Introduction to Leak Testing of Sewers

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1. Background

Leak testing of sewers is an integral part of new asset acceptance as well as ongoing maintenance of the sewer network. Accurate testing is needed to ensure new sewer assets commence service meeting their designed performance objectives while periodic condition assessments are used to identify premature failures and defects and to provide optimum management over the life of these valuable assets.

Figure 1 Common manhole installation, mortar joints

Figure 2 mortar around new cast iron frame

Figure 3 Extreme example of what can happen with soil movement over time due to infiltration and exfiltration leaks in sewers and stormwater systems

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2. Why are Leaks a problem ?

Leaks in sewerage networks are a major and expensive problem for water authorities and residents and can result in underperformance of the sewerage network, an increased whole of life cost (Return on Asset) and significant environmental impacts.

If a new manhole or pipes are not properly sealed, water and soil quickly enters the sewer network through the leaks and makes the new structure more of a liability than an asset and quickly starts to contribute to high operating costs and problems in the network. Ensuring that new assets start their life meeting their design performance criteria and do not leak, along with preventing the early development of leaks will go a long way in ensuring that the new assets have minimal contribution to operational and performance problems. Ongoing testing, inspections and assessments are also critical to ensure that leaks are identified managed before they become a bigger problem.

Leaks can :

1. Allow rainwater and ground water to enter the sewer network causing accelerated degradation of concrete through erosion at cracks, failed joints and other leakage points.
2. Allow ingress of sand, soil and roots into the sewer.
3. Allow foul air emissions from the sewer network resulting in odour complaints.
4. Allow sewage to escape from the sewer network either through the leakage point (known as exfiltration) or through overflows caused by lost capacity (where ground water or rainwater can enter the sewer) or blockages from debris, soil and roots.
5. Cause failure of pipes and structures due to loss of ground material supporting the assets.
6. Result in road or surface damage creating sinkholes. (in worst cases large sink holes can develop threatening buildings, vehicles and damaging other underground assets)

Figure 4 showing a serious large void due to infiltration leak. Image and report posted by ssellen, 10 January 2017, Daily Mercury

3. Where do leaks occur ?

Leaks in sewerage networks occur at a number of locations depending upon many factors including, but not limited to, age, materials and quality of construction, effluent conditions and ground conditions.

Water authorities have requirements for acceptance testing of new sewer manholes and pipes to ensure that joints and materials have been correctly installed and there are no defective components. Where new assets fail the acceptance testing, the defects and leaks must be fixed to ensure that the minimum performance tests are passed. Leaks may occur at joints and pipe connections due to missing or poor joint seals or if a component or seal is damaged prior to, or during installation.

New manholes can be subject to failures soon after completion due to ground vibration and movement during nearby construction activities so, while they may pass initial acceptance testing immediately after installation, when building activities commence, this can result in joint failures as well as damage to adjustment rings, covers and frames.

