TECHNOLOGY SUPPORT OF PLASTIC PIPING SYSTEM

5.1 UPVC/CPVC Piping System

5.1.1 Material Characteristic

Polyvinyl chloride is polymerized of monomer vinyl chloride (VCM). It is used for construction, sewerage pipes and other pipe applications because of its biological and chemical resistance and workability. It's more effective than traditional materials such as copper, iron or wood in pipe and profile applications.

CPVC is PVC (polyvinyl chloride) that has been chlorinated. Depending on the method, a varying amount of chlorine is introduced into the polymer allowing for a measured way to fine tune the final properties. The chlorine content may vary from manufacturer to manufacturer; the base can be as low as PVC 56.7% to as high as 74% by mass, although most commercial resins have chlorine content from 63% to 69%. CPVC can withstand corrosive water at temperatures greater than PVC, typically 40°C to 50°C (104°F to 122°F) or higher, contributing to its popularity as a material for water piping systems in residential as well as commercial construction.

5.1.2 Introduction of UPVC/CPVC Piping System

UPVC/CPVC pipes are in widespread use in a number of industries, ranging from residential plumbing to complex water treatment systems. Because of the material properties of UPVC/CPVC pipes, they are highly valuable as a thermo-resistant structure, fire retardant fabric, and as a high quality water conduit in many construction applications. UPVC/CPVC pipes are superior to most other modern materials due to environmental friendliness, chemical resistance, inherent toughness, heat resistance, and being electrically non-conductive/non-corrosive

Max working temperature of UPVC pipes is 60℃, and they are usually used below 45℃. They are applied for water supply system, agriculture irrigation system, and pipes for air conditioning.

Max working temperature of CPVC pipes is 110℃, and they are usually used below 95℃. They are applied for petro, electronics, chemical engineering, food, and metal plating industries.

5.1.3 Physical Properties

5.1.3.1 UPVC Physical Properties for UPVC

Item	Unit	Standard Value	Standard
Density	kg/m³	1350～1460	ISO 1183
Vicat	℃	（Pipe）≥80，（Fitting）≥74	ISO 2507
Tensile Strength	MPa	≥40	ISO 6259
Impact Strength	KJ/m²	11.0	ISO 179
Vertical Retraction Ratio	%	≤5	ISO 2505
Drop-weight Test（0 ℃）	TIR	≤10%	ISO 3127

5.1.3.2 CPVC Physical Properties for CPVC

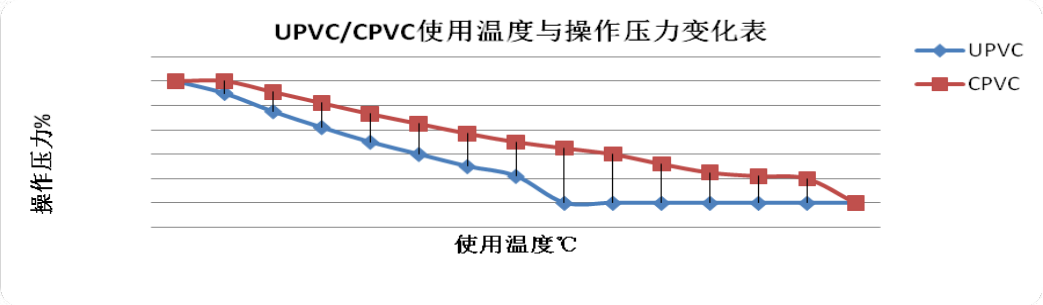
Item	Unit	Standard Value	Standard
Density	kg/m³	1450～1650	ISO 1183
Vicat	℃	（Pipe）≥110，（Fitting）≥103	ISO 2507
Tensile Strength	MPa	≥50	ISO 6259
Impact Strength	KJ/m²	8.0	ISO 179
Vertical Retraction Ratio	%	≤5	ISO 2505
Drop-weight Test（0 ℃）	TIR	≤10%	ISO 3127

