditions of the flow,
- low noise level of the flow,
- weldability that together with increased temperature makes solid, monolithic connection.

Other features of polypropylene pipes that differ them from the steel pipes and make necessary to treat them in quite different way during assembly, use and the installation in the building are as follows:

- less thermal resistance,
- brittle in the temperature below 0°C,
- low resistance to the mechanical damages and some chemical substances,
- sensitiveness to the ultraviolet radiation,
- higher thermal expansion.

There are three well-known polypropylene types used for pressure pipes and fittings production :

- PP-H type 1 used only in cold water installations,
- PP-B type 2 may be used in cold and hot water installation but with restrictions,
- PP-R type 3 the most popular material due to the highest technical and usage parameters of pipes and fittings. It is used for cold and hot water installation without any restrictions.

2. Basic features of installation system

Pipes and fittings of USMetrix®PP system are made of polypropylene, type 3 PP-R. Due to the high quality of the raw material USMetrix®PP sanitary installations can be used in the building trade, industrial installations and agriculture and at places which need high quality of chemical resistance to the supplied medium.

Due to the working conditions for various values of temperature and pressure the following series of pressure pipes types are used :

- PN 10 used for working under nominal pressure 1,0 MPa,
- PN 16 used for working under nominal pressure 1,6 MPa,
- PN 20 used for working under nominal pressure 2,0 MPa,
- PN 20 stabilized pipe, used for working under nominal pressure 2,0 MPa.

Assignment and usage range of USMetrix®PP system pipes is as follows :

- PN 10 pipes installations for cold water with temperature up to 20°C and working pressure up to 0,6 MPa,
- PN 16, 20 pipes installations for cold water with temperature up to 20°C and working pressure up to 1,0 MPa,
- PN 16 pipes installations for hot water with temperature up to 60°C and working pressure up to 0,6 MPa,
- PN 20 pipes installations for hot water with temperature up to 60°C and working pressure up to 1,0 MPa,
- PN 20 pipes installations for the central heating with analytical temperature up to 80°C and working pressure up to 0,6 MPa,
- STABI pipe installations for hot water with analytical temperature up to 80°C and working pressure up to 0,6 MPa.

In STABI pipes special aluminium insert has been used that makes the pipe less susceptible to the extension connected with the temperature changes.

USMetrix®PP system connectors belong to PN 25 pressure series.

3. USMetrix®PP system elements

USMetrix®PP installation system includes the following elements :

- pipes in 3 meter sections (STABI pipe in 4 meters),
- fittings to the joints welded with the pipes,
- pass pipe connectors with pipe thread that make possible to connect the polypropylene system with threaded steel connectors and pipes,
- poppet and ball valves,
- fastening elements,
- tools for welding,
- tools for pipes cutting and treatment,
- insulations.

All elements are made in the dimensions from 16 to 75 mm.

4. Description of polypropylene PP-R type 3

4.2. Corrosion resistance

Polypropylene PP-R type 3 is inactivate to the majority of the compounds organic, as well as inorganic ones. Restrictions in usage of above mentioned material are related to the highly oxidable substances such as : concentrated sulfuric acid, nitric acid, chlorine, bromine and derivates. Ultraviolet radiation could have negative influence on polypropylene products and due to that elements made of that material should be protected by insulation or by covering the protecting coating. This requirement concerns only those elements of installation that are directly exposed to the solar radiation during longer period.

4.3. Chemical resistance

Polypropylene type 3 products have very good resistance to the most often met chemical substances. Detailed information of the chemical resistance to the most often met chemical substances with their influence level to the polypropylene products is included in Enclosure 1.

4.4. Electric charges cumulation

Polypropylene cumulates static electricity on the material's surface and that is why it should not be used for supply of inflammable and explosive fluids.

