PVC VS HDPE PRESSURE PIPE FOR WATER MAINS

A COMPARISON BASED ON SIXTY YEARS OF WATERWORKS EXPERIENCE

In North America today, new installations of drinking-water distribution systems are primarily PVC pipe. More than one million miles of PVC pressure pipe are currently in service, including hundreds of millions of gasketed joints and tens of millions of taps. PVC pipe has now been in service for more than sixty years and is used in over 40,000 municipalities. PVC users are enjoying the benefits of an easy-to-install, long-life, maintenance-free product which meets all North American health and safety regulations.

In addition, the longevity and sustainability of PVC pipe are unsurpassed:

- PVC pipe's life expectancy is 100+ years (AWWARF / Utah State University studies).
- PVC pipe's long life results in favorable life-cycle costs.
- PVC pipes provide a larger flow area, thereby reducing pumping costs.
- PVC pipes are not subject to oxidation of the inside surface caused by chemicals used for both initial water main disinfection and in-service disinfection.

Drawbacks to the Use of HDPE Pressure Pipe

The first ASTM standards for PVC and HDPE pressure pipe were written in the early 1960s. During the intervening fifty years, PVC water pipe has seen a period of sustained growth, while HDPE water pipe has been primarily limited to trenchless applications. Some of the major drawbacks with HDPE's use for water mains are:

- The lower strength of HDPE compared to PVC requires HDPE to have pipe walls that are 2½ times as thick in order to provide equivalent pipe strength and safety factor. This adds significantly to the resources consumed and the cost of the pipe and appurtenances.
- HDPE pipe does not have a bell-and-spigot joint option. This represents a disadvantage for open-cut installation and for system maintenance.
- The thicker walls of HDPE result in reduced flow area. The higher velocities needed to provide the same gpm result in increased friction loss and additional pumping costs. Alternatively, HDPE pipes would need to be up-sized to match the inside diameter of PVC pipe.
- HDPE pipes may be susceptible to oxidative degradation when exposed to common water disinfectants.
- HDPE pipes are susceptible to permeation in contaminated soils, even when contaminant concentrations are low (AWWARF study "Impact of Hydrocarbons on PE/PVC Pipe and Gaskets")

Summary: the costs for a polyethylene water pipeline are higher throughout its life.

HDPE Decreases Safety Factor

The HDPE industry has reduced the safety factor for its new PE4710 pipe products. The traditional safety factor of 2.0 has been reduced to 1.6 in HDPE ASTM and AWWA standards. A simple calculation proves the point:

- For any structure, the Safety Factor = Material Strength / Design Stress
- For new and old HDPE materials, the Material Strength (called "HDB") = 1600 psi
- For the old HDPE materials, Design Stress = 800 psi
  - Safety Factor = 1600 psi / 800 psi = 2.0
- For the new PE4710 material, Design Stress = 1000 psi
  - Safety Factor = 1600 psi / 1000 psi = 1.6

This concept is very simple. If two materials have the same strength, the only way to increase the design stress is to decrease the safety factor. This practice represents increased risks and shorter life-expectancy for any material, but especially for a new and unproven material in a 100-year life application. On the reverse side of this page is information about the differences between PVC and HDPE materials used for pressure pipe.

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PVC vs HDPE Pressure Pipe Comparison Sheet

Item	PVC Pipe	HDPE Pipe	Comments
ASTM Pressure Pipe Standards (Date of First Publication)	ASTM D1785 (1960) ASTM D2241 (1964)	ASTM D2239 (1964) ASTM D3035 (1972) ASTM F714 (1981)	Using a safety factor of 2.0, PVC is available in ASTM Pressure Ratings up to 315 psi (DR13.5) and HDPE up to 254 psi (DR7.3).
AWWA Pressure Pipe Standards (Date of First Publication)	AWWA C900 (1975) AWWA C905 (1988)	AWWA C906 (1990)	AWWA C900 preceded C906 by 15 years. Using a safety factor of 2.0, PVC is available in AWWA Pressure Classes up to 305 psi (DR14) and HDPE up to 254 psi (DR7.3).
Long-term Sustained Strength (Hydrostatic Design Basis @ 73F)	4,000 psi	1,600 psi for PE3408 1,600 psi for PE3608 1,600 psi for PE4710	PVC's HDB is 2.5 times the HDB of HDPE. The new PE4710 has the same HDB as the older PE3608 and PE3408 materials.
Tensile Strength	7,000 psi	3,000 psi for PE3408 3,000 psi for PE3608 3,500 psi for PE4710	PVC has a much higher tensile strength. The new HDPE has a slightly higher short-term tensile strength than the earlier materials.
Modulus of Elasticity--Short-Term	400,000 psi	110,000 psi for PE3408 110,000 psi for PE3608 110,000 psi for PE4710	PVC has a much higher modulus. The new HDPE has the same modulus as the older materials. Higher modulus materials hold grade better and provide greater resistance to soil loading.
Specific Gravity (Density))	1.40	0.94 for PE3408 0.94 for PE3608 0.95 for PE4710	HDPE floats, even when filled with water.
AWWA Safety Factor for Transmission/ Distribution Pipe	2.0	2.0 for PE3408 2.0 for PE3608 1.6 for PE4710	PE4710 higher pressure classes are not due to higher long-term sustained strength (HDB), but instead to a lower safety factor (equal to higher design factor).
ASTM Safety Factor for Transmission/ Distribution Pipe	2.0	2.0 for PE3408 2.0 for PE3608 1.6 for PE4710	PE4710 higher pressure ratings are not due to higher long-term sustained strength (HDB), but instead to a lower safety factor (equal to higher design factor).
Coefficient of Linear Expansion	0.3×10^{-4} in/in/F	1.2×10^{-4} in/in/F	HDPE expands and contracts four times as much as PVC, which can cause HDPE to develop leaks with shallow-socketed MJ fittings.
Joints	Gasket - Restrained Joint Gasket - Unrestrained Joint Butt-Fused	Butt-Fused	PVC and HDPE joints are both watertight.
Oxidative Degradation Due to Disinfection (Initial and In-Service)	High Resistance	Susceptible	Both the new PE4710 and the older materials have low resistance to oxidation. The HDPE industry is developing a classification system for new PE4710 materials, but the newly published AWWA C906-15 does not include any provisions to prevent oxidative failure.
Permeation by Hydrocarbons	High Resistance	Permeable	HDPE pipe has low resistance to permeation.
Sustainability	Less embodied energy. Lighter to transport. Lower pumping costs.	Higher embodied energy. Heavier to transport. Higher pumping costs.	PVC pipe is the more sustainable product.
Longevity	100+ year life expectancy	PE4710 -- new product -- unknown life expectancy	PVC pipe has a long history of success. PE4710 pipe is a new product with unknown longevity.

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