

PVC VS POLYETHYLENE (HDPE) PRESSURE PIPE

OCCASIONAL SURGE PRESSURE: PVC PIPE OUTPERFORMS HDPE

The Plastics Pipe Institute (PPI), the trade association for HDPE pipe, has developed a software package for determining surge pressure which includes a comparison to PVC pipe. The approach used by PPI misrepresents PVC pipe's performance. With the correct methodology, using *constant flow volume* instead of *constant flow velocity*, PVC clearly outperforms HDPE pipe.

Example 1: AWWA C905-10 PVC Pipe Design

The design example in Appendix B of the AWWA C905 standard is repeated here for the purpose of our discussion (minus the cyclic surge portion, which is generally not appropriate for municipal water systems, but would be applicable for sewer forcemains).

Project conditions:

- Pipe diameter: 18 in.
- Operating (or static) pressure – called “working pressure” (WP) in the standard = 160 psi
- Occasional surge: defined in C905 as “surge pressure caused by emergency operations, usually caused by a malfunction” – for this design, occasional surge pressure is based on an instantaneous change in flow velocity = 7.0 fps
- For this velocity, the flow volume is about 5140 gpm

Pipe selection:

- Try DR18 Pressure Class 235 psi

Analysis:

- Design Check #1: Long-term pressure
 - Working pressure = 160 psi
 - Allowable long-term pressure = Pressure Class = 235 psi
 - PC 235 psi > WP = 160 psi *DR18 pipe is okay for long-term pressure*
- Design Check #2: Short-term pressure
 - Occasional surge pressure from a 1 fps instantaneous flow change = 17.4 psi (based on a modulus of elasticity $E = 400,000$ psi for a DR18 wall thickness of 1.083 inch)
 - Velocity change = 7.0 fps
 - Anticipated occasional surge pressure = $17.4 \times 7.0 = 122$ psi
 - Total pressure = 160 psi + 122 psi = 282 psi
 - Allowable short-term rating (STR) = $1.6 \times$ Pressure Class = 376 psi
 - STR 376 psi > Total pressure 282 psi *DR18 okay for short-term pressure*

Summary: DR18 PVC pipe has sufficient capacity for both long-term and short-term pressures.

For comparison purposes, the same project conditions are used for HDPE pipe (see next page).

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Example 2: AWWA C906-07 HDPE Pipe Design

Pipe selection:

- Try DR7.3 Pressure Class 250 psi

Analysis:

- Design Check #1: Long-term pressure
 - Working pressure = 160 psi
 - Allowable long-term pressure = Pressure Class = 250 psi
 - PC 250 psi > WP 160 psi *DR7.3 okay for long-term pressure*
- Design Check #2: Short-term pressure
 - Occasional surge pressure from 1 fps instantaneous flow change = 17.2 psi (Source: calculated using $E = 130,000$ psi and wall thickness = 2.671 inches)
 - Using the same flow volume of 5140 gpm as in the PVC pipe example above, the velocity in the HDPE pipe is 10.5 fps (The velocity is much faster than in the PVC pipe because HDPE pipe's much thicker walls result in a smaller flow area)
 - Anticipated occasional surge pressure = $17.2 \times 10.5 = 181$ psi
 - Total pressure = 160 psi + 181 psi = 341 psi
 - Allowable short-term rating (STR) = $2.0 \times$ Pressure Class = 500 psi
 - STR 500 psi > Total pressure 341 psi *DR7.3 okay for short-term pressure*

Summary: DR7.3 HDPE okay for long-term pressure and for short-term pressure.

SUMMARY TABLE

			Long-Term Check			Short-Term Check		
Material	DR	Pressure Class	Required	Provided	Okay?	Required	Provided	Okay?
PVC	DR 18	PC 235	160	235	Yes	282	376	Yes
HDPE	DR 7.3	PC 250	160	250	Yes	341	500	Yes

PVC Pressure Class 235 pipe and HDPE Pressure Class 250 psi are okay for the given conditions. However, the higher velocity in the HDPE pipe has resulted in a higher surge pressure than for the PVC pipe.

Key Points of the Comparison:

- The project conditions came directly from Appendix B of the AWWA C905-10 standard. The 7 fps velocity is conservative for typical operations and was chosen as an example of fire flow.
- The HDPE pipe is not overstressed, but the system has been subjected to a pressure spike of almost 350 psi, perhaps enough to cause damage to non-pipe components such as fittings or valves. In contrast, the total pressure in the PVC pipe system for the same conditions was only 282 psi - more than 20% lower than for the HDPE system.
- This engineering analysis shows that HDPE pipe does not have an occasional surge pressure advantage over PVC pipe. Because the HDPE material has 60% lower pressure capacity, much thicker walls are required. These thicker walls result in higher surge pressures compared to PVC.

References: AWWA Standards C905-10 and C906-07; Handbook of PVC Pipe