Hydraulics of PVC Pipe

IPEX USA LLC.
Tol l Free: (800) 463-9572
ipexna.com

One of the key performance advantages of a PVC piping system is its glass-like internal finish. This hydraulically smooth surface means that PVC systems can cut friction losses and increase flows for a given pipe size. These hydraulic benefits apply to both pressure and gravity flow applications, and have been proven through extensive research and field testing.

Fluid will flow over a smooth surface more easily than it will over a rough or uneven surface. Since the inside finish of various pipe materials have varying degrees of roughness, flow characteristics of each pipe material differ significantly. This article compares hydraulic characteristics of PVC with those of older technology materials, in both pressure and drainage applications.

Pressure Systems: The Hazen-Williams Equation

The Hazen-Williams equation is one of the most commonly used methods of calculating fluid flow in pressure conduits. Friction loss (h_f) may be calculated using the formula below:

$$f = 0.2083 \times \left(\frac{100}{C}\right)^{1.85} \times \frac{Q^{1.85}}{D_I^{4.86}}$$

where:

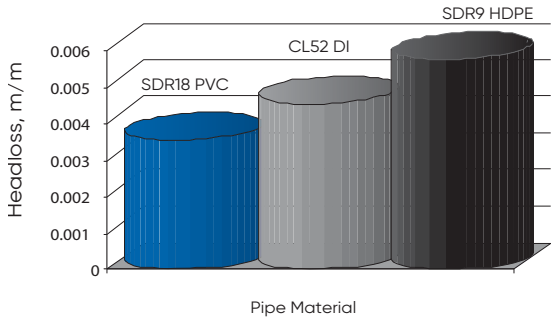
- f = friction loss (ft. of H_2O/100 ft.)
- Q = flow rate (gpm)
- D_I = pipe inside diameter (in.)
- C = flow coefficient (for PVC, C = 150)

While experimental data has shown that the 'C' factor can be as high as 155-165 for both new and used PVC pipe, the AWWA M23 Manual recommends a 'C' factor of 150 for PVC.[1]

Table 1. Hazen-Williams flow coefficient, 'C'[2]

Material	'C' Factor
Plastic (PVC & HDPE)	150
Iron (new)	130
Iron (20 yrs old)	100

Headloss - 200 mm Pipe at 25 L/s



The 'C' factors obviously have a significant effect on flow rates. Comparing various materials it can be seen that PVC pipe has a much lower headloss at any given flow than other common piping materials.

Class 52 DI has a slightly higher inside diameter than SDR18 PVC, but its low long-term 'C' factor of 100 or less results in poor flow characteristics.

SDR9 HDPE has a high 'C' factor of 150, however it has a much thicker pipe wall and thus has a much lower inside diameter than PVC SDR18.

[1] American Water Works Association, AWWA Manual M23, 2nd Edition – PVC Pipe – Design and Installation, 2002
[2] "Pump Handbook – Third Edition" – Karassik, Messina, Cooper & Heald, pp. 8.36
[3] Uni-Bell PVC Pipe Association Handbook of PVC Pipe, Fourth Edition, p.359

Gravity Flow Systems: Manning's Equation

The most common procedure for calculating open channel or partially full pipe flow conditions is to use the Manning Formula below:

$$V = \left(\frac{1.49}{n}\right) R^{0.67} S^{0.5}$$

Where: V = the average velocity at a cross section, ft/sec
R = the hydraulic radius, ft
S = slope, ft/ft
n = the coefficient of roughness

The "n" factor varies both with the degree of roughness of the inside of the pipe, and the flow velocity. Higher flow velocities tend to reduce the "n" factor in sewers as solids deposition and slime build-up on the bottom of the pipe is reduced.

Designing with PVC sewer pipe, an "n" factor of 0.009 is recommended.[3] This is supported by a large number of scientific studies, many of which were carried out on "in service" pipes that had been operating for many years.

The "n" values in these studies were found to range between 0.007 and 0.011. No published study has ever found an "n" value as high as 0.013 for a PVC system in any sewer operation even at minimum velocities of 2 ft/s (0.6 m/s). Please contact us if you wish to review the results of these studies.

Average Values of the Manning Roughness Factor

Material	Manning n
PVC	0.009
Concrete	0.013
Cast Iron	0.015

The relatively low "n" values associated with PVC pipe are a result of various factors:

- Smooth, nonporous inside surface of the pipe
- Longer laying lengths (i.e. fewer joints)
- Lower profile gap at the joints
- Chemical and abrasion resistance of the material

By designing PVC sewer systems with the scientifically appropriate Manning value of 0.009, sewers can be installed at tighter grades, thus reducing excavation costs and disturbance. In some cases, it may even be possible to downsize the pipe while maintaining a particular flow capacity.

IPEX by aliaxis