5.1.4 Temp & Pressure relation between UPVC and CPVC pipelines

The operating pressure in the UPVC and CPVC pipelines at higher temperatures is listed in the following table, with the pressure at the at normal operating temperature 73℉ (23℃) scaled to be 100%

℉	73	80	90	100	110	120	130	140	150	160	170	180	190	200	210
℃	23	27	32	38	43	49	54	60	66	71	77	82	88	93	99
UPVC	100%	90%	75%	62%	50%	40%	30%	22%	0%	0%	0%	0%	0%	0%	0%
CPVC	100%	100%	91%	82%	73%	65%	57%	50%	45%	40%	32%	25%	22%	20%	0%

Note: UPVC pipes with screws should not be operated over 110 ℉(43℃); CPVC ones should not be operated over 150℉ (66℃)



5.2 PPR/PPH Piping System

5.2.1 Material Characteristics

Polypropylene (PP), also known as polypropene, is a thermoplastic polymer used in a wide variety of applications including packaging and labeling, textiles (e.g., ropes, thermal underwear and carpets), stationery, plastic parts and reusable containers of various types, laboratory equipment, loudspeakers, automotive components, and polymer banknotes. There are three general types of polypropylene: homopolymer, random copolymer, and block copolymer. The comonomer is typically used with ethylene. Polypropylene Random Copolymer (PP-R) is formulated by adding randomly polymerized ethylene monomer to polypropylene homopolymer. It decreases the polymer crystallinity and makes the polymer more transparent.

Polypropylene Homopolymer (PP-H) is another type of PP. It has better temperature & creep resistance than PPR, and with low temperature impact strength.

5.2.2 Introduction of PPR/PPH Piping System

Presently PPH/PPR pipes & fittings are most reliable in plumbing and water supply plants, due to their chemical features and fusion welding, which ensures the plumbing to have a perfect seal tight system. Approved by the Health Organization with characteristics such as Eco-friendly and high temperature resistance, PPH/PPR pipes & fittings have been taken as one of the best solution for piping systems.

Max working temperature of PPR pipes is 95℃, and they are usually used below 70℃. They are applied for transferring corrosive material below 70℃, and also for pressured liquid transfer, for example, household water system.

Max temperature of PPH pipes is 110℃, and they are usually used below 90℃. They are applied for cooling water transfer, corrosive material transfer, fume ducts, electrolyze systems, and other piping systems with acid liquids.

5.2.3 Physical Properties

5.2.3.1 Physical Properties of PPR Pipes

Item	Unit	Standard Value	Standard
Density	kg/m³	900～920	ISO 1183
Vicat	℃	≥75	ISO 306
Tensile Strength	MPa	≥25	ISO 6259
Impact Strength（23 ℃）	KJ/m²	40	ISO 179
Vertical Retraction Ratio (135 ℃)	%	≤2	ISO 2505

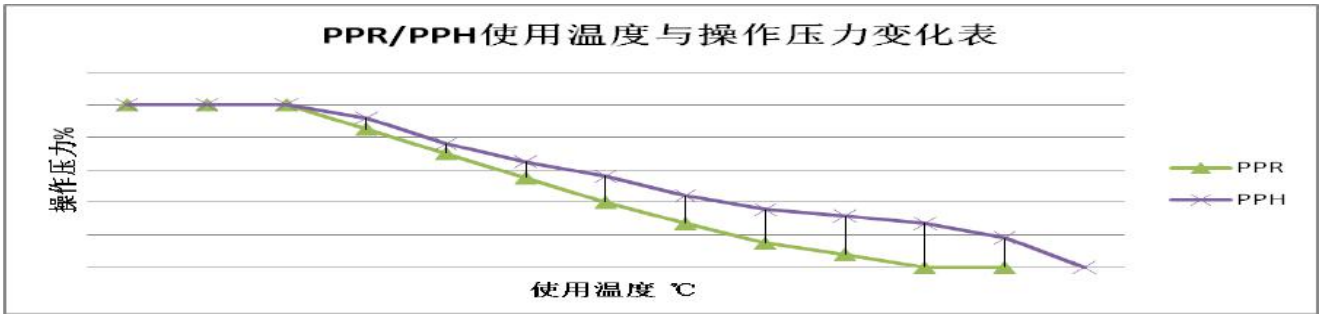
5.2.3.2 Physical Properties of PPH Pipes

