Leakage Management & Control
(An overview)

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- Causes of leaks and benefits of leakage control
- Leakage management strategy
- Economic level of leakage
- Leak detection and control program
- Methods of leak and break location
- Difficulties in locating leaks
Introduction (1)

Leakage
- Loss of water by unintentional escape from the distribution network
- Can range from slow leak or “drip” to “main break”

Break/Burst
- A large opening caused when a network component fails due to excessive high loads, high internal pressure, corrosion or a combination of above factors.

Very often, leakage is the main component of water loss

Introduction (2)

Effect of Leakage
- Primary economic loss – cost of raw water, its treatment, and its transportation.
- Damage of the pipe network and other properties e.g. - erosion of the pipe bedding leading to pipe breaks, - foundation of roads and buildings
- Risk to public health caused by contaminants entering the pipe through leak openings.
Introduction (3)

Volume of the water lost by leakage will depend
- Characteristics of the pipe network
- Leak detection and repair policy practised, such as:
  - the pressure in the network.
  - whether soil allows water to be visible at the surface
  - “awareness” time (how quickly the loss is noticed);
  - repair time (how quickly the loss is repaired)
Leakage Management and Control

A 10-metre-long section of a key thoroughfare in north-end Toronto is seen on April 26, 2006 after sinking into its foundation. Heavily-travelled Steeles Avenue West (between Bathurst and Sanel) was weakened by a break in a water main. Police say all four lanes, just east of a bridge straddling the West Don River, sunk about three metres.

(CP Photo/Toronto Star - Ron Bull)

Common factors influencing leakages

<table>
<thead>
<tr>
<th>Factor</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ground movement</td>
<td>27</td>
</tr>
<tr>
<td>Pipe corrosion</td>
<td>19</td>
</tr>
<tr>
<td>Heavy traffic loadings</td>
<td>11</td>
</tr>
<tr>
<td>High system pressure</td>
<td>8</td>
</tr>
<tr>
<td>Damage due to excavation</td>
<td>8</td>
</tr>
<tr>
<td>Pipe age</td>
<td>6</td>
</tr>
<tr>
<td>Winter temperature</td>
<td>6</td>
</tr>
<tr>
<td>Defects in pipes</td>
<td>5</td>
</tr>
<tr>
<td>Poor quality of joints</td>
<td>4</td>
</tr>
<tr>
<td>Ground conditions</td>
<td>3</td>
</tr>
<tr>
<td>Poor quality of workmanship</td>
<td>2</td>
</tr>
</tbody>
</table>
Benefits of leak detection and repair

- Water savings
- Energy savings (treatment and pumping)
- Reduced O&M costs (reduced salary costs and outage times)
- Reduced consumer complaints and improved public relations
- Reduced property damage and reduced risk of contamination

Deferment of capital expenditure with leakage reduction
Leakage Management Strategies (1)

- In general, leakage management strategies can be of two main groups:
  - Passive Leakage Control (Reactive Control)
  - Active Leakage Control (Proactive Control)

- Passive Leakage Control (PLC) is a reaction to visible leakage due to bursts or drops in pressure, which are usually reported by customers or noted by the company's staff.

Leakage Management Strategies (2)

- Passive leakage control is a procedure whereby water loss is tackled when leakage is visible or when problem are reported from the public.

- The adoption of this policy minimizes day to day operating costs of leakage detection, but increases the risk of water being wasted.

- This policy is applicable if:
  - The costs of leakage detection are high
  - The costs of production are low, and there is ample capacity to supply all foreseen demands
  - Bursts are readily visible and easily repaired.
Leakage Management Strategies (4)

- **Active Leakage Control (ALC)** refers to set of procedures and steps taken by the water utilities (with special team of dedicated staff) to monitor, repair and maintain the leakage level as an regular activity. This includes:
  - Regular survey (sounding, waste metering)
  - Leakage monitoring in zones or sectors (DMA monitoring and management)

Leakage run time

- The level of leakage will depend on the flow rate and the time for which they run. The run time comprises of three elements.
  - **AWARENESS TIME**: Time taken for the water supplier to be aware of the leak or burst.
  - **LOCATION TIME**: Time taken to locate the leak or burst once the water supplier is aware of its existence.
  - **REPAIR TIME**: Time taken to make the repair, once the location has been pinpointed.
Leakage Management and Control

Typical duration and losses from different bursts

- **For a given network reducing leakage to zero would be virtually impossible and enormously expensive for the consumers.**
- **Water companies strike a balance between the cost of reducing leakage and the value of water saved.**
- **The level of leakage at which it would cost more to make further reductions in leakage than to produce the water from another source is known as "Economic Level of Leakage (ELL)".**
Economic level of leakage (2)

- Operating at ELL means the total cost to the customer of supplying water is minimised and water companies are operating efficiently.
- At ELL
  \[ \text{Marginal cost of leakage control} = \text{Marginal benefit of water saved} \]
- ELL is not fixed, for all time. It depends on a wide range of factors, which will vary both between companies and over time
  - e.g. When the cost of leak detection decreases with new technology, ELL will be lower.
  - e.g. ELL will be higher when the demand for water falls and there is a large surplus.

