



COMMON FAILURE MODES IN PRESSURISED PIPELINE SYSTEMS

The following tables summarise the most common types of field failure modes in water supply mains and pressure sewers and associated fittings and appurtenances. The table has been developed specifically for Australian pipes, environments and operating conditions and is designed to standardise the reporting of field data for entry into Water Agency failure databases.

Failure Mode	SCL	DICL	PVC	PE	CICL	AC	GRP	Copper	Comments
PIPES									
Piece blown Out		✓	✓	✓	✓	✓	✓		➤ Common in cast iron pipes
Perforation	✓	✓	✓	✓	✓			✓	➤ Perforations in PVC and PE pipe are usually small splits
Broken back (Circumferential break)					✓	✓		✓	➤ Common in cast iron pipes
Longitudinal split			✓		✓	✓			➤ Longitudinal fractures are also possible in PE pipe but are very uncommon
Pipe wall rupture/tear	✓						✓	✓	➤ Ductile pipe wall ruptures are also possible in DICL pipe but are very uncommon
Associated with or during tapping		✓	✓						<ul style="list-style-type: none"> ➤ DICL pipelines experienced localised corrosion adjacent to uninsulated copper property service connection points ➤ PVC-U pipelines have experienced failures during tapping operations under pressure where the pipe fractures from the tapped hole
Leaking joint	✓	✓	✓	✓	✓	✓	✓	✓	➤ Pipelines with non-elastomeric seal joints e.g. lead, lead compound are more likely to experience joint leaks. Flange gaskets are also prone to leakage especially at higher operating pressures
Third-party damage	✓	✓	✓	✓	✓	✓	✓	✓	Third party damage should not be considered a pipe failure as such.

FITTINGS AND OTHER APPURTENANCES									
Failure Mode	Fittings	Mechanical couplings - Gibault	Stop valves - Gate, butterfly etc	Air valves	Hydrants	Plastic bodied ball valves	Metal bodied ball Valves	Tapping bands	Tapping ferrules
Leak at seal or gasket	✓	✓	✓	✓	✓	✓		✓	
Split / Cracked body						✓		✓	
Perforation	✓	✓							
Bolt/nut failure*		✓						✓	
Spindle failure*			✓						✓
Coating failure	✓		✓	✓	✓				
Seized ball/mushroom				✓	✓		✓		
Jumper valve failure*									✓
Internal corrosion	✓		✓	✓	✓		✓		✓
Degradation of material apart from corrosion and coating failure ²	✓	✓	✓	✓	✓	✓	✓	✓	✓
Failure to operate ³			✓	✓	✓				

NOTES

✓ Represents likely/common failure mode for this product

1 Failure may include fracture, distortion, corrosion, erosion and other mechanisms

2 Often involves degradation and/or attack of plastic, elastomeric or other non-metallic components

3 Failure to operate may be the result of one or more of the above failure mechanisms and may lead to pipe failure

Predominant Pipe Materials

SCL–Steel Cement (Mortar) Lined. Highly ductile material, usually coated externally and internally. Pitting and perforation is the most common failure where coating has been breached/damaged. Where extensive wall thinning has occurred ductile rupture and tearing of the wall are possible. This category is also applicable to “wrought” iron pipe, which is often used to describe riveted or locking bar steel pipe. Prone to leaking joints prior to use of elastomeric seals (rubber rings).

DICL–Ductile Iron Cement (Mortar) Lined. Ductile material lined internally and often externally sleeved with loose fit polyethylene, behaves mechanically in a similar manner to steel pipe. Most failures are associated with corrosion as a result of coating system damage and/or galvanic corrosion associated with copper property (house) service connections.

PVC–Polyvinyl Chloride. Polymeric material not affected by corrosion but often fails in a brittle manner. Failures often associated with mechanical damage, point loadings induced during construction, material/manufacturing defects or during under pressure tapping operations. At this stage there is no differentiation in terms of failure modes for PVC-U, PVC-M and PVC-O.

PE–Polyethylene. Polymeric material, relatively new to the water reticulation market in Australia. Failures to date have mainly been associated with butt welded joints, electrofusion joints and fitting problems.