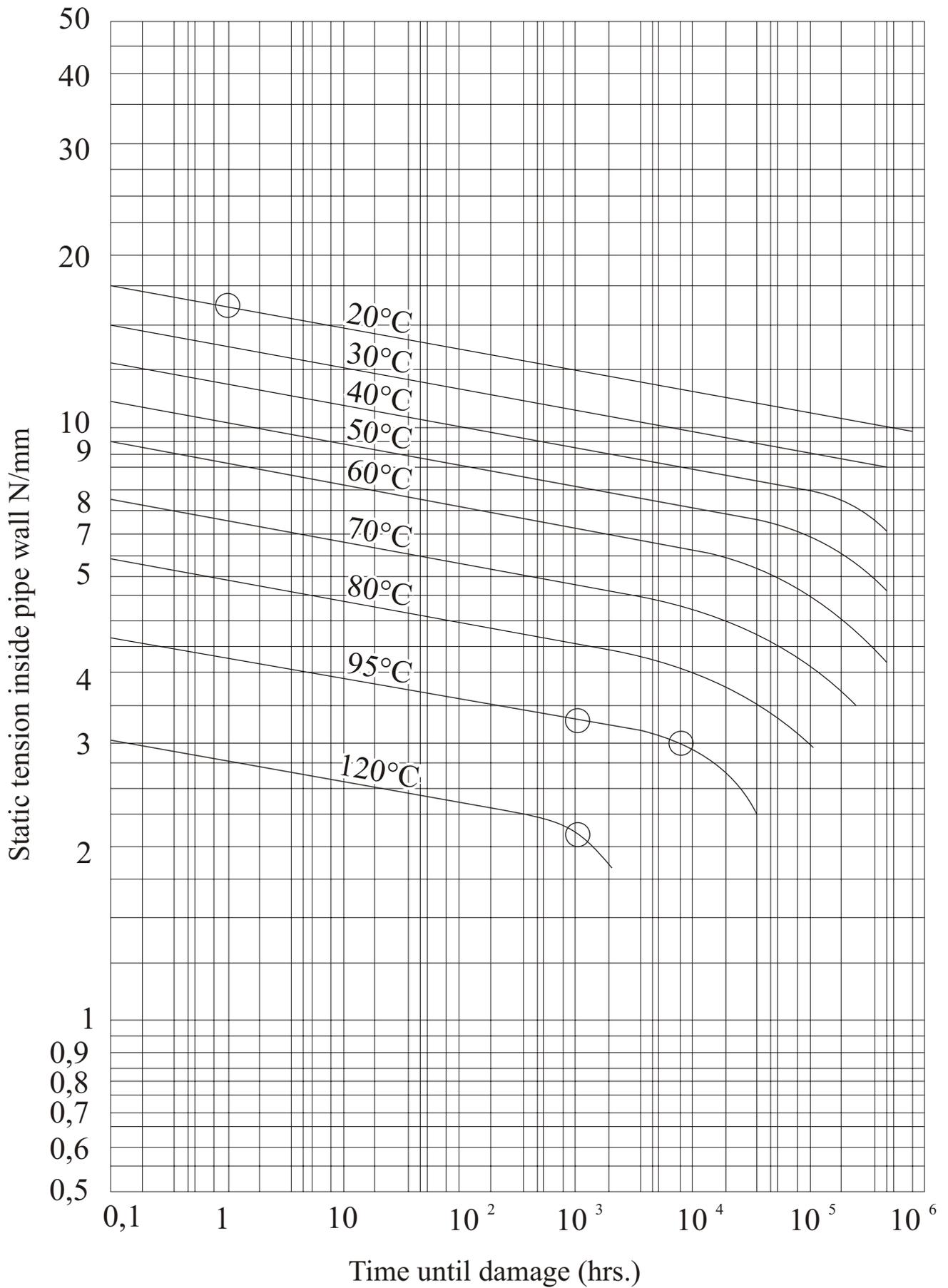
4.5. Strength and life

Life of USMetrix®PP system elements depends directly on the following factors : working factor temperature and pressure under that it is supplied. Admissible working pressures depending on temperature, series of pipes' types and working time were shown at the Table 2.

Table 2. Admissible pressures in function of temperature and exploitation time.

Temp. (°C)	Operating years	Nominal pressure - PP-3 pipes (bar)		
		PN 10	PN 16	PN 20
20	10	13,5	21,7	27,1
	25	13,2	21,1	26,4
	50	12,9	20,7	25,9
40	10	10,2	16,2	20,3
	25	9,7	15,6	19,5
	50	9,2	14,7	18,4
50	10	8,7	13,9	17,3
	25	8,0	12,8	16,0
	50	7,3	11,7	14,7
60	10	7,2	11,5	14,4
	25	6,1	9,8	12,3
	50	5,5	8,7	10,9
70	10		8,5	10,7
	25		7,3	9,1
	50		7,0	8,8
80	10	3,9	6,3	7,9
95	1	6,1	7,6	9,5
	5	4,6	5,7	7,2

Strength of polypropylene installation is shown at the diagram 1.



5. Designing

5.1. General rules of designing polypropylene installation

During designing the installation of polypropylene pipes and fittings, the one should be aware of this particular material that is quite different from steel pipes and also include this fact in the project, as well as the installation is laid.

- Pipes and fittings PP-R are different from the steel ones in dimensions, especially in the higher series (PN 20). It is connected with bigger thickness of the wall pipes that makes smaller internal diameter in the propylene. Average nominal diameter of the steel pipe meets polypropylene one but two values bigger. Hydraulic calculations should be done each time for the best choice of ducts' diameters.
- Second basic difference, resulting in designing process, is the linear expansion of polypropylene pipes which is much more bigger than steel ones that needs including the compensation during designing for leveling elongations and stresses that will appear. Ducts elongations are more bigger more higher is the installation working temperature. Due to that different rules of fastening the ducts should be used.
- Polypropylene ducts should not be exposed to the damages. Due to that they are laid in protective pipe shells when passing through the building dams. Duct is protected by soft covering in the wall chases (specially in the place when direction is changed). Above all, they should be covered by the coatings when laid on the top of building construction at the easily accessible places.

5.2. Designing of cold and hot water installation

5.2.1. General instruction

While designing water supply installation the up-to-date standards should be used, e.g. PN 92/B-01706 Instalacje wodociągowe. Wymagania w projektowaniu. (polish Standard PN 92/B 01706. Water supply installations. Requirements in designing) together with information and data included in this work out. Above mentioned work out includes all necessary elements to be taken into consideration while designing due to PP-R pipes.

5.2.2. Settling the ducts' route

- Ducts' route should be projected so that the ducts would not be loaded by the stresses from the building construction
- The route should be possibly the shortest and the most simple one. It should be made in the way that uses building construction and makes natural compensations of the distributing pipes or risers (offset pipes). When there is no such possibility, compensators should be projected.
- It is the best to lay the risers and approaches to the draw-off points in the chases in which properly fastened ducts while elongated, place in the chase and there is no need to build compensators. The chases inside should be smoothed so that the pipes would not be scratched and damaged.

5.3. Ducts dimensioning

5.3.1 Analytical flow

Analytical flow that is typical for each analytical section is made by taking draw-off points quantity and taking into consideration not simultaneous water consumption. Standard water outflow is stated for each draw-off point, as well as required pressure that should be assured before this point.

Table 3 shows formula for making the analytical flows for the different objects.

Table 3. Formulas for making analytical flows in the water supply installations for the different buildings (according to DIN 1988, part 3).

