1. General information

PVC and CPVC are not new materials. In the United States PVC is used since 1959 and CPVC since 1968. ASTM Standards were also worked out there (American Society of Testing and Materials) and they concerned usage of these materials in the building installations. They have also use admittance for the potable water, established by NSF (National Sanitarion Foundation).

PVC and CPVC were used in Europe since 1979. English Institutions like WRC (Water Research Council), WFD (Water Fittings Directory) and BBA (British Board of Agreement) established adequate attestations and certificates about entire usefulness of this plastics in the water internal installations.

In 1979 Germany (DVGW Deutscher Verein des Gas und Wasserfaches) added them to DIN standards, as the following materials to be used in the potable water installations.

Now PVC and CPVC are the most popular materials in the world used for the production of installation tubes. In many countries plumbers and users appreciate plastics more than metals due to their corrosion resistance, small hydraulic resistance and permanent connections.

PVC and CPVC installation advantages are as follows :

- corrosion resistance which makes 50 years of life without any need of change,
- excellent hydraulic parameters,
- leakproofness of the connections,
- chemical inertness and resistance to over 500 different chemical substances including the majority of acids, bases and alcohols, detergents and bleachers,
- easy and quick assembly that doesn't need any special equipment or electric energy,
- excellent fire-resisting properties.

2. PVC and CPVC description

2.1. Physical properties

PVC and CPVC plastics have the properties that decided about their wide usage in installation building. They generally have small specific gravity, long life and mechanical strength.

Table 1. Basic physical properties of PVC and CPVC.

Properties	Unit	PVC	CPVC
mechanical in temperature of 23 ^{0} C			
Specific weight	g/cm^3	1.41	1.57
Tensile strength	MPa	48.3	57.9
Bending strrength	MPa	100	107.7
Compression strength	MPa	62	62
Young's modulus	MPa	2758	2898
Rockwell hardness		110-120	120
thermal			
linear expansion coefficient	x 10^{-5}1/K	5.2	6.2
thermal conductivity coeficcient	W/mK	0.22	0.16

2.2. Chemical properties

USMetrix installations have very good chemical resistance. Tests of PVC and CPVC samples immersed for 90 days into many different chemical substances with different temperatures were the base for describing their resistance to acids, bases, oxidizers, fuels and other compounds. General note of the average resistance in relation to the different chemical substances (scale : 0 not resistant to 10 entirely resistant) for CPVC is 8,6 and e.g. for polypropylene is 6,2.

2.3. Fire-resisting properties

PVC, as well as CPVC have excellent fire-resisting properties. PCV firing temperature is over 388^{0}C and CPVC over 433^{0}C and they are almost non-flammable in the standard conditions.
LIO (Limitting Oxygen Index) decides about that. It describes minimal oxygen requirement for combustion process maintenance. For PVC it is 40 % and for CPVC 42 %.
Oxygen concentration in the earth's atmosphere is 21 % so PVC and CPVC don't keep firing process and they go out automatically when fire source is removed.
In comparison LIO for polypropylene is 17 %, for polybutylene 18 %, cotton 15 %, nylon 20 %. Studies made by independent universities and laboratories proved that burning PVC and CPVC emit gases not more harmful than those during burning wood.

3. Approvals and certifictes

USMetrix tubes and fittings made of PVC-U are produced according to the Polish Standard PN 1452. C-PVC elements were tested and admitted for using in the building trade by COBRTI-INSTAL.
All elements have also certificates of Państwowy Zakład Higieny w Warszawie
(State Hygiene Institute in Warsaw).

4. Tubes types and working parameters

USMetrix system includes wide range of PVC and CPVC tubes, fittings and valves.
PVC-U tubes and pressure fittings are used for supplying cold water with temperature not over 50^{0}C. They are produced according to the Polish Standard PN 1452 in the sections of 3 m and they belong to the pressure series PN 16, ½" and ¾" also to PN 20.
Diameters from 1" belong to PN 12,5. Technical parameters of PVC-U tubes were shown in the table 2.
PVC fittings of USMetrix System belong to pressure series PN 25.

Table 2. Technical parameters of PVC tubes.

Dimension	Pressure series	Min. wall thickness	Internal diameter	External diameter
inches	PN	mm	mm	mm
1/2	16	1.7	17.94	21.34
1/2	20	2.1	17.14	21.34
3/4	16	1.9	22.87	26.67
3/4	20	2.5	21.67	26.67
1	12.5	2.2	29.00	33.40
1 1/4	12.5	2.7	36.76	42.16
1 1/2	12.5	3.1	42.06	48.26
2	12.5	3.9	52.52	60.32
2 1/2	12.5	5.16	62.09	73.02
3	12.5	5.49	77.92	88.90
4	12.5	6.02	101.56	114.3
6	12.5	7.11	153.22	168.28

CPVC tubes and fittings are used for supplying cold and hot water with temperature not over 95^{0}C. CPVC tubes are usually produced in SDR11CTS version (Copper Tube Size). They have length of 3,048 m and due to their dimension they are adequate to the copper pipes.

Table 3. Technical parameters of CPVC tubes.

Dimension	Max. working pressure in 23^{0}C	Min. wall thickness	Internal diameter	External diameter
inches	kPa	mm	mm	mm
1/2	2760	1.73	12.40	15.86
3/4	2760	2.03	18.16	22.22
1	2760	2.59	23.38	28.56
1 1/4	2760	3.18	28.55	34.91
1 1/2	2760	3.76	33.74	41.26
2	2760	4.90	44.16	53.96

Remarks:

1) PVC and CPVC tubes cannot be used for compressed air and gas installations.
2) Tubes are not suitable for threading.
3) Over 23^{0}C maximum working pressure is decreased. Decreasing reducing coefficient kr was shown in the table 4.

Table 4. Value of kr coefficient for water temperature.

Water temperature	kr		Water temperature	kr	
°C	PVC	CPVC	°C	PVC	CPVC
23	1.00	1.00	60	0.22	0.55
27	0.90	0.96	66	x	0.47
32	0.75	0.92	71	x	0.40
38	0.62	0.85	77	x	0.32
43	0.50	0.77	82	x	0.25
49	0.40	0.70	93	x	0.18
54	0.30	0.62	99	x	0.15

5. Projecting PVC and CPVC installations

5.1. General instruction

During projecting the installation the up-to-date standards should be used together with information and data included in this work out.
Above mentioned work out includes all necessary elements to be taken into consideration while projecting due to PVC-U and C-PVC tubes.

5.2. Settling the ducts' route

- Ducts should be laid so that the stresses from the building's construction wouldn't influence at the installation.
- The route should be possible the shortest and the most simple one. It should be done in the way that uses building construction and makes natural compensations of the distributing tubes or risers. When there is no such possibility, compensators should be designed.
- It is the best to lay the risers and approaches to the draw-off points in the chases in which properly fastened duct while elongated, places in the chase and there is no need to build compensators. The chase should be smoothed inside so that the tubes wouldn't be scratched and damaged.