Item	Unit	Standard Value	Standard
Density	kg/m³	905～915	ISO 1183
Vicat	℃	≥95	ISO 306
Tensile Strength	MPa	≥27	ISO 6259
Impact Strength（23 ℃）	KJ/m²	50	ISO 179
Vertical Retraction Ratio (150 ℃)	%	≤2	ISO 2505

5.2.4 Temp & Pressure relation between PPR and PPH pipelines

The operating pressure in the PPR and PPH pipelines at higher temperatures is listed in the following table, with the pressure at the at normal operating temperature 77℉（25℃）scaled to be 100%

℉	50	68	77	86	104	122	140	158	176	194	203	212	230
℃	10	20	25	30	40	50	60	70	80	90	95	100	110
PPR	100.0%	100.0%	100.0%	85.0%	70.0%	55.0%	40.0%	27.0%	15.0%	8.0%	0.0%	0.0%	
PPH	100.0%	100.0%	100.0%	92.0%	76.0%	65.0%	56.0%	44.0%	35.5%	31.5%	27.0%	18.0%	0.0%



5.3 PVDF Piping System

5.3.1 Material Characteristics

Polyvinylidene fluoride, referred to as PVDF, it is a monomer formed by trifluoroethylene, hydrofluoric acid and zinc powder, and after polymerization to generate white crystalline solid. It is a homopolymer.PVDF has excellent heat and cold resistance, chemical resistance and excellent physical and mechanical properties.

5.3.2 Introduction of PVDF Piping System

Max working temperature of PVDF pipes is 200℃, and they can be used for a long time in the temperature range of -50℃ ~ 150℃. Except hydrochloric acid and strong solvent, PVDF can withstand all salt, acid, alkali, aromatic hydrocarbon, halogen and other media. And with its excellent corrosion resistance, long service life and high safety performance, PVDF products widely used in severe environment which high temperature, high pressure, low

temperature, high vacuum and heavy corrosion. PVDF products is one of the best choice of the current industrial pipeline system.

5.3.3 Physical Properties

Physical Properties of PVDF Pipes

Item	Unit	Standard Value	Standard
Density	kg/m³	1760～1790	ISO 1183
Vicat	℃	≥140	ISO 306
Tensile Strength	MPa	≥40	ISO 6259
Impact Strength（23 ℃）	KJ/m²	≥160	ISO 179
Vertical Retraction Ratio (150 ℃)	%	≤2	ISO 2505

5.4 Plastic piping system constructing method & Hydrostatic Pressure Testing Notification

5.4.1 Constructing Method of UPVC/CPVC Pipes

UPVC/CPVC piping systems are bonded by special cement. Hereunder are the steps:

5.4.1.1 Cutting

Power Saw and plastic tubing cutters can be used for pipe cutting. Cut the pipes as squarely as possible to provide maximum bonding area.

5.4.1.2 Deburring

Burrs must be removed from the inside, as well as the outside, of the pipe ends by pliers, filer and sandpaper on both inner side and outside of the cutting edge so that pipes and fittings are bond tightly.

5.4.1.3 Marking

Making marks on all pipes according to the length & depth of fitting parts. It can be used to ensure the pipe completely bottomed into the fitting during assembly.

5.4.1.4 Solvent Coating

Bonding surface should be softened by detergent, and then coat cement on both sides of bonding parts evenly.

Standard Volume of Cement

Nominal Outside Diameter（mm）	20	25	32	40	50	63	75	90	110	125	140	160
Cement Volume（g/piece）	0.40	0.58	0.88	1.31	1.94	2.97	4.10	5.73	8.43	10.75	13.37	17.28

5.4.1.5 Assembling

After coating cement, insert pipe into fitting socket while rotate the pipe a quarter turn. Pipe must bottom completely to the fitting stop. Hold the assembly part for 10-15 seconds to ensure initial bonding (2 persons work together to bond pipes larger than 6”). A bead of cement should be evident around the pipe and fitting juncture. If this bead is not continuous around the socket shoulder, it may indicate that insufficient cement was applied. If insufficient cement is applied, the joint must be cut out, discarded and begun again. Cement in excess of the bead can be wiped off with a rag.