Building types*	Formulas	Notes
Residential buildings	$q = 0,682 \cdot (q_n)^{0,45} - 0,14$	for $0,07 < q_n < 20 \text{ dm}^3/\text{s}$ for bath and kitchen fixtures at $q_n < 0,5 \text{ dm}^3/\text{s}$
	$q = 1,7 \cdot (q_n)^{0,21} - 0,7$	for $q_n > 20 \text{ dm}^3/\text{s}$ oraz for bath and kitchen fixtures at $q_n < 0,5 \text{ dm}^3/\text{s}$
Commercial buildings	$q = 0,682 \cdot (q_n)^{0,45} - 0,14$	for $q_n < 20 \text{ dm}^3/\text{s}$
	$q = 0,4 \cdot (q_n)^{0,54} - 0,48$	for $q_n > 20 \text{ dm}^3/\text{s}$
Hotels and Shopping Malls	$q = 0,4 \cdot (q_n)^{0,366}$	for draw-off points at $q_n > 0,5 \text{ dm}^3/\text{s}$ and in the area $1 < q_n < 20 \text{ dm}^3/\text{s}$
	$q = 0,698 \cdot (q_n)^{0,5} - 0,12$	for bath and kitchen fixtures at $q_n < 0,5 \text{ dm}^3/\text{s}$ and in the area $0,1 < q_n < 20 \text{ dm}^3/\text{s}$
	$q = 1,08 \cdot (q_n)^{0,5} - 1,82$	for $q_n > 20 \text{ dm}^3/\text{s}$ (for Hotels)
	$q = 0,698 \cdot (q_n)^{0,5} - 0,12$	for $q_n > 20 \text{ dm}^3/\text{s}$ (for Shopping Malls)
Hospitals	$q = 0,698 \cdot (q_n)^{0,5} - 0,12$	for $q_n < 20 \text{ dm}^3/\text{s}$
	$q = 0,25 \cdot (q_n)^{0,65} - 1,25$	for $q_n > 20 \text{ dm}^3/\text{s}$
Schools	$q = 4,4 \cdot (q_n)^{0,27} - 3,41$	for $1,5 < q_n < 20 \text{ dm}^3/\text{s}$; for $q_n < 1,5 \text{ dm}^3/\text{s}$ $q = q_n$
	$q = -22,5 \cdot (q_n)^{0,5} - 11,5$	for $q_n > 20 \text{ dm}^3/\text{s}$

Key:

q_n – standard outflow from the draw-off points dm^3/s ,

q_n – sum of all standard outflows from the draw-off points serviced by dimensional section of the installation, dm^3/s ,

q – analytical flow, dm^3/s

* For the water supply installations in the objects different from mentioned the formula for the analytical flow should be made similar to way of installation usage by its users.

Standard outflows from the draw-off points are given in the Table 4 and water analytical flows stated due to the formulas for apartment building are shown in Table 5.

Table 4. Standard water outflows from the draw-off points and the pressures required before draw-off point.

Type of Draw-off Point	Required Pressure MPa	Nominal water flow		
		mixed ¹⁾		cold and hot only
		q _n cold, dm ³ /s	q _n hot, dm ³ /s	q _n dm ³ /s
Draw-off valve: without perlator ²⁾ Dn 15 ⁴⁾ Dn 20 Dn 25 with perlator Dn 10 Dn 15	0,05			0,3
	0,05			0,5
	0,05			1,0
	0,1			0,15
	0,1			0,15
Shower head Dn 15	0,1	0,1	0,1	0,2
Toilet flush Dn 15 Dn 20 Dn 25	0,12			0,7
	0,12			1,0
	0,04			1,0
Urinal flushing valve Dn 15	0,1			0,3
Dishwasher (residential) Dn 15	0,1			0,15
Washer (residential) Dn 15	0,1			0,25
Draw-off fixtures for showers Dn 15 for bathtubs Dn 15 for kitchen sinks Dn 15 for bathroom sink Dn 15 for bathtubs for sitting Dn 15	0,1	0,15	0,15	
	0,1	0,15	0,15	
	0,1	0,07	0,07	
	0,1	0,07	0,07	
	0,1	0,07	0,07	
Faucet with mixer Dn 20	0,1	0,3	0,3	
Tank flush Dn 15	0,05			0,13
Hot pot ³⁾ Dn 15	0,1			0,1

Key:

- ¹⁾ – cold water T_z = 15°C, hot T_c = 55°C
- ²⁾ – if the valve with hose L ≤ 10 m, the pressure is 0,15 MPa
- ³⁾ – with entirely opened screw gland
- ⁴⁾ – D_n nominal diameter of the draw-off point, mm

Table 5. Total standard outflows from the draw-off points and analytical flows (PN 92/B 01706).

q_n for fixtures		q	q_n	q	q_n	q
< 0,5 dm³/s	0,5 dm³/s	dm³/s	dm³/s	dm³/s	dm³/s	dm³/s
0,06		0,05	21,89	2,55	331	5,05
0,10		0,10	23,54	2,60	345	5,10
0,15		0,15	25,28	2,65	360	5,15
0,21		0,20	27,13	2,70	374	5,20
0,29		0,25	29,08	2,75	390	5,25
0,38		0,30	31,15	2,80	406	5,30
0,48		0,35	33,32	2,85	422	5,35
0,60		0,40	35,62	2,90	439	5,40
0,72		0,45	38,04	2,95	456	5,45
0,87	0,50	0,50	40,58	3,00	474	5,50
1,03	0,55	0,55	43,26	3,05	493	5,55
1,20	0,60	0,60	46,08	3,10	512	5,60
1,39	0,65	0,65	49,04	3,15		
1,59	0,70	0,70	52,15	3,20		
1,81	0,75	0,75	55,41	3,25		
2,04	0,80	0,80	58,83	3,30		
2,29	0,85	0,85	62,41	3,35		
2,55	0,90	0,90	66,17	3,40		
2,83	0,95	0,95	70,10	3,45		
3,13	1,00	1,00	74,21	3,50		
3,45	1,15	0,105	78,51	3,55		
3,78	1,31	1,010	83,01	3,60		
4,12	1,50	1,15	87,84	3,65		
449	1,70	1,20	92,62	3,70		
4,87	1,92	1,25	97,74	3,75		
5,26	2,17	1,30	103,08	3,80		
5,68	2,44	1,35	108,65	3,85		
6,11	2,74	1,40	114,45	3,90		
6,56	3,06	1,45	120,50	3,95		
7,03	3,41	1,50	126,79	4,00		
7,51	3,80	1,55	133	4,05		
8,02	4,22	1,60	140	4,10		
8,54	4,67	1,65	147	4,15		
9,08	5,17	1,70	155	4,20		
9,63	5,70	1,75	162	4,25		
10,21	6,27	1,80	170	4,30		
10,80	6,89	1,85	178	4,35		
11,41	7,56	1,90	187	4,40		
12,04	8,28	1,95	196	4,45		
12,69	9,05	2,00	205	4,50		
13,36	9,88	2,05	215	4,55		
14,05	10,76	2,10	225	4,60		
14,76	11,84	2,15	235	4,65		
15,48	12,72	2,20	246	4,70		
16,23	13,80	2,25	257	4,75		
16,99	14,95	2,30	268	4,80		
17,78	16,17	2,35	280	4,85		
18,58	17,48	2,40	292	4,90		
19,40	18,86	2,45	305	4,95		
20,24	20,33	2,50	318	5,00		

5.3.2. Flow speed

For dimensioning the water supply ducts under the pressure, the following maximum flow speeds should be used :

- in the distributing levels 1,7 m/s,
- in the risers and branches 2,0 m/s.