5.3. Water hammer

Water hammers appear in case of rapid opening of the valves or change of the direction of high speed flowing water. Even momentary appearing water hammer can cause connectors and valves damage.

Equation that calculates appearing water hammer is as follows :

$$P = 0{,}023 \times k \times w \text{ [MPa]}$$

where :

k water hammer constant
w speed of the water flow [m/s]

Entire pressure in the installation shouldn't be over 150 % of installation pressure rating.
For avoiding water hammer problems it should be used as follows :
- limit the water flow speed ($w < 1{,}5$ m/s),
- use valves with releases that will make impossible to open or close the value rapidly

5.4. Pressure losses in the ducts of PVC and CPVC tubes

Pressure losses in the PVC and CPVC ducts depend on many factors, flow speed and connecting system among others.
Entire loss of the installation analytical pressure is described by the following equation :

$$p = l_i * R_i * {}_i * P_{di}$$

where:
R_i - unit linear pressure loss due to the friction
l_i - length of analytical cycle lots in (m) that have Ri frictional resistance in [Pa/m]
${}_i$ - local loss coefficient
P_{di} - dynamic water value of the water jet that overcomes some local resistance in [Pa]

Unit linear pressure losses can be precisely calculated by Wiliams-Hazen equation :

$$R = 3468{,}85\ (100/c)^{1{,}852}\ Q^{1{,}852}\ (0{,}04d)^{-4{,}8655}$$

where::
R - pressure losses as the result of friction in [Pa/mb]
d - internal diameter of the tube
Q - water flow in [l/s]
c - smoothing constant of tube internal surface

5.5. Pressure losses at the connectors

Pressure losses at the local resistances are calculated, as follows :

$$Z = {}_i P_{di} \text{ [Pa]}$$

where:
Z - pressure loss at the local resistance
${}_i$ - local loss coefficient
P_{di} - dynamic pressure loss of the water jet that overcomes some local resistance in [Pa]

Coefficient values of local losses for the most often found connectors were shown in the table 5.

Table 5.

Connector	x
Straight connctor	0.25
Reducing tube connector	
by 2 diameters	0.55
by 3 diameters	0.85
straight elbow 90°C	1.20
straight elbow 45°C	0.50
straight tee - inflow	0.80
straight tee - outflow	1.20
straight tee - inflow on both sides	3.00
flow straight tee	1.80
screw set	0.40

Z loss dependence on water flow speed in [m/s] for local losses coefficient x=1 (for water temperature t = + 10^0C) was given in the table 6 for the simplified calculations of the local losses.

Table 6. Pressure losses dependence on the water flow speed.

Water flow speed	Z pressure drop	Water flow speed	Z pressure drop
m/s	Pa	m/s	Pa
0.1	5	2.6	3380
0.2	20	2.7	3655
0.3	45	2.8	3920
0.4	80	2.9	4200
0.5	125	3	4500
0.6	180	3.1	4800
0.7	245	3.2	5120
0.8	320	3.3	5440
0.9	400	3.4	5780
1	500	3.5	6125
1.1	600	3.6	6480
1.2	720	3.7	6845
1.3	845	3.8	7220
1.4	980	3.9	7600
1.5	1125	4	8000
1.6	1280	4.1	8400
1.7	1445	4.2	8820
1.8	1620	4.3	9245
1.9	1800	4.4	9680
2	200	4.5	10125
2.1	2200	4.6	10580
2.2	2420	4.7	11045
2.3	2645	4.8	11520
2.4	2880	4.9	12000
2.5	3125	5	12500

Pressure drop in the connector is often taken in project calculations as the equivalent to the pressure drops in the tube with the proper length.
Tables 7 and 8 show substitute tube's length in meters for the standard connectors.

Table 7. Substitute tube's lengths in meters for the standard CPVC connectors.

Connector type	1/2"	3/4"	1"	1 1/4"	1 1/2"	2"
Elbow 90°C	0.49	0.64	0.79	1.06	1.22	1.67
Elbow 45°C	0.24	0.34	0.34	0.55	0.64	0.85
Branched tee	1.22	1.55	1.83	2.1	2.47	3.66
straight tee	0.3	0.43	0.52	0.7	0.82	1.31

Table 8. Substitute tube's lengths in meters for the standard PVC connectors.

Connector type	1/2"	3/4"	1"	1 1/4"	1 1/2"	2"	2 1/2"	3"	4"	6"
Elbow 90°C	0.46	0.61	0.77	1.16	1.23	1.75	2.11	2.42	3.49	5.11
Elbow 45°C	0.25	0.34	0.43	0.55	0.64	0.8	0.95	1.23	1.56	2.45
branched tee	1.16	1.5	1.84	2.24	2.57	3.68	4.5	5.02	6.74	10.01
staright tee	0.31	0.43	0.52	0.7	0.83	1.23	1.5	1.87	2.42	3.77

5.6. Pressure losses at the valves

Similar to the connectors, pressure losses for the valves are given as the equivalent to the pressure drops in the tube with the proper length.
Table 9 shows substitute tube's length in meters for the different valves.

Table 9. Substitute tube's lengths for valves

	1/2"	3/4"	1"	1 1/4"	1 1/2"	2"
valve	0.13	0.17	0.21	0.28	0.33	0.42
poppet valve	5.36	7.10	9.05	11.90	13.90	17.90
angle valve	2.37	3.14	3.99	5.27	6.13	7.86

Pressure losses at the ball valves are calculated by the following formula :

$$P = 1733 * G^2/k \text{ [kPa]}$$

where :
G - flow in [l/s]
k - coefficient depending on valve's diameter and construction

Value of that coefficient for the ball valves was shown in the table 10.
Practically pressure losses at the valves are ignored due to their low value.

Table 10. Value of k coefficient for the ball valves.

	1/2"	3/4"	1"	1 1/4"	1 1/2"	2"
k	64	225	841	5625	8100	19600

5.7. Compensation of PVC and CPVC ducts installation

5.7.1. Linear elongation

PVC and CPVC, as most of the materials are influenced by temperature.
Due to temperature increase, plastics tubes are elongated but much more that steel or copper pipes.

l elongation (in cm) caused by temperature increase t Dt (in ^{0}C) is calculated by the following formula:

$$l = \quad * \ l_o \ * \quad t$$

where:

- linear extension coefficient (for CPVC = 6,2 * 10^{-5} [l/K])

l_o - length of tube section [m]

t - temperature increase [K]

t increase is the difference between temperature of the factor in the installation and assembly temperature. Table 11 shows l length increase depending on t temperature increase for CPVC tubes.

