

# PVC vs DUCTILE IRON (DI) PIPE

## OCCASIONAL SURGE PRESSURE: PVC OUTPERFORMS DI

The Ductile Iron Pipe Research Association (DIPRA), the trade association for iron piping, has long maintained that PVC pipe's lower pressure rating is justification for limiting the use of PVC. Furthermore, some utilities believe that the AWWA PVC pipe standards require de-rating PVC pipe significantly below its pressure class. Using a design example and comparison to DI PC 350, it is clear that PVC outperforms DI.

### Example 1: AWWA C900-07 PVC Pipe Design

The design example in Appendix B of the AWWA C900 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: 8 in.
- Operating (or static) pressure – called “working pressure” (WP) in the standard = 160 psi
- Occasional surge: defined in C900 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 1110 gpm.

#### Pipe selection:

- DR18 Pressure Class 235 psi

#### Analysis:

- Design Check #1: Long-term pressure
  - o Working pressure = 160 psi
  - o Allowable long-term pressure = Pressure Class = 235 psi
  - o PC 235 psi > WP = 160 psi *DR18 pipe okay for long-term pressure*
- Design Check #2: Short-term pressure
  - o 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 0.503 inch)
  - o Velocity change = 7.0 fps
  - o Anticipated occasional surge pressure =  $17.4 \times 7.0 = 122$  psi
  - o Total pressure = 160 psi + 122 psi = 282 psi
  - o Allowable short-term rating (STR) =  $1.6 \times$  Pressure Class = 376 psi
  - o STR 376 psi > Total pressure 282 psi
  - o *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 ductile iron pipe (see next page).**

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### Example 2: AWWA C150-08 Ductile Iron Pipe Design

#### Pipe selection:

- Pressure Class 350 psi

#### Analysis:

- Design Check #1: Long-term pressure
  - Working pressure = 160 psi
  - Surge allowance included = 100 psi (equivalent to 2 fps velocity change)
  - PC350 wall thickness is greater than required (for pressure design, service allowance, & casting tolerance)
  - Allowable long-term pressure = Pressure Class = 350 psi
  - PC 350 psi > WP 160 psi *PC350 pipe okay for long-term pressure*
- Design Check #2: Short-term pressure
  - Occasional surge pressure from 1 fps instantaneous flow change = 52.4 psi (Source: calculated using  $E = 24,000,000$  psi and wall thickness 0.25 inch)
  - Using same flow volume of 1110 gpm as in the PVC pipe example, velocity in the DI pipe is 6.4 fps. (Source: calculated using wall thickness of 0.250 inch iron plus 0.063 inch cement-mortar lining) Note: velocity is lower than for PVC because DI pipe's thinner walls result in a larger flow area.
  - Anticipated occasional surge pressure =  $52.4 \times 6.4 = 335$  psi
  - Total pressure = 160 psi + 335 psi = 495 psi
  - Allowable short-term pressure = Pressure Class + 100 psi surge allowance = 450 psi
  - Allowable short-term pressure = 450 psi << Total pressure 495 psi  
*PC 350 psi pipe is NOT ADEQUATE for short-term pressure – wall thickness would need to be increased.*

**Summary: PC350 psi ductile iron pipe is okay for long-term pressure, but not for short-term pressure.**

#### SUMMARY TABLE

Material	DR	Pressure Class	Long-Term Check			Short-Term Check		
			Required	Provided	Okay?	Required	Provided	Okay?
PVC	DR 18	PC 235	160	235	Yes	282	376	Yes
DI	NA	PC 350	160	350	Yes	495	450	No

*Ductile Iron Pressure Class 350 pipe is NOT adequate for the design conditions.*

#### Key Points of the Comparison

- Project conditions came directly from Appendix B of the AWWA C900-07 standard. The 7 fps velocity is conservative for typical operations and was chosen as an example of fire flow.
- “Strong” is not always the bottom line. DI’s high modulus of elasticity causes large surges to develop in response to a change in velocity. In this case, the high modulus of elasticity (which is touted as an advantage by DI) is actually a disadvantage that needs to be appropriately considered by the design engineer.
- This comparison shows that PC350 DI pipe’s capacity was exceeded, but PC235 PVC pipe’s was not. More importantly, for DI the system would be subjected to a pressure spike of 495 psi (enough to cause damage to valves, fittings, or service lines). In contrast, the total pressure in the PVC pipe system for the same conditions was only 282 psi (DI about 75% higher than PVC).
- This analysis shows that the perception of PVC pipe “weakness” is false and actually proves the opposite.

References: AWWA Standards C900-07 and C150-08; *Handbook of PVC Pipe*