5.3.3. Preliminary choice of the diameters

The diameters of hot water circulation ducts are chosen as follows :

- for the supplying ducts ř 20 35 ř 20,
- for the supplying ducts ř 40 50 ř 25,
- for the supplying ducts ř 63 75 ř 32.

Duct ř 16 should be used only for the single approach to the draw-off point.

If during the hydraulic calculations the available pressure is sufficient for the most unfavorable draw-off point that means that the diameters are chosen in appropriate way.

5.3.4. Linear resistances

Calculation of the pressure linear losses for each section should be made by using the following formula :

$$p = 1 \cdot \frac{L}{d_w} \cdot \frac{V^2}{2} \cdot \rho \quad [\text{Pa}] \quad [\text{N/m}^2]$$

Dp -pressure drop

1 -linear resistances' coefficient,

L - ducts length in the section [m]

d_w -internal diameter [m]

V - flow speed [m/s]

ρ - medium density [kg/m³]

Value of coefficient 1 should be calculated by using Colebrook-White's formula and taking absolute roughness coefficient k 0,007 mm for the polypropylene pipes.

Enclosure 2 includes particular R pressure losses settled for different flows and diameters, as well as typical analytical temperatures to make the calculations easier.

When too big linear resistances are noticed, they should be decreased at the most unfavorable sections by increasing ducts' diameters.

5.3.5. Local resistances

Calculation of local losses of the pressure, made by the fittings, connectors and fixtures present in the projected installation, should be done by using the following formula :

$$Z = z \cdot \frac{v^2}{2} \quad [\text{Pa}]$$

z local resistances coefficient

Z coefficient value for the fittings and connectors in the USMetrix®PP system is shown in the table 6.

Table 6. Z coefficient value in the USMetrix®PP system.

Fitting		
	coupling	0,2
	reducing coupling	0,55
	90° elbow	1,5
	tee	1,1
	tee	1,5
	reducing tee	1,1
	reducing tee	4,3
	adapter	0,4
	union	8,3

5.4. Ducts' compensation of the polypropylene installation

5.4.1. Linear elongation

Polypropylene has much more bigger extension coefficient than steel or copper :

- polypropylene 0,15 mm/mK,
- steel 0,012 mm/mK,
- copper 0,0165 mm/mK.

This property results in polypropylene pipes elongation or shortening when the working conditions are changed.

Strain size is defined by the formula :

$$l=L \times a \times t$$

where:

l - elongation or shortening size [m]

L - duct's length [m]

a - linear coefficient of linear extension (for Ppa = 0,15 mm/mK)

t - difference between assembly temperature and installation temperature

$t=t_m-t_p$ for $t_m < t_p$ (duct's elongation)

$t=t_p-t_m$ for $t_m > t_p$ (duct's shortening)

Elongation of hot water ducts is met in the most cases.

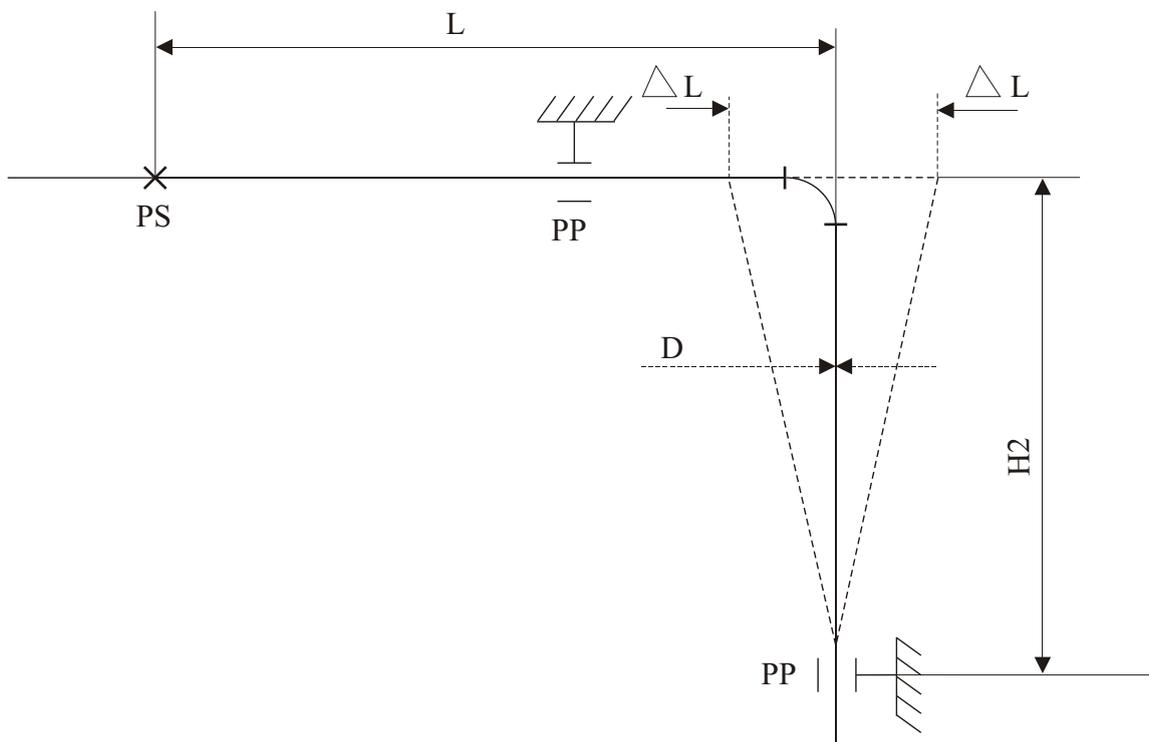
5.4.2. Methods of elongation compensation

Linear elongations cannot cause the danger of the installation damage and must appear in a safe way to the installation. In that case natural compensation should be used by laying the duct in the appropriate way by covering the route near the walls and columns construction etc. And fastening in such way as to have the appropriate compensation.

