Interior Diameter Matching (aka ID Matching)

Background Competitive influences have done an excellent job pushing water pipeline projects to go with a larger nominal HDPE OD than is necessary. They say that utilities need to match ID's and pressure class so that pipe pressure capabilities and pipe IDs can "match up." The net result of this platitude is that a larger diameter HDPE can be more expensive than the smaller diameter PVC, thereby making the PVC pipe more price competitive. This issue effectively knocked HDPE out of contention when the contractor has control over pipe type on a given project. In 2022, this is not the case because HDPE is typically less expensive than PVC given PVC availability issues.

For example, on a 6" line that can go PVC C900 PC 235psi DR 18 6.09" ID, many specifications require a 8" DR 11 DIPS 7.31"ID PE4710 vs the 6" HDPE pipe. A 6" DR 11 DIPS 5.57"ID PE4710 is ½" smaller than the PVC so it makes sense that they can argue as described. The argument is primarily a flow argument as design engineers will presumably not have to do flow calculations if the ID's match. They also insinuate that the PVC C900 DR 18 is more pressure capable that an HDPE 4710 DR17. While making sense on the surface, *both* of these are arguments are hollow once facts are studied.

ID Match The interior diameter match argument advanced by legacy pipe systems, disregards flow volume, flow velocity and the ability of a pressure pipe system to accommodate different pipe materials, different C factors and different flow velocities. When, in fact, these systems accommodate these factors constantly. Municipal distribution systems operate with pipes of various types and various diameters and do not operate with a perfect diameter distribution across the system. Diameters vary while pressure remains relatively constant throughout the system absence surge and breaks etc. When a smaller diameter pipe is asked to carry water from a larger diameter pipe it is connected to, the velocity will increase during the given smaller diameter run. It is like a garden hose when you put your thumb over it. The flow continues, but at a greater velocity, that is why you can shoot water farther when you use your thumb. The same is true in a distribution system. That smaller ID produces a greater velocity for the given run and exits the smaller diameter/greater velocity pipe section at a greater velocity than a larger ID would carry it. If your pipe system cannot handle the marginal velocity increases that system is in need of repair. Higher pressures in a system overall can be a concern, but the velocity dissipates relatively quickly. Utilities that have a water main break issue, find relief when they lower system pressure.

Pressure Class The pressure class argument is complex given the calculations are dynamic given certain scenarios. That same PVC C900 DR 18 6.09" ID pipe has an advertised pressure class of 235 psi. But that 235psi is a pressure class with no flow. Once you add flow which is the whole purpose of water pipe, the pressure capability is immediately reduced to 125 psi at 5' per second. You must also add surge demand so the PVC pressure capability is further reduced. Whereas, HDPE has a much easier to understand and implement pressure class system. That 8" DR11 has a working pressure capability of 200 PSI and that is with flow AND it will take occasional surges to 400 psi. So, the HDPE is actually quite a bit more pressure capable than its PVC counterpart.

Engineering View The basic hydraulics equation Volume = Velocity multiplied by Area is understood for simple systems. When a smaller pipe ID is provided the Velocity increases. These higher velocities can be easily accommodated by HDPE because of its material properties, notably its viscoelasticity and apparent Modulus of Elasticity. From a technical standpoint, simply stating "a smaller Area (ID) yields lower Volume (flow) conditions" does not accurately portray what actually occurs within the pipeline.

The same Volume (flow) can be achieved with a smaller Area (ID) and higher Velocities. To understand the effect on a pipeline system by achieving higher Volume with lower Area and higher Velocities, effort should be made to understand the potential for Pressure Surge due to these Velocity changes.

For the evaluation of these flow velocities, pressure surges and their relation to pipe material types for DIP, PVC and HDPE the Alliance for PE Pipe looks to the May 2002 American Water Works Services, Co. document "*EPA Office of Water (4601M) Deteriorating Buried Infrastructure Management Challenges and Strategies*" for some guidance. We paraphrase this reference specific to this project details below (American Water Works Service, 2002.)