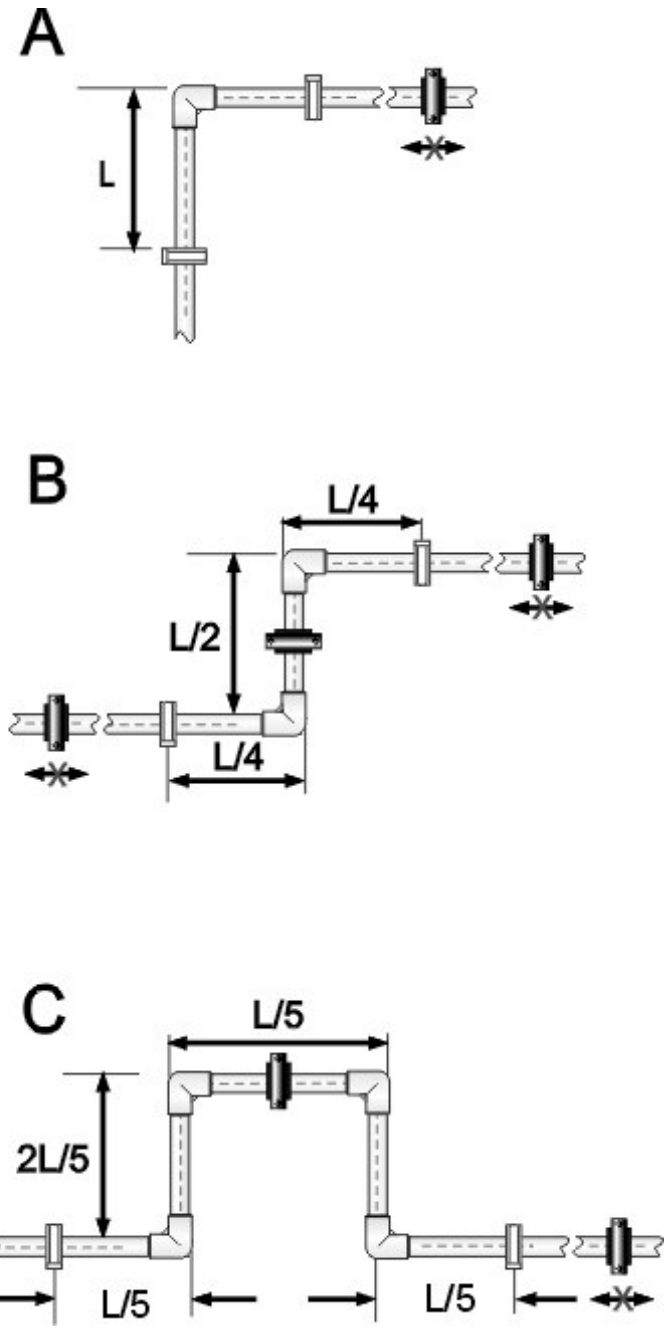
Table 11. Increase of tubes length in mm.

Tube's length m	Temperature increase									
	10K	20K	30K	40K	50K	60K	70K	80K	90K	100K
0.1	0.062	0.124	0.186	0.248	0.31	0.372	0.434	0.496	0.558	0.62
0.2	0.124	0.248	0.372	0.496	0.62	0.744	0.868	0.992	1.116	1.24
0.3	0.186	0.372	0.558	0.744	0.93	1.116	1.302	1.488	1.674	1.86
0.4	0.248	0.496	0.744	0.992	1.24	1.488	1.736	1.984	2.232	2.4
0.5	0.31	0.62	0.93	1.24	1.55	1.86	2.17	2.48	2.79	3.1
0.6	0.372	0.744	1.116	1.488	1.86	2.232	2.604	2.976	3.348	3.72
0.7	0.434	0.868	1.302	1.736	2.17	2.604	3.038	3.472	3.906	4.34
0.8	0.496	0.892	1.488	1.984	2.48	2.976	3.472	3.968	4.464	4.96
0.9	0.558	1.116	1.736	2.232	2.79	3.348	3.906	4.464	5.022	5.58
1.0	0.62	1.24	1.984	2.48	3.1	3.72	4.34	4.96	5.58	6.2
2.0	1.24	2.48	2.232	4.96	6.2	7.44	8.68	9.92	11.16	12.4
3.0	1.86	3.72	2.48	7.44	9.3	11.16	13.02	14.88	16.74	18.6
4.0	2.48	4.96	4.96	9.92	12.4	14.88	17.36	19.84	22.32	24.8
5.0	3.1	6.2	7.44	12.4	15.5	18.6	21.7	24.8	27.9	31
6.0	3.72	7.44	9.92	14.88	18.6	22.32	26.04	29.76	33.48	37.2
7.0	4.34	8.68	12.4	17.36	21.7	26.04	30.38	34.72	30.06	43.4
8.0	4.96	9.92	14.88	19.84	24.8	29.76	34.72	39.68	44.64	49.6
9.0	5.58	11.16	16.74	22.32	27.9	33.48	39.06	44.64	50.22	55.8
10.0	6.2	12.4	18.6	24.8	31	37.2	43.4	49.6	55.8	62
11.0	6.82	13.64	20.46	27.28	34.1	40.92	47.74	54.56	61.38	68.2
12.0	7.44	14.88	22.32	29.76	37.2	44.64	52.08	59.52	66.96	74.4

5.7.2. Methods of elongation compensation

Linear elongation 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 ducts in the appropriate way. If such solution is not possible compensators should be projected at level ducts and risers route. Compensators' size depends on elongation of duct's section and its diameter.
Ways of ducts' compensation by route "A" bend by building Z-shaped compensator "B" and by using U-shaped compensator "C".

Dwg.5.7.2. Methods of elongation compensation.



Limited possibility of tubes' strain is used in all these cases. Compensators cannot function without properly placed permanent and movable supports. Permanent fastening supports set the duct's length that is strained by l. Movable supports should be placed so that they wouldn't stop compensator's work.

Elastic arm length is calculated by using the following formula :

$$L = \sqrt{\frac{3 \times E \times D \times l}{}}$$

where:
E - Young's modulus
l - length increase [mm]
D - external diameter [mm]
- admissible stresses [MPa]
Young's modulus and admissible tensile stresses have different values for the different temperatures what is shown in the table 12.

Table 12. Relation of Young's modulus to the admissible stresses and temperature.

T °C	E MPa	s MPa
23	2920	13,8
32	2780	12,4
43	2560	10,4
49	2450	9,0
60	2227	6,9
71	2006	5,2
82	1855	3,5

6. Assembly

6.1. Rules of installation assembly

PVC and CPVC sanitary installations can be assembled as follows :

- at the internal walls of the buildings and in the installation spaces,
- in the chases under the plaster and under the floor,
- in the excavations.

6.1.1. Installation-laying at the walls and spaces

Rules of laying USMetrix installation are not far away from the rules concerning metal installation. Tubes should be fastened to the construction elements by permanent and movable supports. Fastening method should protect them against the buckling and direct contact with the dam surface.

USMetrix installation ducts should be laid at the internal walls. In some reasonable cases it is allowed to lay the ducts on the internal side of the external walls. They should be then protected against freezing and condensing of the water steam.

The same activities should concern the installation laid in the rooms without heating.USMetrix installations should be laid in the distance min. 10 cm from the heating pipelines or any other heating sources.