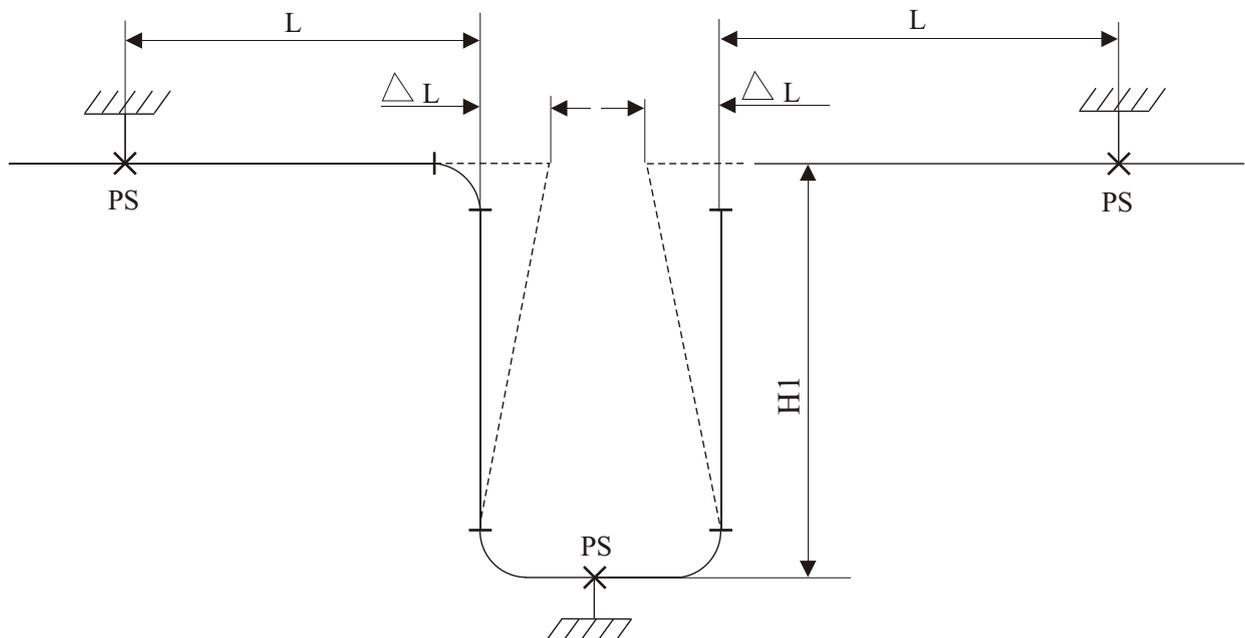
If such solution is not possible compensators should be projected at level ducts and risers route. Compensators' size depends on elongation of duct section and its diameter.

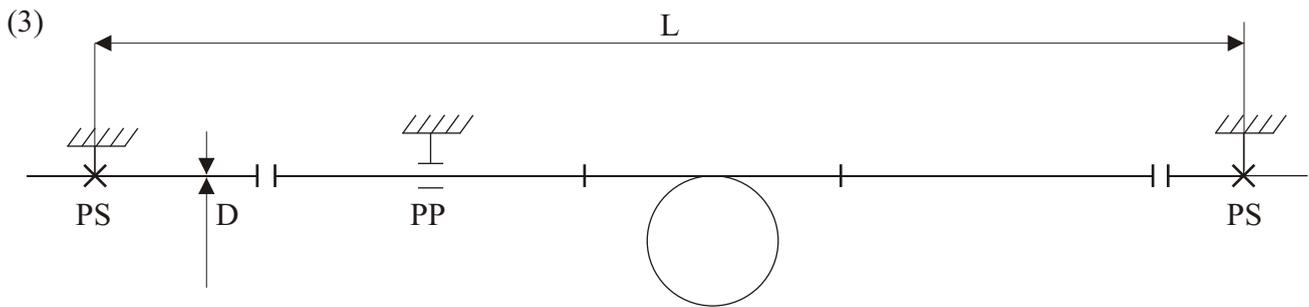
Ways of ducts' compensation by route bend (1), building U-shaped compensator (2) and by compensation loop (3) are shown below.

(1)



(2)



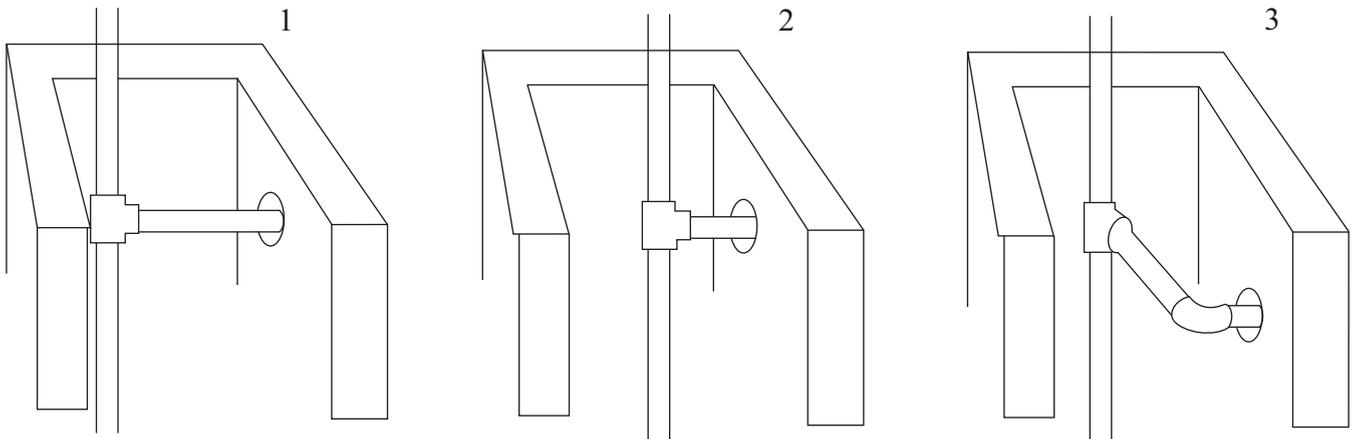


Compensation loop as a ready-to-build element can take elongation of 7-10 cm (it is suitable e.g. for PP-R pipe with the length of 12 m and by the temperature of 50°C).