The cost of reducing leakage and of replacing lost water

![Diagram showing cost per unit of water delivered, total cost, cost of lost water, cost of controlling leakage, and economic level of leakage vs. volume of leakage.](image)

- Cost per unit of water delivered
- Total cost
- Cost of lost water
- Cost of controlling leakage
- Economic level of leakage
- Volume of Leakage
Leak detection and location

- Leak detection
  - “narrowing down” of a leak or leaks to a section of the pipe network
  - may be carried out routinely

- Leak location
  - identification of the position of a leak prior to excavation and repair, although finding the exact location cannot be guaranteed.
  - location surveys may be carried out with or without prior detection activity

Leak detection techniques

- There are a number of techniques to detect where leakage is taking place in the network, including:
  - sub-division of DMAs into smaller areas by temporarily closing valves or by installing meters;
  - variations of the traditional step-test;
  - the use of leak localizers;
  - sounding surveys.
Main steps in leak detection and control

- Data collection
  - network data, leak frequency and repair data, pipe rehab data, operation and maintenance system
- Network evaluation
- Physical leak detection (detection in the field)
- Planning and implementation of repair program
- Network maintenance and rehabilitation program

District Metered Area (DMA)  
Source: (Farley and Trow, 2003)
Network evaluation

Network evaluation data allows identification of area where field leak detection will be most cost-effective.

Methods available for network evaluations

- Passive observation
- Water Audit
- Continuous flow measurement (minimum night flow)
- Zero-consumption measurement
- Hydrostatic testing

Key points for leakage monitoring and detection

Source: Farley (2001)
**Minimum night flow**

- **Maximum flow**: 480,000 litres/day
- **Average flow rate**: 210,000 litres/day
- **Night flow rate**: 80,000 litres/day

**Zero consumption measurement**

(Source: Weimer 1992)
Methods of leak and break location

- Acoustic
- Acoustic with correlation
- Infrared thermography
- Chemical
- Mechanical

Factors affecting leak sounds

- Pressure
  - It should be 15 psi (~10 m) or more for sonic leak detection.
- Pipe material and size
  - Sonic techniques can be used for pipe and fittings of any material. Metallic pipe is much better sound conductor than non-metallic pipe.
- Soil type
  - Influences the amount of sound transmitted to the surface. Observations indicate that sand is normally a good conductor of sound; clay is a poor conductor.
- Surface type
  - the surface on which the sounding instrument is placed also influences how the sound travels.
Acoustic leak location (3)

(Source: Smith et al. 2000)

Leak Pro
Lmic Sounding System

- easy-to-use, low cost, electronic listening stick and ground microphone combined.
- ideal for general leak sounding operations
- can be fitted with either a tripod foot (for use as a ground microphone) or probe rods (for sounding at fittings or in soft ground).

Source:
www.accuratedetection.com
www.palmer.co.uk/products/lmic.htm

Listening devices and leak-noise correlator
Schematic of correlator functioning

\[ L = \frac{(D - V \cdot Td)}{2} \]

- \( L \): Leak position
- \( D \): Distance between detectors
- \( V \): Velocity of sound in pipe
- \( Td \): Transit time difference

Leak Noise Correlator
Acoustic Loggers - Noise Recorders

The system is inserted into a transmission main through any tap 2” or greater in diameter and is completely safe for all potable water systems. In operation, the probe is carried along the pipe by the flow of water.

Sahara locates leaks through identification of the distinctive acoustic signals generated by leaks in the pipe wall, the joints or steel welds. 

Source: www.wrcplc.co.uk/sahara/
Leakage Management and Control

Acoustic mat (Sensor mat)

- The instrument is a close-coupled surface array of eight linked sensors, embedded in an acoustic polymer mat, about 1.5 metres long.
- The mat is continuously moved along the line of the main to confirm the position of a suspect leak.
- A location accuracy of 20 cm is claimed, reducing the chance of dry holes to 10%.
- At around US$ 12000, equipment is comparable in price to a mid-range leak noise correlator.