The surge potential for 8" pipe experiencing 100 psi operating pressure for all three pipe materials (DIP, PVC and HDPE) vary widely. DIP allows for 100 psi of pressure surge. For 14" and larger pipe, PVC does not allow for pressure surge. HDPE allows for 50-100% of the pipe pressure rating. When calculating the hydraulic transients using the equation provided in the technical study, DIP provides a 53.6 psi increase per 1 ft/sec change in velocity, PVC provides 17.6 psi increase per 1 ft/sec change in velocity and HDPE provides 9.8 psi increase per 1 ft/sec change in velocity. Therefore, PVC provides a pressure increase of **1.80 times higher than HDPE** while DIP provides a pressure increase of **5.5 times higher than HDPE** for the ***same change in velocity.*** The 2002 EPA technical memo also evaluated an earlier generation of HDPE so the recent HDPE offerings are vastly superior to the statistics shown in the EPA memo (American Water Works Service, 2002.)

Exhibit No. 11b

Comparison of Distribution Size Pipe Materials - Pipe Properties

Pipe Property	DI	PVC	HDPE
Trade organization	DIPRA	Uni-Bell	PPI
AWWA designation	C151	C900 and C905	C906
Diameter range	3" - 64"	4" - 12" (C900) 14" - 48" (C905)	4" - 63"
Pressure range	350 psi	100 psi - 200 psi	50 psi - 255 psi
ID range (8")	8.425"	7.76" - 8.33"	6.918" - 8.136"
Wall thickness range (8")	0.25"	0.362" - 0.646"	0.265" - 1.182"
Weight range (8")	21.1 lbs/ft	6.6 lbs/ft - 11.4 lbs/ft	5.1 lbs/ft - 11.06 lbs/ft
OD nominal (8")	9.05"	9.05"	9.05"
Buoyant (8" 100 psi)	No	Yes	Yes
Surge allowance	100 psi	125 - 200% of press. rating None for 14" - 48" (C905)	50 - 100% of press. rating
Surge potential (8" 100 psi)	53.6 psi per 1 ft/sec <V	17.6 psi per 1 ft/sec <V	9.8 psi per 1 ft/sec <V

(Exhibit No. 11b provided by American Water Works Service, 2002.)

For HDPE pipe, the surge allowance is 1.5 times the operating pressure for recurring surge and 2 times the operating pressure for occasional surge. Without knowing the operating pressure of this proposed force main, we assume an actual operating pressure of 70 psi maximum. For operating conditions in the 55-70 psi range, the DR17 HDPE pipe will provide an **2.68 factor of safety** for the actual operating pressure conditions for recurring surge and **3.6 times factor of safety** the actual operating pressure for occasional surge. The 16" DR25 PVC pipe has a pressure rating of 165 psi but doesn't provide any additional protection for surge so the PVC pipe provides a 2.3 factor of safety for the assumed 70 psi operating pressure, ***less than that provide by DR17 HDPE***.

Conclusion Installing HDPE pipe in a municipal water system does require all pipe diameters to be the same diameter as other pipe materials. HDPE is designed to carry water at greater velocities than other pipes without damage to pipe. It is our opinion that the pipe will operate safely and provide suitable flow at higher velocities with less pressure surge than the PVC and DIP counterparts over the full 100+ year life span of operation, even at the DR17 rating.

Resources

JM Eagle Brute C900 PVC pipe chart, jmeagle.com https://www.jmeagle.com/sites/default/files/BlueBrute_web.pdf
WL Plastics https://wlplastics.com/wp-content/uploads/Docs/WL104-0117%20DIPS%20Pipe.pdf
PPI Pace online calculator http://ppipace.com
US EPA, Office of Water (4601M), Office of Ground Water and Drinking water, Distribution System Issue Paper, Deteriorating Buried Infrastructure Management Challenges and Strategies, May 2002. Prepared by: American Water Works Service Co., Inc. Engineering Department.