5.4.2 UPVC/CPVC Hydrostatic Pressure Testing Notification of UPVC/CVPC Pipes

5.4.2.1 Cemented pipes must be tested 48 hours after installation. If pipes are installed underground, the test must be done after the trench is backfilled.
5.4.2.2 Support to tees, elbows, and fitting stops in the end must be stable. Thrust block made of concrete must be cured completely before test.
5.4.2.3 The end of the system should be blocked. Then, the system must be filled slowly with water, venting air from valves at piping run ends and at elevations during the filling process.
5.4.2.4 After the system is filled with water, make watertight test.
5.4.2.5 Hand pump or electro pump is used to rise up the pressure. The process must be slowly, more than 10 mins.
5.4.2.6 After rising up to the test pressure, hold it for 1 hour to check if there is leakage. If the pressure lowers down, rise up the pressure again. Within 15mins, if the pressure lowers smaller than 0.05MPA, the result is qualified.

5.4.3 Constructing Method of PPR/PPH /PVDF Pipes

PPR/PPH/PVDF piping systems are bonded by heating. Hereunder are the steps:

5.4.3.1 The process requirement of hot melt socket welding

5.4.3.1.1 Cutting & Deburring

Power Saw and plastic tubing cutters can be used for pipe cutting. Cut the pipes as squarely as possible to provide maximum bonding area and keep it clean without oil. Burrs must be removed from inside, as well as the outside, of the pipe ends by pliers, filer and sandpaper on both inner side and outside of the cutting edge so that pipes and fittings are bond tightly.

5.4.3.1.2 Marking

Making marks on all pipes according to the length & depth of fitting parts. It can be used to ensure the pipe completely bottomed into the fitting during assembly.

5.4.3.1.3 Heating

Guide the pipes into heater straight to the marked assembly depth. In the meanwhile, push the fitting onto the heater and reach the marked depth.

5.4.3.1.4 Assembly

Heating time must be complied with the values in the under table. After heating time, remove pipe and fitting from the heater immediately and assemble them to the marked depth straight so that there is even bulge is the assembly place. Within the working time, tiny adjustment can be made but rotation must be prohibited. Keeping pipe and fitting from being wrenched, bent, and stretched.

Nominal Diameter（mm）	Heating Depth (mm)	Heating Time (s)	Assembly Time (s)	Cooling Time（min）
20	14.0	5	4	2
25	15.0	7	4	2
32	16.5	8	6	4
40	18.0	12	6	4
50	20.0	18	6	4
63	24.0	24	8	6
75	26.0	30	8	8
90	29.0	40	8	8
110	32.5	50	10	8

If the environment temperature is lower than 5℃, extend heating time by 50%.

5.4.3.2 The process requirement of hot melt butt welding:

5.4.3.2.1 The five stages of hot melt butt welding:

Pre-heating stage; Heating stage; Transfer stage; Welding stage; Cooling stage.

5.4.3.2.2 Preparation before welding. The following preparation should be carried out before welding:

A) It should have a good climate environment in welding area.

B) The tools must be clean and the welding area must free of grease.

C) Connect all parts of the welding machine correctly, and clean the oil-way; Measure the supply voltage of electricity to confirm that the voltage meets the requirements of the hot melt butt welding machine;

D) Heating, cooling time and heating component temperature shall be set correctly according to the welding process. The hot plate of the first welding port shall be preheated for 10min at the welding temperature.

5.4.3.2.3 Clamp pipe/fittings

Assemble the two welding components on the hot melt butt welding machine, use holder to flatten the pipe (fittings), adjust the concentricity, adjust the two pipes (fittings) at the same axis, check the alignment, the displacement value of welding side shall not exceed the allowed tolerance, 0.1* the thickness of the pipe or the outer wall thickness of the plate.