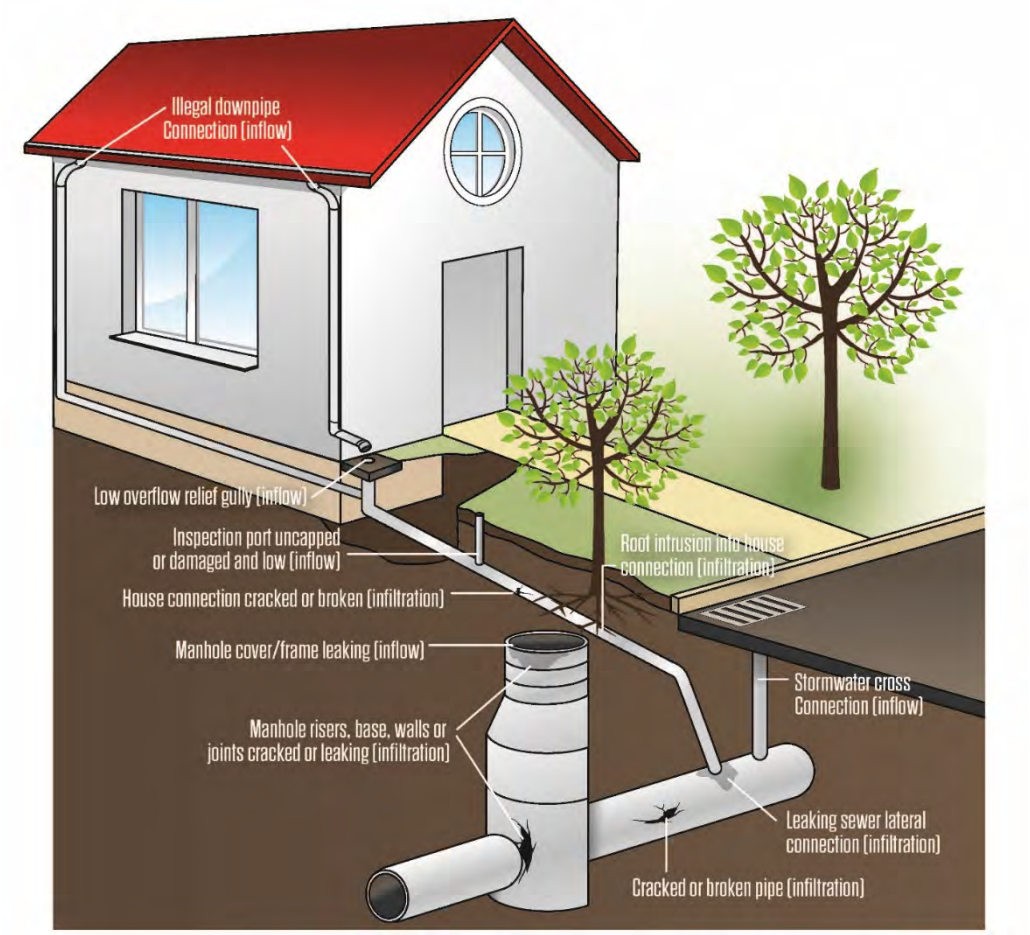

Figure 5 Schematic showing typical sewer components and leakage points

In older catchments, leaks can develop as joints and components fail though ground expansion and contraction caused by cycles of drying and wetting, seasonal heating and cooling (or even freezing), movement of soil caused by ground water movement, corrosion of mortar joints and concrete by hydrogen sulphide as well as tree root damage.

4. Types of leak testing

There are a number of tests that can be conducted depending upon the type of asset (manhole or pipe) and whether the purpose is acceptance testing of a new asset or assessments of the many existing manholes, pump stations and pipes in service. A number of these tests and assessments can also be applied to stormwater pipes.

Typically for acceptance testing of new assets, it is required that either vacuum (or pressure) testing or hydrostatic testing be carried out. These tests are designed to provide a definitive measure of performance that demonstrate that the new assets have been built to an acceptable standard.

Vacuum (or pressure) and hydrostatic testing typically require a measured vacuum (or head of water in the case of hydrostatic testing) to be maintained within specific parameters for a set period of time. The parameters are essentially dependent on the size (diameter and depth) of the manhole or (diameter and length) of pipes being tested with the specific details and requirements outlined in the relevant sewerage code, normally the current Water Services Association of Australia Sewerage Code (or a specific version of this adapted for the water authority), used by the water authority.

Types of testing and assessments include:

- Smoke testing
- Dye testing
- Water testing
- Vacuum and air pressure testing
- Hydrostatic testing
- Flow gauging
- CCTV

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5. Smoke testing

Smoke testing is a simple method used to identify where sewer mains, house connections, maintenance holes, pump stations and other structures have leaks or where illegal connections of stormwater to sewer have been made.

Smoke testing is carried out by both water authorities' in-house teams as well as by external contractors as part of specific investigations or general ongoing inspection programs.

The process of smoke testing is relatively simple and can quickly provide a visual indication of defective or incorrect plumbing, illegally connected downpipes and stormwater connections to the sewer as well as identifying failed joints in MH's, leaking pipes and even poorly fitting pump station covers that may also lead to odour complaints.

