Volume : 3 | Issue : 4 | April 2014 • ISSN No 2277 - 8160

Research Paper Engineering

Testing Method for Determine the Characteristics of PVC-C Pipes

Mihai Ioan CINCA	Associate Professor University Politehnica Timisoara Str. T. Lalescu 2A Timisoara.
Olga BANCEA	Associate Professor University Politehnica Timisoara Str. T. Lalescu 2A Timisoara.
Marius ADAM	Assistant Professor University Politehnica Timisoara Str. T. Lalescu 2A Timisoara.

ABSTRACT

The choice of piping systems for water utilities depends on factors like long term costs, reliability, versatility, environmental effect, drinking water safety and public health. Chlorinated Polyvinyl Chloride (PVC-C) is modified PVC with additional high temperature strength, to handle hot, corrosive liquids at temperatures up to 100°C. It has greater rigidity and lower thermal expansion, is corrosion resistant, durable, smooth, friction free, resistant to bacterial growth and environment friendly. PVC-C is four times quieter than copper plumbing systems reduces noise of running water and the pounding noise of the water hammer. The paper presents experimental methods for determining some characteristics of PVC-C pipes, as: density, resistance by interior pressure, thermal dilatation and the roughness coefficient. The experimental methods are in accordance with the actual European Standards and the results confirm the characteristics presented in the technical data lists for the analyzed pipes.

KEYWORDS : Piping systems, Chlorinated Polyvinyl Chloride, water utilities.

GENERAL CHARACTERISTICS

PVC-C is inert to many mineral acids, bases, salts, paraffinic hydrocarbons, halogens and alcohols. It will not support combustion and is rated as self-extinguishing. The low thermal conductivity of the material reduces moisture condensation on water lines, and will maintain the temperature of fluids with minimal insulation. With a similar working temperature range to polypropylene, PVC-C has greater rigidity and lower thermal expansion [1], making it particularly suitable for above ground process pipework.

Post-chlorinated Polyvinylchloride (PVC-C) is a highly versatile material that is used for both pressure and drainage piping systems for above and below ground applications. It is a rigid thermoplastic material with good tensile, flexural and mechanical strength, low moisture absorption, good flammability characteristics, exceptional dimensional stability and good tenacity.

PVC-C also has excellent chemical resistance across its operating temperature range of 0°C to 90°C with a broad band of operating pressures. In addition, because of its long-term strength characteristics, high stiffness and cost effectiveness, PVC-C systems are suitable for a wide diversity of thermoplastic piping installations.

PVC-C is thermally stable in the temperature range 5°C to 100°C, however at low temperatures the impact strength of PVC-C decreases. It is therefore not recommended for use at very low temperatures unless there is no likelihood of the piping materials being disturbed or subjected to impact damage. PVC-C is free from toxic metals thus ensuring that it is physiologically harmless for drinking water and foodstuffs applications.

Some important characteristics of PVC-C are:

- Low Specific weight 1.5 g/cm^3
- Wide range of applications
- Good chemical and corrosion resistance
- Safe for potable water applications
- Low friction loss
- Self-extinguishing
- High mechanical strength
- Low coefficient of thermal expansion
- Rigid and requires less support

The pressure ratings for PVC-C pipes according to DIN 8079 and PVC-C fittings according to DIN 8063 are defined by the "nominal pressure" method, whereby pipes, fittings and valves are grouped together according to a single nominal pressure rating. The PN rating is the maximum permitted operational pressure in bars calculated at 20°C, for example PN6 indicates a maximum working pressure of 6 bars. According to this method the pressure ratings [5] of metric sized PVC-C pipes and fittings according to the nominal pressure system is as presented in Figure 1.

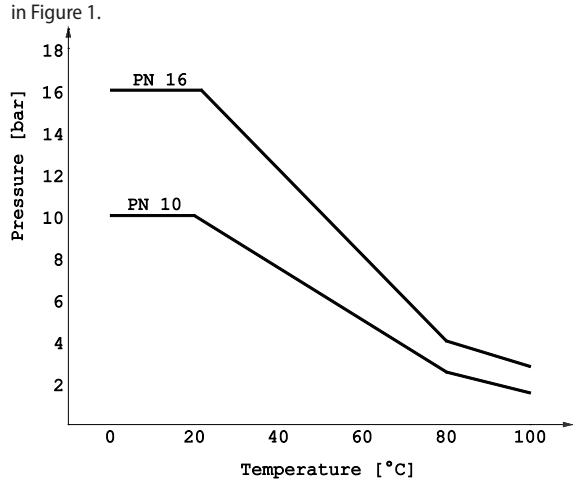

Figure.1: Temperature – pressure diagram (water)

EXPERIMENTAL METHODS FOR TESTING PVC-C PIPES

Material specification: Friatherm pipe and fittings [7] are manufactured from Chlorinated - Poly Vinyl Chloride (PVC-C). Material: FRIAPLAST 110-65 to DIN 8079/8080.