While laying, the ducts under the plaster there should be left some place for duct's buckling and the fastening points (permanent and movable) should be placed so that the bucklings would be safe.

While laying the ducts under the plaster the way of connecting the branch to the installation riser is also important. It should be done in the way to make the compensation possible.

It is shown at the below drawing :



- 1 - riser location in the chase,
- 2 - free pass through the wall
- 3 - elastic arm usage

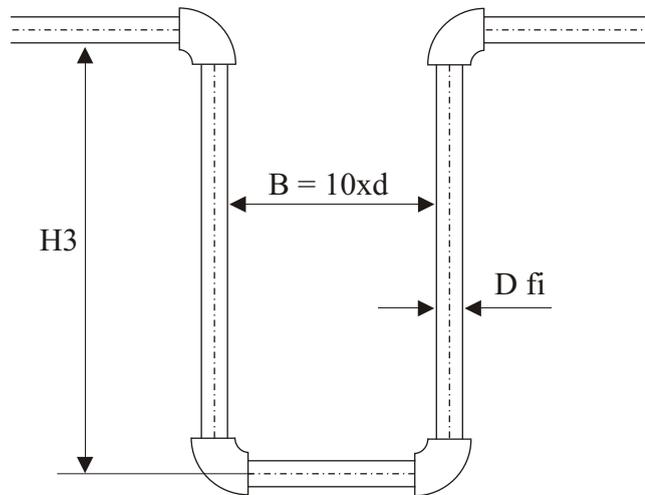
It is stated that elastic arm should also be used at the places of connecting to the level distributing pipes.

5.4.3. Dimensioning method and compensators' dimensioning

Below drawing show that good placing of the fastening points is very important for the proper compensation of the ducts.

Permanent fastening supports (PS) set the length of the duct that is strained by 1. Movable supports (PP) should be placed so that they do not stop compensator's work (minimal length from the place of route bend $> M_s$).

U-shaped compensator was shown in the drawing below.



where:

M_s - compensator elastic arm

d pipe's external diameter

Proper U-shaped compensator is located in the middle of the section between two permanent supports and it has central located permanent fastening.

Length of compensator elastic arm :

$$M_s = c \cdot \sqrt{d \cdot l} \cdot mm$$

where:

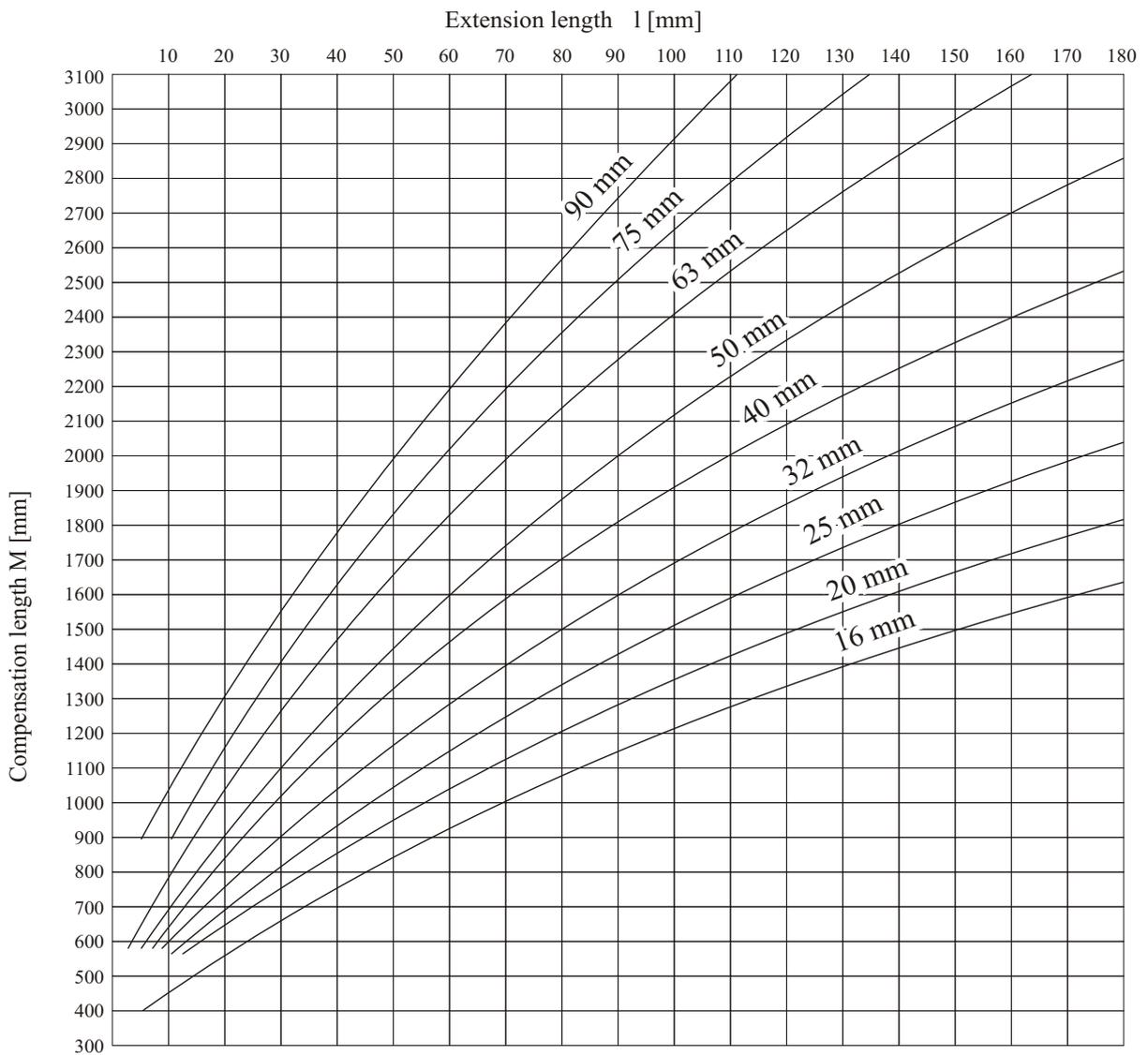
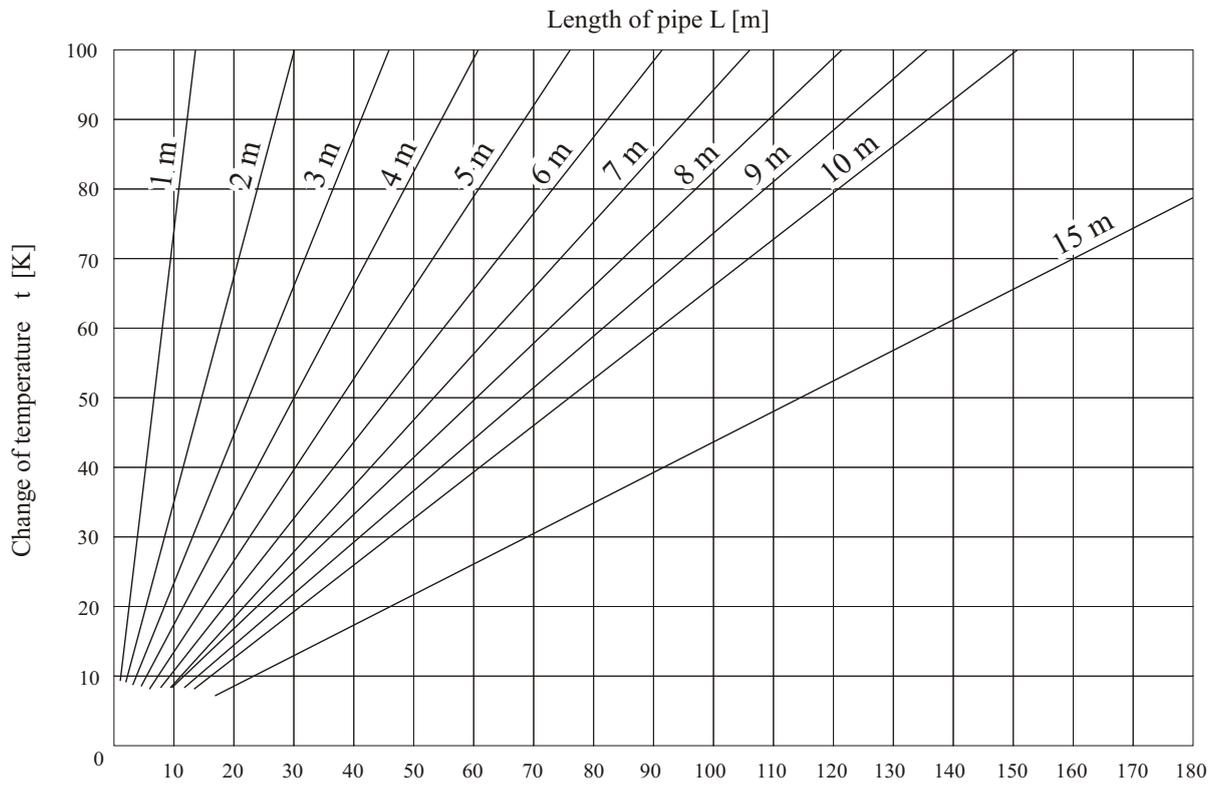
c - constant that depends on material (for PP-R $c = 30$)