CICL–Cast Iron Cement (Mortar) Lined. Brittle material lined internally and externally protected from corrosion by bitumen coatings, behaves mechanically like all brittle materials with catastrophic failures common. Most failures are associated with corrosion by contact with the water internally which occurred prior to cement mortar lining of pipes and externally by the soil environment and galvanic corrosion associated with copper property (house) service connections. Prone to leaking joints prior to use of elastomeric seals (rubber rings).

AC–Asbestos Cement pipe is a brittle material that is degraded by contact with the water internally and by the soil environment externally. The rate of degradation is dependant on water quality and soil conditions. Common failures are longitudinal splits associated with general pipe deterioration and broken backs associated with soil loadings or movement

GRP–Glass Reinforced Polyester. A thermoset polymer material and is not affected by corrosion but usually fails by pipe wall rupture. This is commonly associated with damage to the pipe during construction or at tapping points.

Copper: Copper is mainly used as a service pipe from mains-to-meter or for fire services. Copper can suffer from both internal and external corrosion and in some cases, cracking. Cracking is usually circumferential.

Failure Type	Brief Description	Example Photographs of Pipes		
Piece blown Out	Removal of a piece of pipe wall. This form of failure is brittle in nature. Size can vary depending on pipe material but generally greater than 100 cm ² .	 <p>PVC-U</p>	 <p>DICL</p>	
Perforation	Small holes usually less than 10 mm ² . In sewer pipes internal erosion from grit can result in perforation of CML pipes	 <p>DICL</p>	 <p>PE - small split</p>	 <p>PVC (rare) - note water spurt</p>
Broken back (Circumferential break)	A single crack extending part or full way around the pipe circumference	 <p>Cast iron</p>	 <p>Copper</p>	
Longitudinal split	A crack along the pipe axis. The length can vary from a few mm to the full length of the pipe.	 <p>AC</p>	 <p>Cast iron</p>	 <p>PVC</p>

<p>Pipe wall rupture/tear</p>	<p>A rupture to the pipe wall where the material tears and creates an opening in the pipe wall. This form of failure is ductile in nature</p>	 <p>GRP</p>	 <p>Steel</p>	
<p>Associated with or during tapping</p>	<p>Failure of the pipe by a perforation through the wall adjacent to the tapping saddle or a longitudinal split and blow out. The later can occur during the tapping operation.</p>	 <p>Corrosion adjacent brass tapping ferrule</p>	 <p>Blow out at PVC tapping ferrule connection</p>	 <p>Fracture of PVC-U pipe adjacent to tapping point</p>
<p>Leaking joint</p>	<p>Water leakage through the joint. Often a result of a displaced rubber ring joint or debris left in the ring groove during installation of RRJ pipes. Lead jointed steel pipe can also leak.</p>	 <p>Displaced rubber ring in PVC pipe</p>	 <p>Debris under elastomeric joint seal (rubber ring)</p>	
<p>Other examples</p>	 <p>Ductile iron splits - note water spurts</p>	 <p>Copper pipe perforation from external corrosion</p>	 <p>Manufacturing defects in PVC-U pressure pipe</p>	

Fitting	Failure Examples - Photograph and Description			
Tapping ferrule, connection fittings, insulation bushes	 <p data-bbox="392 491 757 549">Leaking joint and erosion of brass fitting</p>	 <p data-bbox="810 491 1207 549">Leaking brass elbows</p>	 <p data-bbox="1229 491 1626 549">Section through leaking brass elbows</p>	
Tapping band and clamps	 <p data-bbox="392 847 779 904">Crevice corrosion under adhesive label on SS clamp</p>	 <p data-bbox="810 847 1184 904">Corrosion of 304 SS repair clamp</p>	 <p data-bbox="1229 847 1626 904">Cast copper alloy stud failures</p>	 <p data-bbox="1648 847 2045 904">Erosion of tapping band subsequent to band casting failure</p>
Valves	 <p data-bbox="392 1203 788 1260">Badly corroded and fractured uncoated valve</p>	 <p data-bbox="810 1203 1207 1260">Badly corroded and fractured uncoated valve</p>	 <p data-bbox="1229 1203 1626 1300">Reflux valve failure due to corrosion of shaft component</p>	

PE Fittings



Split adjacent to butt weld



Leakage from electrofusion fitting

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