Determination of the PVC-C pipes density

Through density we represent the ratio between the mass of a sample and his volume (by a temperature of 23°C). For density determination [10] it used an equipment according to SR ISO 1183/2 – 2005 composed by:

- Balance with 0.1 mg precision;
- Tripod;
- Pycnometer with a side placed capillary tube for overflow in order to determine mass volume of the immersed volume, other than water. The pycnometer will be equipped with a an thermometer graded in °C between 0 and 30 °C;
- Liquid bath with thermoregulation and precision of 0.1 °C.

The sample must have such size that allows maintaining it at a sufficient distance from the tanks walls.

Operating mode:

1. Weighing of the sample hanged by a metallic wire having a section of maximum 0.125 mm^2.
2. Immersion of the sample hanging all the time on the wire, in the immersion thank with liquid, placed on the tripod. The temperature of the immersion liquid must have 23±0.1°C. The cohesive air bubbles must be removed with a fine metallic wire. It is useful spotting the immersion level. The immersed sample is weighted. Density is calculated with the following relation:

$$\rho = \frac{m_A \times \rho_L}{m_A - m_I} \qquad (1)$$

where:

m_A - mass of the sample in air, grams;
m_I - mass not reviewed of the immersed sample, grams;
ρL - density, grams per cubic centimeter of the immersion liquid, for water at 23°C it is 0.9976 g/cm^3.
The sample characteristics are presented in Table 1.

TABLE – 1 CHARACTERISTICS OF SAMPLES

	Mass [g]	V [cm^3]	ρ [g/cm^3]
Sample 1	6.4	4.1	1.561
Sample 2	6.5	4.2	1.548
Sample 3	6.2	3.9	1.590
Sample 4	6.4	4.1	1.561
Sample 5	6.4	4.2	1.524
Average density			1.557

The calculated average density is ρ=1.557 g/cm^3

Determination of the thermal expansion coefficient

The testing method [3], [4] is in accordance with SR EN ISO 2505-2005, available for liquid bath. The necessary equipment contains:

- thermal controlled bath with temperature t_R, specified in standard, for PVC–C the temperature is t_R = 150 ± 2°C;
- device that allows to maintain the samples in the liquid bath thus the samples does not reach the bottom of the bath, also a distance between the upper limit of the tested portion (corresponding to a distance of 100 mm between the two markers) and the interface air/liquid should be at least 30 mm distance;
- thermometer with gradation values of 0.5 °C.

A sample representing a pipe with the length of 200 mm ± 20 mm is marked down with two round marks at 100 mm distance corresponding to the tested section and at equal distance from the end. For each pipe are prepared three identical samples which are conditioned for less than 2 hours at a temperature of 23°C ± 2 °C. The working stages are:

a) bath temperature is regulated for t_R = 150 °C;
b) samples are introduced in the bath;
c) samples are hold immersed 15 minute according to SR ISO 2502/2;
d) samples are carried out from the bath and before they are completely cooled at 23 °C ± 2°C it is measured de distance between the marks along the maximum and minimum generating lines (diametrically opposite) attending all the buckles of the marked surface.The results are elaborated for each sample and it is calculated the longitudinal dilatation through heating, with the equation 2.

$$\alpha = \frac{\Delta l}{L - L_0} \times \frac{1}{t_R - 23} \quad [mm/(mK)] \qquad (2)$$

The results are presented in Table 2.

TABLE – 2 LONGITUDINAL DILATATION

	Temp. t_R [°C]	Final length [mm]	α [mm/(mK)]
Sample 1	150	100.88	0.0698
Sample 2	150	100.89	0.0702
Sample 3	150	100.87	0.069
Average expans. coefficient			0.06966

Determination of the roughness coefficient

The necessary equipment consists of:

- differential piezometer (sensors for differential pressure) with precision of de 0.5 mmH_2O;
- regulating valve;
- flow rate measuring system;
- micrometer for measuring the interior diameter of pipe, with a precision of 0.01 mm;
- manometer with precision.

A pipe with the length of 1.200 ±10 mm will be connected to a water source. The two ends of the differential manometer are fixed at 1000 mm distance.

The working stages are:

a) pressure regulation through a regulating valve, MPa;
b) measurement of water flow through the pipe, l/s;
c) measurement of the differential pressure drop, mm H_2O.