5.4.3.2.4 Cut the welding side

The maximum width of the gap between welding sides after cutting must meet the requirements in table 1 and table 2 which as below:

Table 1 the maximum width of the gap between welding sides of PP pipe, fittings and plate after cutting.

Unit：mm

Nominal O.D. of pipe(dn)	Width of the gap	Width of the plate B
dn≤355	0.5	
400＜dn≤630	1.0	≤1500
630＜dn≤800	1.3	1500＜B≤2000
800＜dn≤1000	1.5	2000＜B≤2300
dn＞630	2.0	2300＜B≤3000

Table 2 the maximum width of the gap between welding sides of PVDF pipe, fittings and plate after cutting.

Unit：mm

Nominal O.D. of pipe(dn)	Width of the gap	Width of the plate B
dn≤355	0.5	
400＜dn＜630	1.0	≤1500
400＜dn＜630	1.3	1500＜B≤2000
400＜dn＜630	1.5	2000＜B≤2300
400＜dn＜630	2.0	2300＜B≤3000

5.4.3.2.5 Adjust the pipes (fittings) at the same axis

Check the welding sides of pipe or fittings which have no uneven milling, big gap or other defects. If it meets the requirements, adjust the pipes (fittings) at the same axis.

5.4.3.2.6 Test and check drag pressure

The frame of closing machine pressing evenly and slowly, when the frame starts to move, the recorded pressure value is drag pressure (pt), which is not fixed and must be measured every time when it is welding. The gap of welding

side of pipes and fittings must less than 0.3mm; the displacement value of welding parts must be less than 10% of the thickness of welding parts.

5.4.3.2.7 Heating the welding sides stably

When the temperature of the heating component meet set temperature requirement, then assemble the heating component on the hot melt butt welding machine, keep the pressure and complete specified flanging formation time or flanging size, the pipes or fittings can't interrupt touch with the heating component, meanwhile adjust the pressure to meet required butt welding heating pressure, and keep heating to meet the heating time's requirement. Lowering the pressure to drag pressure (pt) and start heating timing, the heating tools must fit with welding sides tightly without any gap.

5.4.3.2.8 Transfer and butt welding

After the heating, pull the pipe or fitting out from the heating component, and joint the welding sides of pipes or fittings quickly, and increase the pressure uniformly to the total hot melt butt welding pressure (p1), high-pressure collision is strictly prohibited.

When aligning, put the welding sides on the hot iron until the whole side full touch the hot iron completely, side to side, and it can observing the flanging formation. When the flanging height around the entire circumference of the tube or the entire top of the plate up to the required value, then it's aligned.

5.4.3.2.9 Connector cooling

After hot melt butt welding, the connector shall be fixed in the hot melt butt welding machine, and cooling the connector according to cooling period which specified in the regulations of pressure maintaining and cooling of hot melt butt welding machine.

5.4.3.2.10 Remove pipes/fittings

After the cooling, reduce pressure to zero, and then remove the welded pipes/fittings.

Hot melt butt welding process reference table of PPH pipes and fittings

Nominal wall thickness/MM	Aligning	Heating	Transfer	Welding	
	Heating component temperature 210℃±10℃				
	After the alignment time is over, the flanging height on the heating part(min) （alignment p=0.01N/mm2)/mm	Heating time≈10e+40s (Heating p≤0.01N/mm2)/s	Transfer time （max）/s	The formation time of welding pressure /s	Cooling time (min) 【 p=(0.10+0.01)N/mm2】/min
6.0～7.0	0.5	135～175	5～6	6～7	6～12
7.0～12.0	1.0	175～245	6～7	7～11	12～20
12.0～19.0	1.0	245～330	7～9	11～17	20～30
19.0～26.0	1.5	330～400	9～11	17～22	30～40
26.0～37.0	2.0	400～485	11～14	22～32	40～55
37.0～50.0	2.5	485～560	14～17	32～43	55～70