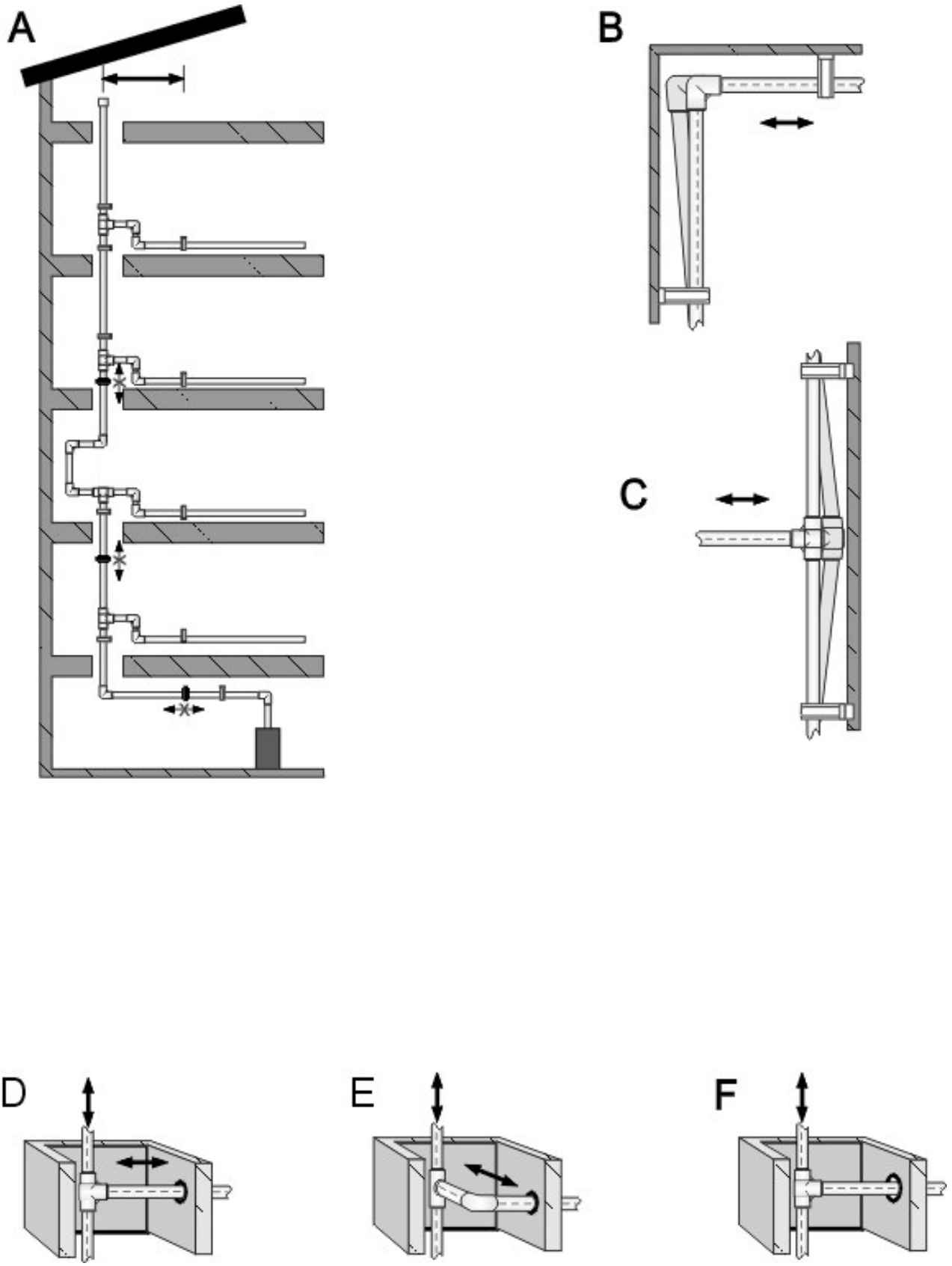
When that distance is smaller thermal insulation should be used. Ducts should be also insulated when effects of any heating source could cause the increase of pipeline's wall temperature of 30°C. Tubes should be additionally protected when laying at the places especially exposed to the mechanical damages.

Caution! PVC and CPVC don't conduct the electric current. The one shouldn't treat the installation executed in USMetrix as the earthing. Additional requirements concern hot water and central heating installations and they are the result of bigger thermal extension of the used material. So it is very important that risers and distributing tubes were assembled without any stresses and with the most often usage of self compensation "A". That means that holders' assembly should be done in the proper distance from the points of direction change "B" and installation branches "C".

When the ducts pass through building dams (walls, ceiling, continuous footing) they should be assembled with the tube shells (tubes with bigger diameters best) filled with the polyethylene insulation, polyurethane foam or any other attainable flexible packing.

Used materials should be inactive to CPVC.
Tube shells should jut out a bit from the dam's surface. Tubes' connections or fastenings should not be situated in the pass places. Risers and branches laid in the installation spaces should have the compensation possibility of vertical route length change. Then the following elements are located in the proper way :vertical tube in "D" channel, "E" compensation arm assembly or suitable redimensioned opening for branch "F" leading.

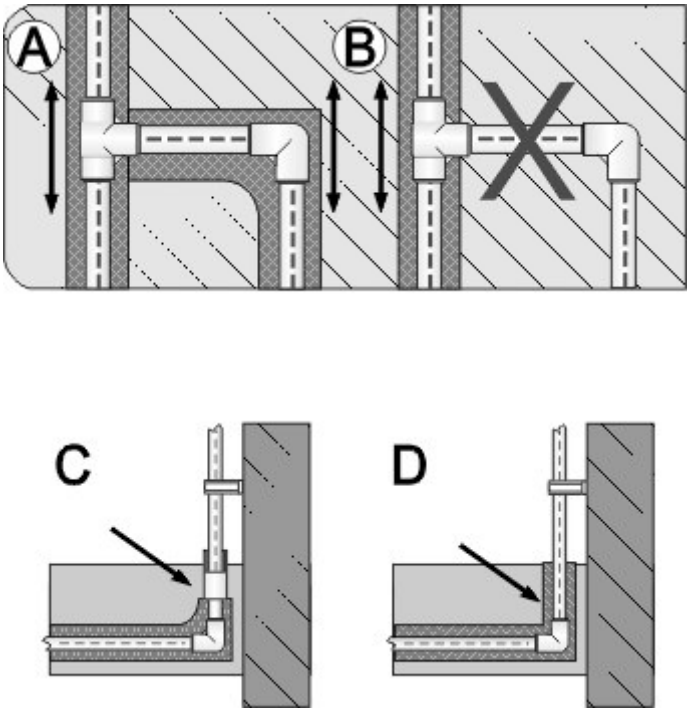
Dwg.6.1.1. Installation laying on the walls and in the spaces.