Smoke testing process

A nonhazardous, nontoxic white smoke is typically introduced into the sewer through either a sewer manhole or inspection port using a smoke generator and fan arrangement.

Introduction into sewer manholes allows for a large section of the network to be examined while introduction into inspection ports can be done where it is necessary to only inspect an individual property.

Where properties are correctly connected to sewers, smoke will normally only be seen discharging from the roof vent(s) or from gully's where water traps have dried out. If floor wastes within the building have been allowed to dry out, smoke may be found in the building from these points. If this occurs, generally filling the waste traps with water by running taps (or pouring directly into the waste) and opening the windows and doors to the room for a few minutes will allow the smoke to clear away.

Smoke may be seen discharging from downpipes, loose, cracked or broken pipes and fittings, and even from below ground or under paving and concrete slabs.

Smoke may also be seen from manhole covers, under manhole surrounds as well as from under pavement, slabs and other ground sources.

Where leaks and other defects are identified the following information should be recorded:

- the location, address or asset number (in the case of manholes and pump stations),
- a close up photograph of the defect & at least one photo from further away showing the defect point relative to easily identifiable surroundings (with the address or asset number also shown in the photo),
- an electronic record of the observed defect
- the date the defect was observed.
- Where possible, a measure of the size of the area contributing to the defect should also be made to help quantify the problem (eg roof area or ground / road area draining to that point).

Water authorities & councils will normally have a protocol for advising residents of a planned smoke testing program and it is a wise idea to inform local fire brigades of the planned smoke testing program in advance of the works.

What to do with this information

The results of a well conducted smoke testing program will enable the asset owner to plan an effective mitigation program and reduce the impacts and cost of inflow and infiltration including reclaiming network capacity, preventing wet weather overflows, reducing pump station operation and extending the useful asset life.

Outcomes of the smoke testing program can include:

- notification of illegal connections to property owners
- Prioritising leak sources
- Quickly addressing major / critical leakage points
- Medium and long term rehabilitation planning/ program of asset maintenance.

Figure 6 Smoke generator and fan arrangement – positioned ready to introduce smoke into sewer

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Figure 7 Typical commercially available smoke machine for manholes

Figure 8 Schematic showing how smoke is introduced at a manhole and shows leaks from a cracked pipe

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Figure 9 Smoke from a Roof Vent – correctly operating and not a defect

Figure 10 Smoke from the ground, likely a damaged pipe allowing infiltration

Figure 11 Smoke from under the surround of a MH – I/I source

Figure 12 Smoke from cracks in a driveway – I/I source

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6. Dye testing

Dye testing is the introduction of dyed water into the area around a suspect manhole or pump station. Dye testing will help identify specific locations where water can flow in or infiltrate through gaps, cracks and other defects. Dyed water can also be introduced into downpipes of buildings to confirm illegal connections.

Dye testing Process

Dye testing is easily carried out with minimal equipment required. A non hazardous, non toxic, biodegradable coloured dye (Fluorescein) also known as a tracer dye is made up with water and either introduced into stormwater downpipes and fixtures to identify cross connections with sewer services or can be used by flooding the ground around manholes and pump stations to look for inflow and infiltration. Dyes are available in a number of colours but should be highly visible to be most effective.

For properties and roof drainage, dyed water is poured into roof gutters while an observer watches the flow through the property sewer connection. Care must be taken prior to conducting dye testing by confirming if stormwater connection is to rainwater storage tanks and to minimise visual impacts where dyed water may flow into waterways. While the dye used is non toxic, visual impacts may be undesirable.

Dyed water can also be poured into the ground immediately adjacent to a manhole or pump station. The dyed water flows down through the ground and infiltrates the structure at defects allowing quick confirmation of specific defect locations as shown in the following sample images.