d - external diameter

l - elongation

Compensator width B should have the value at least $10xd$.

For setting compensator's dimensions the one can use enclosed diagrams (on the next page).



6. Assembly

6.1. Installation assembly rules

Polypropylene sanitary installation can be assembled as follows :

- on the buildings' walls,
- in the wall chases,
- in the installation ducts (shafts),
- in the spaced above the ceiling or floor spaces.

6.2. Types of used connections

- Welded connections
- bell (by using bell fittings for welding)
- frontal (without fittings usage)

- Threaded connections
- fittings with plastic made thread,
- fittings with metallic fusion thread.

6.3. Assembly instructions

Ducts' pass through building dams (ceilings, constructional walls) should be done in PVC protecting pipe shells that are jugged out for 2 cm at dam's both sides and that are filled with the plastic filling that will not stop pipe's end movement.

Attention should be paid to the welded connections that should be beyond pass through the dam.

It is better to lay the ducts in the chases or installation space and not at the walls' surface.

Pipes in the chases should be wrapped with corrugated paper for making some space under the plaster (stiff concrete placing results in stresses increase in the pipes which decreases their exploitation life.

Permanent fastening supports should be located at the places of ducts' higher loads e.g. by the water meter, fixtures or the branching point.

Pipes should be protected against direct solar radiation and mechanical damage.

6.4. Ducts' fastening

6.4.1. Level ducts

Polypropylene installation ducts should be fastened to the building construction elements by permanent and movable supports.

Distances between the supports should be chosen in a way that assures ducts' compensation.

Compensators' location results in permanent supports' location and it is required by draw-off points.

Distances between the supports depend on temperature of the medium, as well as duct's external diameter. Admissible maximum distances for the level ducts were shown in the table 7. Table 8 shows distances between supports for the stabilizing pipes.

Table 7. Distances between movable supports (in cm) for the polypropylene ducts horizontally laid.

d (mm)	Distance l in cm with temperature of water flow in °C						
	20	30	40	50	60	70	80
16	75	70	70	65	60	60	55
20	80	75	70	70	65	60	60
25	85	85	85	80	75	75	70
32	100	95	95	90	85	80	75
40	110	110	105	100	95	90	85
50	125	120	115	110	105	100	90
63	140	135	130	125	120	115	105
75	155	150	145	135	130	125	115

Table 8. Distances between movable supports (in cm) for the polypropylene ducts stabilized by aluminium insert and horizontally laid.

Outside diameter Dz (mm)	Water temperature °C					
	20	30	40	50	60	80
16	125	120	120	110	110	90
20	135	125	120	120	110	100
25	145	145	145	135	125	120
32	170	160	160	150	145	125
40	185	185	180	170	160	145
50	210	205	200	185	180	150
63	235	230	220	210	200	180
75	250	245	235	225	210	190
90	265	260	250	240	230	210
110	270	265	255	245	235	215

6.4.2. Risers

Rules of fastening the risers are close to the instructions concerning level ducts.