Hot melt butt welding process reference table of PVDF pipes and fittings

Nominal wall thickness/MM	Aligning	Heating	Transfer	Welding	
	Heating component temperature 210℃±10℃				
	After the alignment time is over, the flanging height on the heating part(min) （alignment p=0.01N/mm2)/mm	Heating time≈10e+40s (Heating p≤0.01N/mm2)/s	Transfer time （max）/s	The formation time of welding pressure /s	Cooling time (min) 【 p=(0.10+0.01)N/mm2】/min
6.0～10.0	0.5～1.0	95～140	4	5～7	8.5～14
10.0～15.0	1.0～1.3	140～190	4	7～9	14～19
15.0～20.0	1.3～1.7	190～240	5	9～11	19～25
20.0～25.0	1.7～2.0	240～290	5	11～13	25～32

5.4.4PPR/PPH/PVDF Hydrostatic Pressure Testing Notification of PPR/PPH /PVDF Pipes

- Hydraulic test has to be performed sectional; tested length should be no longer than 500m.
- Before test, make sure pipes are fixed, joints are not covered, and the whole system is independent from water outlet tools.
- Pressure gage with tolerance 0.01Mpa needs to be installed in the lowest place of the system.
- Fill water from lowest part of the system to remove the air and make watertight test.
- Hand pump or electro pump is used to rise up the pressure. The process must be slowly, more than 10 mins.
- After rising up to the test pressure, hold it for 1 hour to check if there is leakage. If the pressure lowers smaller than 0.06MPA, the result is qualified.
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- Hold the pressure 1.15 times of the working pressure for 2 hours. If the pressure lowers less than 0.03MPA, the result is qualified.
- There must be no leakage in the system during test.
- During 30 mins, if the pressure lowers down, it is allowed to raise up the pressure again 2 times.

5.5 Max Support Distance Requirement

Support distance of plastic pipes is more strictly requested than that of steel pipe. Operating temperature influence the distance. Please refer to the below charts:

5.5.1 UPVC Support Spacing Chart (mm)

Nominal Pipe Size	1/2″	3/4″	1″	1-1/4″	1-1/2″	2″	2-1/2″	3″	4″	6″	8″
Horizontal Pipes	500	550	650	800	950	1100	1200	1350	1550	1800	2400
Vertical Pipes	900	1000	1200	1400	1600	1800	2000	2200	2400	2700	3000

5.5.2 CPVC Support Spacing Chart (mm)

Nominal Pipe Size	1/2″	3/4″	1″	1-1/4″	1-1/2″	2″	2-1/2″	3″	4″	6″	8″
20℃	700	750	800	850	1000	1100	1250	1400	1650	1800	2000
40℃	650	700	750	800	950	1050	1200	1350	1500	1650	1800
60℃	600	650	700	750	900	1000	1100	1250	1350	1500	1650
80℃	550	600	650	700	800	900	1000	1100	1200	1350	1500
Vertical Pipes	1000	1100	1200	1400	1600	1800	2100	2400	2700	3000	3400

5.5.3 PPR/PPH Support Spacing Chart（mm）

5.5.3.1 Max distance for cold water pipes

Nominal Pipe Size	20	25	32	40	50	63	75	90	110
Horizontal Pipes	650	800	950	1100	1250	1400	1500	1600	1900
Vertical Pipes	1000	1200	1500	1700	1800	2000	2000	2100	2500

5.5.3.2 Max distance for hot water pipes

Nominal Pipe Size	20	25	32	40	50	63	75	90	110
Horizontal Pipes	500	600	700	800	900	1000	1100	1200	1500
Vertical Pipes	900	1000	1200	1400	1600	1700	1700	1800	2000

5.5.4 Spacing among water supply system, non-building structures, and other pipelines

	Nonbuilding Structures				Other Pipelines			
	Railway	Building Line	Street Trees	Poles	Electric Wires	Gas Pipelines	Heating Pipelines	Sewage Pipelines
Min. Space （M）	5	5	1.5	1.0	1.0	1.0-2.0	1.5	1.5