Figure 13 Green dye infiltrating through damaged mortar of a brick riser section

Figure 14 Dyed water flowing in through the frame and shaft

Figure 15 Blue dyed water infiltrating through damaged brick riser section

Figure 16 Green dye infiltrating from the wall penetration

Figure 17 Green dye flowing into pump station

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7. Water testing

Water testing is a process for testing sewer manhole joints for a positive seal by applying a head of water pressure and observing both joints and water level to identify leaks. The process can be used for both hard and soft ground areas and is typically used to inspect the upper sections of a manhole. Water testing can also be done following repair of manholes with internal seals or coatings to confirm correct installation.

Figure 18 Ground around the MH is saturated and joints observed for seal

Figure 19 Water is introduced into the space around the MH on a hard stand and observation made to determine quality of joints seals

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8. Vacuum testing

Vacuum (or air pressure) testing of new assets is required to ensure that the new assets commence service meeting their designed performance objectives. While vacuum testing is a requirement for acceptance testing of new assets, vacuum testing can also be used to confirm the condition of manholes at any time after commissioning including prior to the end of typical 12 month warranty periods and ongoing asset assessments.

Air pressure testing is conducted in a similar manner to vacuum testing however uses low pressure air (rather than a vacuum) applied to the system and checks that the pressure is maintained for the required time interval.

Vacuum testing Process

The vacuum testing process involves plugging all inlet and outlet pipes, sealing the surround with a vacuum plate and subjecting the structure to a vacuum. The structure must maintain a vacuum within specific parameters for a fixed period of time in order to pass. The time and permissible loss of vacuum will be dependent upon the size of the manhole and pipes with the specification available from the council or water authority.

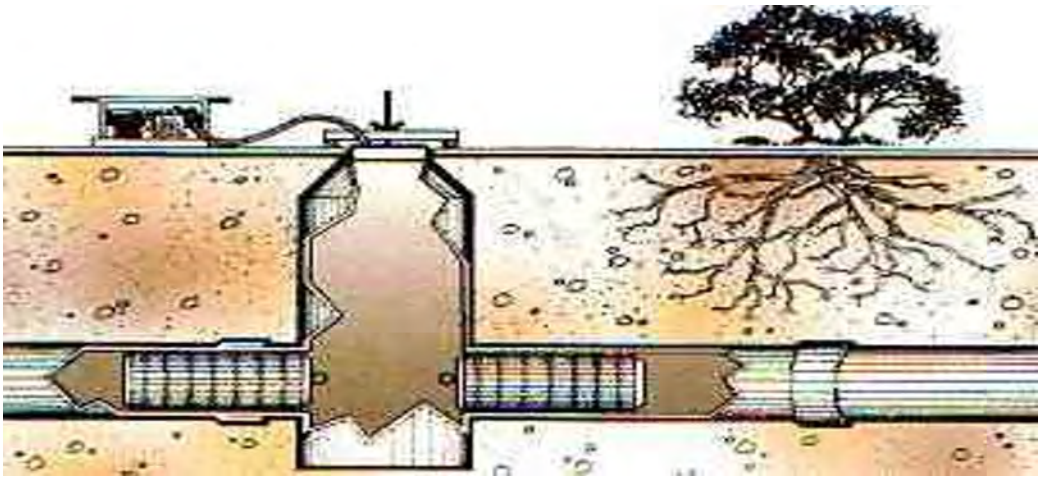

Figure 20 Typical vacuum testing arrangement on a manhole

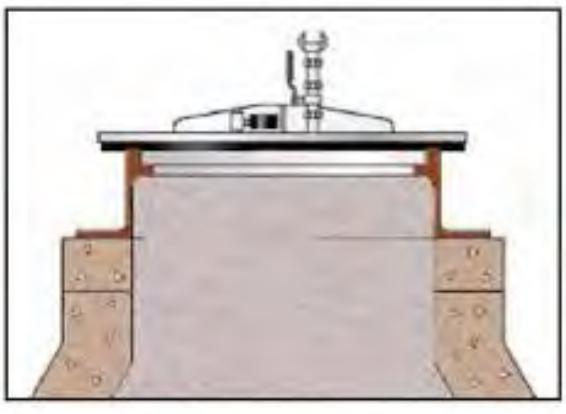

Figure 21 Vacuum testing equipment placed on manhole frame

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Figure 22 Vacuum test a manhole

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9. Hydrostatic Testing

As with vacuum testing, this is normally only performed on new assets.