Distances between supports could be increased by about 30 % as to the installation risers.

Compensation arm should be used in the branches of installation at each storey.

If the way of installation laying allows to have ducts' bucklings from their axis, compensation elements' usage is not necessary.

Permanent supports' location is required near the branch from the installation riser at each storey, as well as near the draw- off points.

6.4.3. Valves' assembly

In case of valves' assembly the one should use both sides ducts' fastening, before and after the valve because fixture makes big load for the propylene installation.

A good solution is to situate the permanent support in the place of valve's assembly (it concerns especially the smaller diameters).

6.4.4. Installation insulation

Polypropylene ducts, type 3 have better insulation properties than the traditional installation materials (steel, copper).

Despite this fact they should be insulated because :

- due to water steam condensation (dropwise condensation) and temperature increase of the supplied water it concerns cold water installation ducts,
- due to temperature increase of the supplied water it concerns cold water installation ducts.

Polish Standard PN 85/B 02421 should be used for the calculation of insulation thickness.

While using polyurethane foam covering ($\lambda = 0,037 \text{ W/mK}$) insulation thickness shown in the table 9 could be used.

Table 9. Insulation thickness due to supplied water temperature and pipe diameter.

d_2	cw 55 °C	co 70 °C
16	10	11
20	10	11
25	11	11
32	12	12
40	13	13
50	15	15
63	16	17
75	17	18

Key:

d- pipe's diameter

c.w.- hot water,

c.o.- central heating

Attention should be paid so that the insulation would not stop the ducts' compensation at the route bends.

6.4.5. Temperature protection

Caution! Hot water installation should be equipped with the devices protecting against uncontrolled temperature increase.

8. Connecting polypropylene pipes and fittings, PP-R type 3

8.1. Bell welding

PP-R pressure fittings and pipes are connected by bell welding method (polyfusion) by using special welders used only for the chosen system.

7.2. Activities during welding

7.2.1. Welder's preparation

- taking welders' ends to the dimensions of connected elements so that the whole surface of the ends adjoined to the welder's surface,
- connecting the welder to the network, switching on the main switch (diode emitting light),
- bring up the heating ends to the temperature of $360^{\circ}\text{C} \pm 10^{\circ}\text{C}$ (diode switches off).

7.2.2. Preparation of welding elements

- pipe's precise cut, perpendicular to the axis, without burrs,
- marking the welding depth at the pipe (table 10),
- removing by the clean rag (or alcohol water solution) all possible impurities of the heating ends,
- in case of STABI pipes with aluminium insert: aluminium coat removal from the pipe by the special scrub tool at the height of the weld.

7.2.3. Welding

- the pipe should be inserted into the heating end at the same time when the fitting was drawn over the mandrel of the second end till the refusal is received
- heating in the time according to the table 10 (till the elements are little melted),
- taking off heated elements at the same time when the pipe is precisely connected in axis with the fitting to the marked depth without mutual turning,
- keep without moving elements counting welding time (table 10) using possible small corrections of axis deviation,
- the connection has no deformation ability heating time and the cooling time must pass. Full strength of the weld is received after complete cooling, i.e. after about 2 hours.

Table 10. Parameters of the heating process by using welders according to DVS 2207.

Outside diameter d_e (mm)	Depth of weld (mm)	Pre-heating time (s)	Welding time (s)	Cooling time (min)
16	13,0	5	4	2
20	14,5	5	4	2
25	16,0	7	4	2
32	18,0	8	6	4
40	20,5	12	6	4
50	23,5	18	6	4
63	27,5	24	8	6
75	30,0	30	8	6

Remark :

- pipes should be cut by using good shears for the plastic pipes,
- the fittings damaged through failed welding cannot be used again,
- heating time should be longer of about 50 % while it is done in low temperatures,
- only good and well-known welders should be used,
- in case of PN10 pipes welding time should be shorter of about 30% than it was given in the table 10.

8. Leak proof tests

8.1. Preliminary test

Preliminary leak proof test is made with the pressure 1,5xthe highest working pressure (not over the value PN + 5 bar) keeping persistent water temperature in the ducts.

Pressure measurement should be done at the highest point of the installation.

Then after 10 minutes we should check and set the pressure. The test lasts 30 minutes.

During next 30 minutes after the preliminary test is finished the pressure should not drop more than of 0,6 bar and there should not be any leakage.

8.2. Main test

Pressure drop (in 1 hour lapse) is observed during 2 hours, while having the working pressure after the preliminary test is made.

During the last readout the pressure drop should not be lower than of 0,2 bar and there should not be any leakage.

8.3. Leak proof test in the working conditions

Hot water installation is tested again in the working conditions, i.e. with the water of the proper temperature, that is called hot test. During that test permanent fastenings and compensators are checked. When the leak proof test is finished the report is made.

Installation execution and acceptance should be based at "Warunki Techniczne Wykonania i Odbioru rurociągów z tworzyw sztucznych wyd. P.K.T.S.G.G.i K. 1994 r.

(Technical conditions of Plastics made pipelines execution and acceptance).

9. Products' storage and transport

- Pipes and fittings should be stored under the roof in a clean and dry room, protecting against direct influence of the weather conditions, solar radiation or dust.
- There should not be together stored any organic solvents, products containing solvents and any other chemical substances that could infiltrate into the stored materials.
- Polypropylene products should be stored away from the heating sources and the temperature of store-room should be not over + 40°C.

- Each sort of the product should be separately stored and divided according to the fittings' types, pipes' pressure series and diameters size. Fittings should be stored in the foil bags and pipes in bundles in or without package.
- During storage the products should not be loaded and bent. Storage area should be smooth and cannot cause any damages to them.
- Pipes are stored at the horizontal plane (minimum 0,10 m above the floor) to the maximum height of 0,60 m.
- Maximum distance of the pipes' pads is as follows :
 - for diameters 16 to 32 mm 0,25 m,
 - for diameters 40 to 75 mm 0,50 m.
- During transportation attention should be paid so that the products' packages would not be damaged.
- When the products do not have packages the transportation should be more careful.
- Pipes should not be hit, thrown or drawn at the ground.
- Special care is needed when the pipes are transported in the low temperatures (about 0⁰) due to the increase of shortness.