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Materials & Products – Water Pipes
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MAXIMUM WATER VELOCITY IN CEMENT MORTAR LINED PIPELINES

This document considers maximum water velocities for Tyco Water's cement mortar lined (CML) pipelines conveying water that contains negligible quantities of particulate material. The limit of suitability depends on a number of factors, including:

1. Quality of the lining – density/compaction and degree of cure
2. Hydraulic smoothness – internal surface roughness
3. Abrupt flow profile changes - bore variations, fittings, joints, irregularities
4. Operating range - flow extremes, surge effects, cavitation, etc
5. Service life required – for both the internal lining and the pipe

Other factors may contribute to the overall lining performance and may need to be considered in conjunction with these factors.

In most water pipeline applications the principal constraint on water velocity is imposed by cavitation and associated "erosion". These effects occur through the formation of vapour bubbles when the local absolute pressure falls to the water vapour pressure at ambient temperature.

The localised pressure will fall as the streamline velocity increases, for example in response to changing the geometry of flow boundaries. Typical geometry changes include high curvature fittings, boundary discontinuities, and changes in cross section or direction. The localised pressure can also fall in transient conditions associated with water hammer.

The vapour bubbles formed flow downstream, and collapse in regions of higher pressure. Extreme pressures are generated as this the vapour implodes. If this occurs adjacent to boundary surfaces, pitting, erosion, or other damage may result.

GUIDELINE MAXIMUM VELOCITY

The following sources provide information on the subject:

1. Neville (Ref. 1) states that cavitation damage can occur *"in closed conduits even at 8 m/s".*
2. Perkins (Ref. 2) states *"At one time it was thought that a maximum velocity of flow of approximately 2.5 - 3 m/s should not be exceeded, otherwise the invert of concrete pipes and the inverts in man - holes would be worn away. However experience over many years has shown that this will not occur except under very exceptional circumstances".*

3. AWWA C205 (Ref. 3) states, *"When the flow velocity exceeds approximately 6.1m/s special studies may be required to determine the suitability of this type of lining material"*. Contact with the AWWA committee indicates the evidence to support this information is both vague and lost in time.
4. For ductile iron pipe the DIPRA (Ductile Iron Pipe Research Association, USA – Ref. 4) provides the following information (with conversions made from ft/s to m/s): *"The abrasive characteristics of potable water are slight since this type of water contains limited amounts of solids and normally has velocities ranging from 0.6 to 3 m/s. Cement-mortar-lined pipes in drinking water service for more than 77 years show no evidence of internal abrasion. In the absence of long term laboratory testing, the available literature lists satisfactory performance for cement/cement-mortar linings for potable water with velocities of 6.1 to 12.2 m/s. However, one has to realize that all installations do not perform the same. Different installations will have different configurations, bend angles, flow characteristics, amount and shape of solids content in the water, etc. Using a velocity of 6.1 m/s and applying a safety factor of 2, remembering that the kinetic energy of a particle is a function of the square of the velocity, will result in a velocity of 4.3 m/s. This should normally be a good conservative maximum design velocity for continuous service for most applications."*

A number of years ago Tyco Water subjected DN100 ductile iron (DI) CML pipes to a water velocity of 3 m/s for over a year. There was no evident wear of exposed cement mortar linings during this exposure.

Based on the above, and assuming there are no exceptional circumstances or factors to be considered, a limit of 4m/s was set for Tyco Water's CML steel and DI pipelines.

To further explore the limits for CML a test program was undertaken whereby CML straight steel pipe sections containing a gap (that occurs when the internal joint is not reinstated), and 90º steel bends (with maximum mitres of 22 ½º) were subjected to flow velocities of 6m/s, 6.6m/s, 7m/s, and 8.5m/s for a total period of approx. 6 months. The results from that work are reported in TWT 14944 (24/9/2009).

That work has led to the following new recommendations for the use of CML in steel and DI pipelines:

1. For Tyco Water's standard ductile iron and steel pipelines (with CML steps at joints), with and without seal coat, continuous operation at velocities up to 6 m/s, with short term excursions up to 7 m/s is acceptable.
2. For Tyco Water's ductile iron and steel pipelines (with CML steps at joints) without a seal coat, continuous operation at velocities up to 7 m/s, with short term excursions up to 8 m/s is acceptable, provided all bends are lined with Tyco Water's Eziline.

Note these recommendations only relate to water pipelines that contain negligible quantities of particulate material. Pipelines conveying particulate material are assessed on an individual basis.

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REFERENCES

1. Neville, AM. *"Properties of Concrete"*, Pitman, London, 1977, pp 444-445.
2. Perkins, PH. *"The durability of Portland cement concrete in underground pipelines"*, BHRA Conference on Internal and External Protection of Pipes, Sept. 1977, Paper G-1.
3. American Water Works Standard AWWA C205 – 2007, *"Cement-Mortar Protective Lining & Coating for Steel Water Pipes–100mm & larger–shop applied"*
4. Ductile Iron Pipe Research Association (DIPRA*), "Cement mortar linings for Ductile Iron Pipe".* Available from DIRA website: *http://www.dipra.org/pdf/cementMortarLinings.pdf*