The Hydrostatic testing process involves plugging all the inlet and outlet pipes with inflatable balls and the structure is filled with water to the top edge of the cover frame.

The system is allowed to stabilise before the testing commences.

The structure must maintain a head of water within specific parameters for a fixed period of time in order to pass. The time and permissible loss of head will be dependent upon the size of the manhole and pipes with the specification available from the council or water authority.

10. Flow Gauging

Sewer Flow gauging is a commonly used process to monitor actual flows at specific locations of the sewer network and for investigating areas where flows are unexpectedly high. This can be used to identify illegal discharges to sewer, monitor trade waste discharges as well as to identify areas in a catchment that may be leaking.

Flow gauges are available in a number of configurations with the most common type incorporating a submerged sensor to measure flow velocity and depth and incorporating an algorithm to convert this data to an instantaneous flow rate (typically reported in litres per second). Non contact systems are also available that are positioned above the flow and utilise ultrasonics to measure depth (or height) of the flow (often used in conjunction with weirs). It is important to ensure that suitable positioning for gauges is selected to ensure quality data and suitability for purpose of the gauging program.

Flow gauging is generally found at the inlet works of a sewage treatment plant and is used to manage the treatment process and monitor impacts of I/I at the plant.

Pump station operations can be a simple and effective first pass approach by water authorities and councils to identify specific catchments in the network that may be affected by rainfall. Depending upon the pump types, configuration and data recorded, it may be possible to compare data during rain events with data from dry weather periods to identify catchments for more detail investigation.

Rainfall dependent flow gauging is an extension of normal flow gauging and incorporates strategically placed sensors to measure rainfall within discrete catchments in conjunction with sewer flow gauging of these catchments. This allows investigation into the different catchments to help identify specific areas of significant contribution during rain events, rainfall intensity that results in significant inflow and infiltration and allow planning for mitigation of these impacts.

11. CCTV

While CCTV and pole camera's are not strictly used for leak testing, they can be used to identify and verify specific locations of leaks and capture visual evidence of leaks including active leaks in pipes and manholes, cracks, breaks, root intrusion points that would allow leakage into structures as well as wall staining which is a visual indicator of leaks.

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12. Frequently Asked Questions

Q. What equipment do I need to conduct smoke testing?

A. There are a number of commercially available smoke generators. Typically they are designed for inspection ports or manholes. The main components will include a fan (fuel or electrical drive) to pump the smoke into the sewer and the smoke generator. The smoke is generated via a special fluid being directed onto a hot surface or from a commercially available smoke bomb.

Q. Is smoke safe to be inhaled?

A. Smoke fluids and bombs typically generate a non hazardous smoke. Always check the label for suitability. The other thing to consider is that when you are blowing smoke into the sewer, you may be displacing gases from within the sewer and while this again is not typically a safety issue (due to dilution from the fan and in the atmosphere, you may get some odour complaints due to displaced air from the sewer.

Q. What happens if I don't see any smoke from roof vents?

A. If you are introducing smoke into a manhole, check that the fan and smoke fluid are operating correctly. If these are operating correctly then it's likely that boundary traps are installed at each of the properties. This is essentially a water trap that will prevent the smoke entering the properties drainage system. It will be necessary either to test each property individually or, you will need to remove the inspection cover and plunge the trap clear of liquid.

Q. Smoke has entered a building via internal pipes, what do I do ?

A. This can happen in properties where a bathroom or spare toilet is used infrequently and the water trap has dried out. Simply run the taps in that room and you can also pour water directly into the trap to stop the smoke entering the building. Open windows and doors and the smoke will quickly dissipate. As mentioned earlier, the smoke used should be non toxic and will not normally leave any residue inside the building.

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