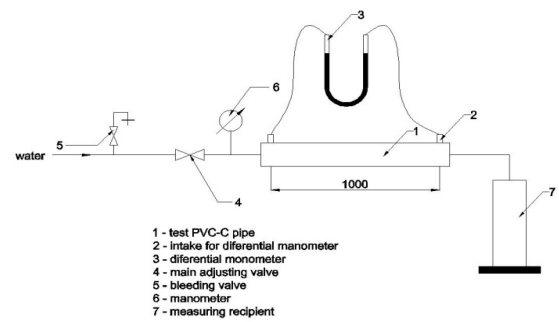

Figure.2: Experimental installation to determine the roughness coefficient

The coefficient of hydraulic linear resistance l, is calculated with (Darcy – Weissbach) relation 3:

$$\Delta p = \frac{\lambda l}{d} \frac{\rho v^2}{2} \qquad (3)$$

where:

l - length of the section pipeline, l = 1.0 m;
d - interior diameter of the pipe, d = 21.2 mm;
ρ - water density, kg/m^3;
v - water velocity in the pipe, m/s;

a) It is calculated Re with relation 4:

$$\mathrm{Re} = \frac{v \times d}{\upsilon} \qquad (4)$$

where: ν - kinematical viscosity of water, m^2/s.

b) The roughness coefficient k is calculated with the Colebrook-White relation recommended for $23\frac{d}{k} < \mathrm{Re} < 560\frac{d}{k}$ in turbulent flow in rough hydraulic pipes, named also as zone, pre-quadric zone, conform relation 5:

$$\frac{1}{\sqrt{\lambda}} = -2\lg\left(\frac{2{,}51}{\mathrm{Re}\sqrt{\lambda}} + \frac{k}{3{,}71d}\right) \qquad (5)$$

The results are presented in Table 3.

TABLE – 3 CALCULATED ROUGNESS COEFFICIENT

No.	Flow [l/s]	Pressure loss [mm H_2O]	Re	k [mm]
1	0.1	71	4622	0.00486
2	0.2	235	9244	0.00492
3	0.3	480	13867	0.00489
4	0.34	598	15716	0.00501
5	0.4	798	18489	0.00508
Average value				0.004952

CONCLUSIONS

According to the experimental tests made on PVC-C pipes produced by Friatherm we concluded that they respect the European Standards regarding:

- PVC-C pipes density;
- response to thermal stress;
- hydraulically characteristics.

The values resulted after the experimental tests are enclosed with the allowed errors in accordance with the Norms in use.

According these properties CPVC pipes make them ideal for:

- Hot and cold water distribution in residential, industrial and public projects;
- Carrying drinking water and food liquids;
- Water and waste water treatment systems;
- Transportation of chemical and hot corrosive fluids, which includes a wide variety of inorganic acids, bases used in chemical processing;
- Use in industries like metal finishing, plating and treatment, pulp and paper, air pollution control, mining, aerospace, textile, food and beverage processing, fine sprinkler piping and municipal projects;
- Use as high tension cable protection pipe for electric net improvement (Large dia. CPV-C Pipes);
- Solar heating, central heating and radiant floor heating application.

REFERENCES

[1] * * *, DIN 8079:2009-10, "Chlorinated polyvinyl chloride (PVC-C) pipes – Dimensions". | [2] * * *, DIN 8080:2009-10, "Chlorinated polyvinyl chloride (PVC-C) pipes - General quality requirements, testing". | [3]] * * *, SR EN ISO 2505:2005, "Ţevi de materiale termoplastice. Contracţia longitudinală la cald. Partea 1: Metode de determinere". | [4] * * *, SR EN ISO 2505:2005, "Ţevi de materiale termoplastice. Contracţia longitudinală la cald. Partea 2: Parametri de determinat". | [5] * * *, SR EN ISO 1167-3:2008, "Thermoplastics pipes, fittings and assemblies for the conveyance of fluids - Determination of the resistance to internal pressure - Part 3: Preparation of components". | [6] * * *, SR EN ISO 1167-4:2008, "Thermoplastics pipes, fittings and assemblies for the conveyance of fluids - Determination of the resistance to internal pressure - Part 4: Preparation of assemblies". | [7] * * *, "Friatherm – Hot and Cold Pipework System. Technical Data". | [8] * * *, ISO 15877-1:2009, "Plastics piping systems for hot and cold water installations. Chlorinated polyvinyl chloride) (PVC-C). Part 1: General". | [9] * * *, ISO 15877-2:2009, "Plastics piping systems for hot and cold water installations. Chlorinated polyvinyl chloride (PVC-C). Part 2: Pipes". | [10] * * *, SR EN ISO 1183-2:2005, "Materiale plastice. Metode de determinare a densităţii materialelor plastice nealveolare. Partea 2: Metoda coloanei cu gradient de densitate". |