6.1.2. Installation laying in the chases under the plaster and under the floor

Ducts in the wall chases, floor or leveling layers should be laid possibly in the perpendicular or parallel directions to the dams' edges. Ducts' routes should be described in the documentation after execution. Ducts laid in the dams should be assembled on the brackets and holders in the way which protect them against contact with the dam's wall. Tube must not contact the mortar filling the dam in hot water and central heating installations due to the influence of thermal extension working. That's why it should be laid in the protecting tube (e.g. peszel type). Duct covered by corrugated board or foil is admitted to be laid in the dam under condition that there is some space around the tube. In the branches and points of changing direction, fittings and tubes should be insulated by the flexible materials to make possible "A" elongations compensation. TERMAFLEX covering is the best solution. It is not allowed to embed in concrete bare section of "B" duct. Duct laid in the floor leveling layer should be placed in plastics protecting tube or in the insulation. In the places where the installation is out of the floor, the tubes should be laid in the protecting tube shells "C" or in the insulation "D".

Dwg.6.1.2. Installation laying method in the chase



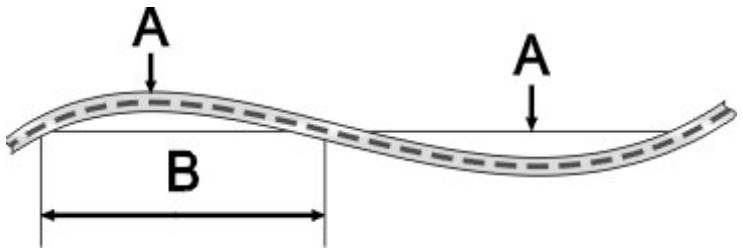
6.1.3. Installation laying in the excavations

USMetrix tubes can be installed in the properly prepared excavations. Excavation's bottom should be smooth and free of stones. If there are some stones or impurities they should be removed or there should be made a bed. Excavation should be made and proofed according to the obligatory regulations and broad enough to make connection works and the so-called hosing. Hosing means such placing the tube in the excavation so that it would be alternately right- or left bent to the axis of the excavation.
Hosing assures suitable space for the shortening and elongating tube due to earth temperature change.

Table 13. Proper hosing parameters.

	Max. temperature deflection in ^{0}C between ambient tempearture during assembly and tempearture of installation regular working									
	-12.2	-6.7	-1.1	4.4	10	15.6	21.1	26.7	32.2	37.8
B [m] - length of arc chord	A [mm] - length of singular bend arc form excavation central axis									
6.1	76.2	88.9	114.3	127.0	152.4	165.1	177.8	177.8	203.2	203.2
15.2	117.8	228.6	279.4	330.2	355.6	393.7	431.8	457.2	482.6	508.0
30.5	330.2	457.2	558.8	660.4	736.6	800.1	889.0	939.8	1016.0	1066.8

Dwg.6.1.3. Installation laying in the excavations.



Ducts should be laid in the ground in the way that don't allow the following :

- their water freezing in winter,
- their excessive heating in summer,
- damages appearing due to external loads,
- negative influence of any other element of underground territorial developments.

The standard describes the depth of ducts' laying directly in the ground and without any additional agents.

6.2. Tubes fastening

PVC and CPVC installations have limited load capacity to their deadweight, as well as supplied water weight.

Water temperature increase results in rigidity decrease and tubes' elongation that is additional reason of undesirable strains. That's why it is important to project the proper holders located in the proper distances.

All USMetrix tubes should be fastened to the construction elements by clamping rings that meet their external diameter. Clamping rings shouldn't cause mechanical damages to the fastened tubes.

A. Clamping rings, permanent holders should make impossible tube movement in relation with the holder. The best solution is the metal clamping ring with rubber insert or any other flexible material (clamping rings with the plastic PVC should not be used because they can cause the tube's solution). Permanent support can be realized by placing the permanent pipeline elements (e.g. valves, fittings, connectors) between plastic holders. It is important then that such construction should take forces from the ducts' elongation.

B. Clamping rings, movable holders made usually of plastics should allow free tube movement to the holder. Tubes should be fastened in the suitable distances for proper working and good look of the installation. Table 14 shows maximum spacing of the supports for the horizontal sections.

Distance between the supports could be increased by 20% for the vertical sections. It is important that vertical tubes should have the fastenings with each pass through the ceilings, branches and change of direction of 90^0.

Independent support should be made in the places where are the ends of the installation (vents, drainage etc.) and taps, valves or any other tackles are assembled.
Fastenings should be projected and made so that they could assure thermal elongation compensation.
Fastenings must regard compensation arm.

Table 14. Maximum spacing of the supports for the vertical sections.

Tube type	Installation type	
	cold water	hot water and central heating
	cm	cm
1/2" CPVC	75	60
3/4" CPVC	85	65
1" CPVC	90	70
1 1/4" CPVC	100	75
1 1/2" CPVC	110	80
2" CPVC	125	90
1/2" PVC	90	
3/4" PVC	100	
1" PVC	110	
1 1/4" PVC	120	
1 1/2" PVC	130	
2" PVC	165	
3" PVC	180	
4" PVC	210	
6" PVC	250	

6.3. Connections of USMetrix system with the steel pipes

USMetrix system includes PVC and CPVC fittings with external and internal threads, pass tube shells with packing and metal screw sets with CPVC elements. They make possible to connect with any other installation systems. Connectors with external thread "A" can be used for connection with metal sleeve in the cold water installations. Lap wound teflon tape should be used for connections' seal at the whole length of the thread.

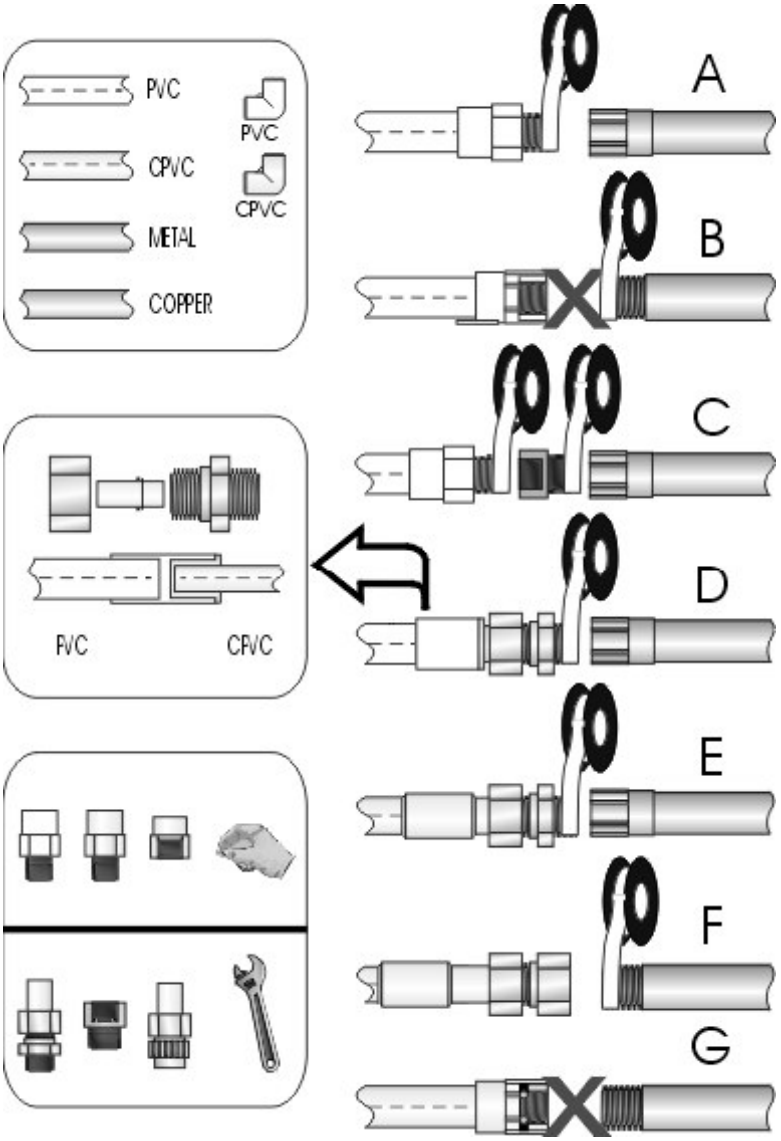
Plastic fittings' thread should be blunted before tape winding. Due to the taper thread profile, fittings with internal thread should not be connected with metal screwed elements "B".