Source: www.swig.org.uk
www.stest.co.uk

Leak detection procedure for different areas

<table>
<thead>
<tr>
<th>Area</th>
<th>First pass investigation</th>
<th>Second pass investigation</th>
<th>Follow up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Town centre</td>
<td>Correlator/ acoustic loggers</td>
<td>Sounding /acoustic loggers</td>
<td>Correlator survey</td>
</tr>
<tr>
<td>Large urban</td>
<td>Acoustic loggers or correlator survey</td>
<td>Sounding/leak noise correlation</td>
<td>Correlator survey</td>
</tr>
<tr>
<td>Small urban</td>
<td>Sounding</td>
<td>Correlator /sounding</td>
<td>Correlator/ sounding</td>
</tr>
<tr>
<td>Large rural</td>
<td>Step-test/ acoustic loggers</td>
<td>Localiser/ correlators</td>
<td>Check night flow</td>
</tr>
<tr>
<td>Small rural</td>
<td>Sounding</td>
<td>Correlator /sounding</td>
<td>Correlator survey/sounding</td>
</tr>
</tbody>
</table>
1. Sources of Interference
   - a variety of common environmental conditions can interfere the acoustic method of leak detection.
   - variation in soil properties, moisture, water table, water pressure
   - locating leaks requires trained and experienced operators and can be problematic in noisy or geologically complexed areas

2. Access to test points
   - distance between a detector and the leak may not be optimal in many cases.

3. Pipe location
   - location of pipe may be difficult in older networks.
   - existing records may be incomplete and of limited use

4. Plastic pipes
   - leaks are difficult to determine in segments containing plastic pipes.
   - plastics dampen vibrations so noise caused by leaks or breaks does not propagate as far as metal pipes.
5. Lined pipes
- the noise response characteristics of lined pipes (composites) are not well defined.
- water leaking from the lines can travel along the interface between the pipe and metal to an escape point that is distant from the leak.

6. Multiple leaks
- Correlators are generally programmed to analyse and locate single leaks or breaks.
- multiple leaks on the same line segment should be treated in different ways.

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Leak location interferences

(Source: Smith et al. 2000)
Recommended frequencies of leakage control activities

<table>
<thead>
<tr>
<th>Activity</th>
<th>Recommended Frequency (No/Year)</th>
<th>Acceptable Range (No/Year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regular sounding</td>
<td>1</td>
<td>0.5 to 2</td>
</tr>
<tr>
<td>Leak Noise Correlation</td>
<td>1.5</td>
<td>1 to 4</td>
</tr>
<tr>
<td>District Metering</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Read meters</td>
<td>25</td>
<td>12 to 50</td>
</tr>
<tr>
<td>- Inspection</td>
<td>1</td>
<td>0.5 to 2</td>
</tr>
<tr>
<td>Waste Metering</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) Areas up to 1500 props</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Monitoring</td>
<td>4</td>
<td>2 to 6</td>
</tr>
<tr>
<td>- Inspection</td>
<td>1.5</td>
<td>1.25 to 2</td>
</tr>
<tr>
<td>b) Areas over 1500 props</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Monitoring</td>
<td>5</td>
<td>3 to 12</td>
</tr>
<tr>
<td>- Inspection</td>
<td>2.5</td>
<td>1.75 to 3</td>
</tr>
<tr>
<td>Combined District and Waste Metering</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Read district meters</td>
<td>25</td>
<td>12 to 50</td>
</tr>
<tr>
<td>- Inspection</td>
<td>2.25</td>
<td>1.75 to 3</td>
</tr>
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Leakage Management Strategy

PREPARE
- Assess current level of leakage
- Understand factors and timescales for leakage reduction
- Understand funding availability

SET TARGETS
- Calculate ELL
- Set provisional short and long term targets
- Set out an investment plan
- Trail exercise

PROCURE
- Provide support services, equipment, materials, I.T. systems
- Manage works

PROJECT
- Train staff
- Review budget

MANAGE WORKS
- Utilize data gathering systems
- Maintain facilities and equipments
- Ongoing ALC + Annual Review

HANOVER
- Monitor and maintain

Source: (Farley and Trow, 2003)
Sustained Leakage Management

- It is vital in leakage management that the advances made in water loss reduction are sustained. This can be achieved by:
  - ensuring appropriate staffing levels
  - staff education and training
  - operation and maintenance
  - assessing and monitoring performance
    - strategic monitoring
    - facilities monitoring and maintenance
    - operational performance monitoring