Change of steel pass tube shells from American thread to the European one "C" is required with plastics-metal connections, for the diameters above 1½".

It is also possible to connect PVC USMetrix installation with the metal pipes and elements by the screw sets with CPVC element. In case PVC/CPVC pass tube shell should be used for connecting CPVC element with PVC fitting "D".
Only metal screw sets with CPVC element "E" and "F" should be used in the hot water and central heating installation for connecting USMetrix system with the traditional steel installation and any other metal elements (heaters, valves, water maters etc.).

Screwed connections plastics metal, sealed at the thread G are not allowed to be made in the hot water and central heating installations..

Dwg.6.1. Connections of USMetrix with steel pipes.



6.4. Flange joints

USMetrix system includes flanges with diameters from ½" to 6" :

- with permanent ring, after sticking on the tube there is no change possibility of the openings position to the clamping screws. It is important to set precisely the openings in the ring in position that meets second flange elements openings before gluing. Next the trial connection using clamping screws should be made and then the flange should be glued on the tube,
- with moving ring that allows to change the openings position to the clamping screws. During flange joints execution, one flange should have moving ring. Screws joining two flange elements should be tightened with the proper order and with the proper moment of A force. List of advised values of screws' tightening force moment is shown in the table 15.

Table. 15. Advised values of screws' tightening force moment.

Tube dimension	Quantity of the openings in the tube flange	Openings dimension for the screw [mm]	Tube flange diameter [mm]	Scre'w tightening force moment [Nm]
1/2"	4	12.70	88.90	13,56 - 20,33
3/4"	4	12.70	99.43	13,56 - 20,33
1"	4	12.70	107.95	13,56 - 20,33
1 1/4"	4	12.70	117.48	13,56 -20,33
1 1/2"	4	12.70	127.00	13,56 - 20,33
2"	4	15.88	152.40	27,12 - 40,67
2 1/2"	4	15.88	177.80	27,12 - 40,67
3"	4	15.88	190.50	27,12 - 40,67
4"	8	15.88	228.60	27,12 - 40,67
6"	8	19.05	279.40	44,74 - 67,80

Screw's tightening force moment should be lower of 1/8 when using plastic packings as Kapron® and Teflon®. If the openings of joined flanges do not fit each other, openings should be drilled in the metal flange at the places that fit plastic flanges B. Never conversely!

Dwg.6.4. Flange joints

6.5. Connections to the water heaters

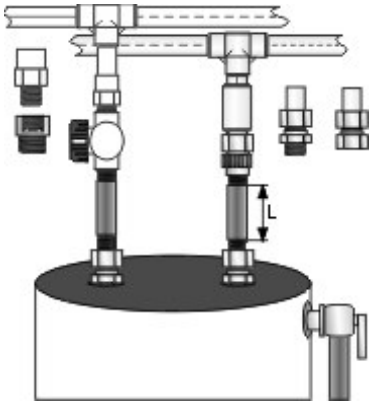
Tubes should be protected against extensive, uncontrolled temperature increase while connecting flow water heaters (gas and electric) central heating heaters or two-function heaters. Heating devices connected with USMetrix system, should have thermostatic protection against overheating set on the temperature not over 90^0C.

In case of heating devices that external surfaces can have high temperature between devices and plastic installation should be assembled metal pipe with the length L at least :

- 0,3 m for factor analytical temperature 60^0C,
- 1 m for factor analytical temperature over 60^0C.

That fact makes the additional protection of the plastic installation in the break-down situations.

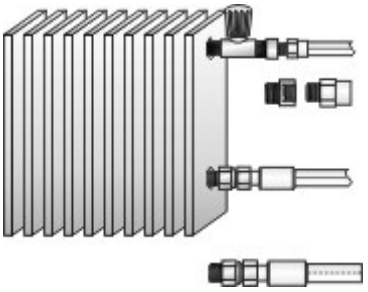
Dwg.6.5. Connections with water heaters.



6.6. Heaters' connections

Rules described in the item 6.2. are obligatory also for heaters' connections with USMetrix tubes. There should be used only the screw sets with CPVC element or pass tube sleeves with packing.

Dwg.6.6. Connections with heaters

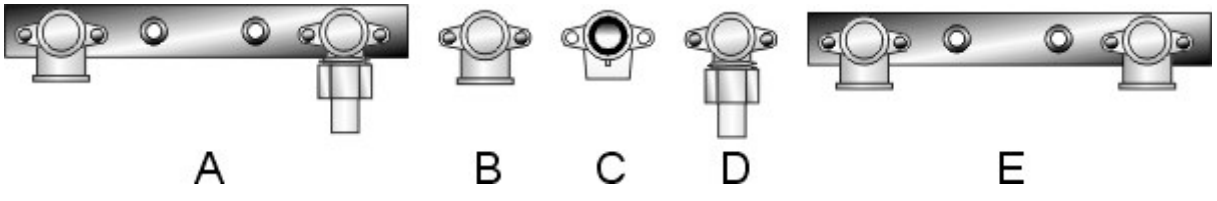


6.7. Taps' connections

Taps and any other sanitary drawing fixtures connected with plastic tubes should have independent fastening.

USMetrix system includes assembly elbows :
Nut brazen B, brazen with semi-screw set D, nut CPVC and assembly plates: with nut elbow, with semi-screw set A with elbow, with two nut elbows E. They make proper connection of single draw-off points and taps. Rules described in item 6.2 should be observed during connecting plastic and brazen elements.

Dwg.6.7. Connections with the taps.



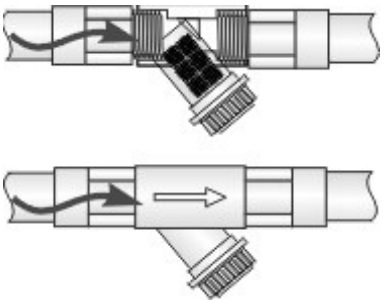
6.8. Linear settling tanks

Linear settling tank is advised to be assembled in case of connecting USMetrix system with supplying water metal installation.

This settling tank protects against damages and makes longer life of water filters, control devices and fixture. Settling tank should be installed between two cutting-off valves, basket for the impurities to the bottom. While assembling the attention should be paid to the sense of the arrow at its body. It should agree with water flow direction. Impurities that are collecting in the basket result in flow lowering and pressure drop. Then the basket should be removed and cleaned.

Caution! Settling tank's connector pipes have internal thread. Tank should be installed very carefully on the metal pipeline without thread crack or stripping.

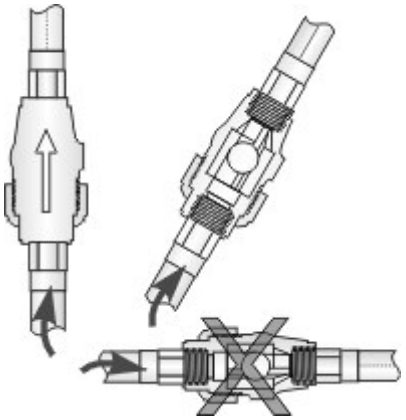
Dwg.6.8. Linear settling tanks



6.9. Non-return valves

Non-return valves should be used on the installation where appears possibility of undesirable change of medium flow direction. Their proper working depends on the proper assembling.
Caution! Valve may not work when assembled at the horizontal installation or installation with the fall.

Dwg.6.9. Non-return valves.



7. Connection of PVC and CPVC tubes and fittings

7.1. Gluing by using power glues

Connection of PVC and CPVC fittings is done by using power glues. Technology of connecting the elements, generally called "gluing" is rather something like "cold welding". Glue dissolves both surfaces and there is material diffusion of joined elements walls in the place of narrow fitting of the tube and connector. This way results in connector homogeneous structure.

7.2. Elements' preparation

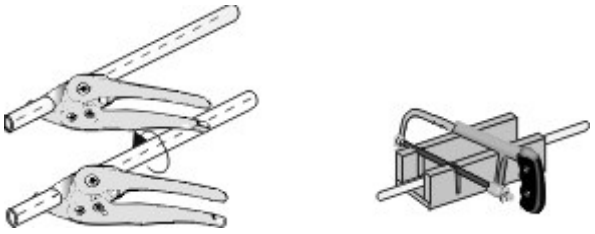
Before gluing the following elements should be prepared :

- installation elements : tubes, fittings, connectors, valves,
- required tools: shears, hack-saw, manual device for tubes' chamfering or sharp knife,
- glues and cleansers.

7.2.1. Tubes' cutting

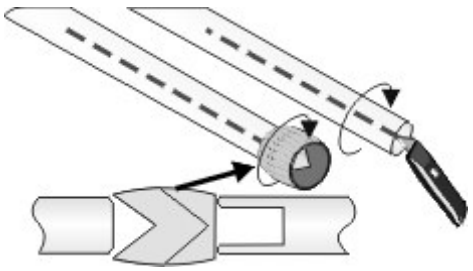
Tubes should be cut perpendicularly to the axis. Special shears should be used for cutting (for diameters ½" 2") or standard hack-saw or any other one with small teeth. During shears cutting attention should be paid so that the walls would not be crushed. So first the tube should be carefully turned round till the shears are put into the wall. It is advised to use mitre box during cutting the pipes by hack-saw. That makes easier to receive the internal area of tube exactly perpendicular to the tube axis.

Dwg.7.2.1. Tubes' cutting



7.2.2. Ends chamfering

After cutting, tubes' ends should be blunted and the feather edges removed when it was cut by the hack-saw. It could be done by sharp knife, fine-grained abrasive paper or special wall scraper. The scraper has two shaped ends for chamfering external and internal surface of the tube.

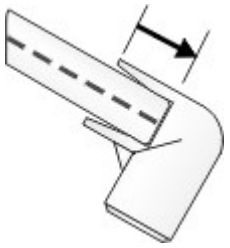


7.2.3. Fitting of the joined elements

Joining technology requires exact fitting and that's why before gluing the fitting of joined elements should be checked.

Tube should have free enter to $^{2}/_{3}$ of connector seat depth and then with the visible resistance. If the tube can slip to the end without any resistance, the tube or fitting should be changed.

Dwg.7.2.3. Fitting of the joined elements.



7.2.4. Cleansers and glues

Only USMetrix cleansers and glues should be used for gluing. The other ones do not guarantee the correctness and persistence of the executed connections. Glues should be new and not over the expiry date. Glues are clear then and they have honey -consistence.

Glues are should not be used when they become thick and they have jelly-like consistence.

Special attention should be paid when using glues and cleansers. They contain volatile substances which easily evaporate. The one should avoid breathing their vapors in, as well as direct contact with the skin. They should not be close to the fire sources because they are inflammable. Boxes should be closed even during short breaks in working.

Caution! The one must not dilute the glue and cleanser.

Dwg.7.2.4. Cleansers and glues

7.3. Gluing

7.3.1. Preparing the surface for gluing

Surfaces of joined elements should be dry and clean. They should be precisely cleaned by the rag moistened with cleanser before gluing. This activity will remove all mechanical impurities, degreasing and softening of the surface.
Then the glue will easily penetrate inside the material.

Dwg.7.3.1. Preparing the surface for gluing

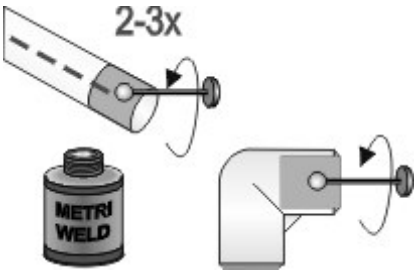
7.3.2. Adhesive spread

Special tampon fastened to the cover of the glue can is used for the adhesive spread.

While holding the cover the one should soak the tampon in the glue and then rub the surfaces of tubes and connectors by decided and circular movement.

Due to the diameters of glued elements, glues with various capacities and tampon sizes should be used. Boxes of 0,118 l, 0,236 l should be used for the small diameters and for the bigger ones of 0,473 l or 1 l. While connecting tubes with the diameters of 4" and 6" it is better first to fill the flat vessel with the proper glue quantity and then apply the glue by brush.

Dwg.7.3.2. Adhesive spread.



7.3.3. Gluing

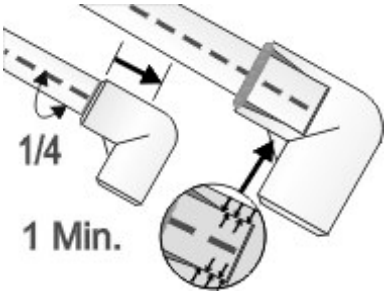
After glue rubbing on the joined surfaces the tube should be slipped quickly into the connector seat (to the resistance) and turned by quarter turn. This activity will cause uniform glue distribution. Next both elements should be held during 10 30 seconds without motion.

All gluing time should not be over 1 minute so that the so-called "dry connectors" did not appear.

Properly made connection has thin glue roller around the tube, at the connector's root.

In case of tubes with the small diameters, the connection has the proper strength almost at once so the next sections can be glued without break.
While gluing the bigger diameters, the one should wait for about 1 2 minutes.

Dwg. 7.3.3. Gluing.



7.3.4. Glue consumption

Glue consumption during the connection of USMetrix system, depends on the diameters of glued elements.
Estimated capacity of each glue type package is shown in the table below.

Table 16. Estimated capacity of standard glue packages.

Diameter of jointed elements	Package size			
	0,118 l	0,236 l	0,473 l	1 l
	Joints quantity			
1/2"	63	126	255	510
3/4"	42	84	170	340
1 1/2"	17	34	68	136
2"	9	18	38	76
3"	7	14	30	60
4"	5	10	21	42

7.3.5. Connections' dry time

Time, after that the connections have the proper strength, depends on the air temperature and humidity, as well as on the diameters of connected elements.

Table 17. Estimated time after that the connection can be loaded.

Ambient temperature	Diameter of jointed item	Glue dry time	Should be tested after (10,5 bar)
15°C - 40°C	1/2" - 1 1/4"	15 minutes	1 hour
	1 1/2" - 3"	30 minutes	2 hours
	4" - 6"	1 hour	6 hours
5°C - 15°C	1/2" - 1 1/4"	1 hour	2 hours
	1 1/2" - 3"	2 hours	4 hours
	4" - 6"	4 hours	12 hours

In case of big air humidity the dry time should last 50 % longer.

8. Pressure test

Executed installation should have the leak proof test but not earlier than after the time when the connections obtain the proper strength.

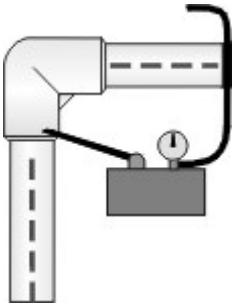
Before the test the installation should be prepared as follows :

- any earlier leakage should be removed,
- elements and fixtures that may be damaged during the increased pressure or disturb in the test should be disconnected,

- disconnected elements should be replaced by the plugs or cutting-off valves,
- manometer with the proper measuring scale and accuracy of reading of 0,01 MPa should be connected with the place of the highest pressure (generally the lowest point of the installation).

When prepared that way the installation should be filled with clean water (24 hours before the test at the very latest), precisely vent and check carefully all elements and control their leakage.
When these activities are done the pressure can be increased to the value of the test pressure.

Dwg.8. Pressure test.



Test pressure is as follows :

- 1,5 of the highest working pressure for water-pipe networks, as well as hot and cold water installations,
- maximum working pressure + 0,2 MPa but not lower than 0,4 MPa for central heating installation.

During 30 minutes that pressure should be increased to the primary value at every 10 minutes. Result of the test is positive when after further 30 minutes pressure drop is not over 0,06 MPa and after 2 hours 0,02 MPa. If any leakage appears it should be removed and the test should be started again.

After receiving positive leak proof test results in the cold state, the leak proof and installation working test could be done in the hot state.

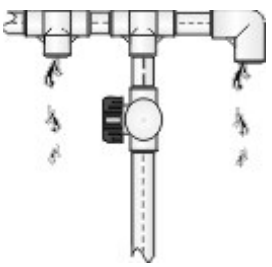
This test is done after heating source was activated and with the highest parameters of the heating medium. Time of installation working test in the hot state should last at least 72 hours. All connectors should be watched, as well as compensators and self-compensation elements controlled in the range of their ability of taking the thermal elongation during leakage test in hot state.

Caution! All test should be made before the installation is covered. During the test constant medium temperature should be held. Change of medium temperature results in pressure change.

9. Installation rinsing

After the pressure test is done the installation should be rinsed by the cold water for impurities removing. Usually they appear as the filings made during cutting the tubes by hack-saw not shears. Then the fixtures could be piped up again and regulated due to the well-known parameters.

Dwg.9. Installation rinsing



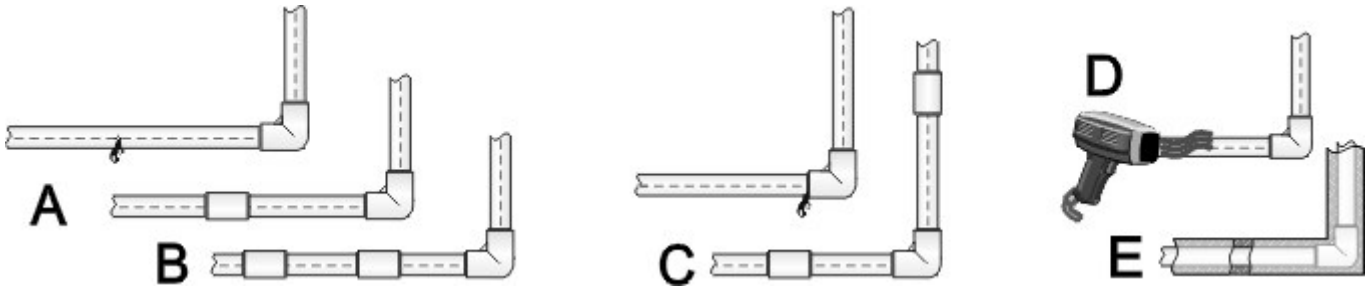
10. Installation repairs

In case of the small leakage at the pipe section, damaged section should be cut and when it is possible to bring the both ends of the tube together and glue them with single connector A. When it is not possible it is necessary to use a new tube section and two connectors B.

In case of leakage at the connector the best method is to cut the connection together with two connectors C. In case of installation freezing the ice should be defrosted by the dryer (D).

The cutting blow-pipe must not be used because it could damage the tube's surface.
Thermal insulation E should be used at each section where water could freeze in the installation.

Dwg.10. Installation repairs.



11. Products' storage and transport

PVC and CPVC tubes and connectors can be stored either in the room or outside (protected against direct solar radiation).

They shouldn't have close covering due to the ventilation reasons and so that not to have temperature increase during big insolation.

During storage the tubes cannot be bent, crushed or abraded so they cannot be laid together with the metal pipes. Tubes should be laid in the piles at the level base or on the pads (the best wooden ones) with the width of at least 10 cm. Distance between the pads should not be over 1 m. It is admitted to put the tubes in seven layers.

Layers should be protected against the displacement.

Layers' height should not be over :

- 1 m for the tubes with the smaller diameters,
- 2 m for the tubes with the bigger diameters.

If there are different tubes in one pile, the tubes with the bigger diameters should be put on the bottom.