Detecting Leaks and Preventing Bursts, The Digital Way

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Agenda

1. Leak and Burst Definition
2. Benefits of Early Leak and Burst Detection
3. Using Digital Technology to Detect Leaks
4. Q & A
5. Using Digital Technology to Prevent Bursts
6. Session Conclusion
7. Q & A
8. Closing Remarks
Leak & Burst Definition
Leak & Burst Definition

A leak is a **failure of the water supply network** such that there is an unplanned loss of water from the water supply network. It is a generic term that can be used on any size or type of asset, from a service pipe to a trunk main or service reservoir or any fitting from a gate valve to a customer meter.

In some utilities, the word “burst” may have a specific connotation in relation to a leak that is large enough to cause a supply disruption or severe impact on customers or general public.

*IWA Standard Definitions for Water Losses, David Pearson 2019*
Benefits of Early Leak & Burst Detection
Benefits of Early Leak & Burst Detection

1. Increased Availability of Water (Taipei – no water shortage for 17 years)
2. Reduced Treatment and Pumping Costs
3. Social Factors
   a) Reduced Risk of Water Contamination
   b) Reduced Inconvenience from Unplanned Shut Downs
   c) Improve Corporate Image (Paju, Korea – customers can drink tap water)
4. Environmental Factors
   a) Reduced Abstraction Volumes
5. Improved Planning of Utility Resources (proactive v reactive repairs (SA Water, Australia))
6. Increased Revenue
Leak Duration

Flow rate

Duration (days)

Awareness  Location  Repair
Using Digital Technology to Detect Leaks
Awareness
Awareness – No Sensors
Awareness – District Meter Areas

District Meter Area (DMA)
Awareness?
# Awareness – Smart Water Analytics Platforms

## Water Balance

<table>
<thead>
<tr>
<th>System Input Volume</th>
<th>Billed Authorized Consumption</th>
<th>Unbilled Authorized Consumption</th>
<th>Unauthorized Consumption</th>
<th>Commercial Losses</th>
<th>Physical Losses</th>
</tr>
</thead>
<tbody>
<tr>
<td>6825.17 (m³/day) ± 2.1%</td>
<td>4671.78 (m³/day)</td>
<td>35.13 (m³/day) ± 15%</td>
<td>34.13 (m³/day) ± 10%</td>
<td>53.49 (m³/day) ± 9.2%</td>
<td>2064.77 (m³/day) ± 8.9%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Billed Unmetered Consumption</th>
<th>Unbilled Unmetered Consumption</th>
<th>Unauthorized Consumption</th>
<th>Commercial Losses</th>
<th>Physical Losses</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.00 (m³/day)</td>
<td>1.00 (m³/day)</td>
<td>53.49 (m³/day) ± 9.2%</td>
<td>6.83 (m³/day) ± 20%</td>
<td>2064.77 (m³/day) ± 8.9%</td>
</tr>
</tbody>
</table>
Using Digital Technology to Detect Leaks
## Location – Pipe Material

<table>
<thead>
<tr>
<th>Diameter</th>
<th>mm</th>
<th>75</th>
<th>100</th>
<th>150</th>
<th>200</th>
<th>250</th>
<th>300</th>
<th>350</th>
<th>400</th>
<th>450</th>
<th>500</th>
<th>600</th>
<th>700</th>
<th>800</th>
<th>900</th>
<th>1000+</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>inches</td>
<td>3</td>
<td>4</td>
<td>6</td>
<td>8</td>
<td>10</td>
<td>12</td>
<td>14</td>
<td>16</td>
<td>18</td>
<td>20</td>
<td>24</td>
<td>28</td>
<td>32</td>
<td>36</td>
<td>40+</td>
</tr>
<tr>
<td><strong>Material</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

Method A  Gas Injection
Method B  Traditional Techniques with Manual Listening Stick
Method C  Non-Intrusive Acoustic Techniques that is Standard Correlator. Correlating Noise Loggers (Accelerometers)
Method D  Intrusive Acoustic Techniques that is Standard Correlator or Correlating Noise Loggers (Hydrophones)
Method E  Inline Inspection Techniques (Tethered & Free-swimming)
Method F  Noise Loggers (Non-Correlating), Non-Intrusive Magnetic Connection
Method G  Electronic Amplified Listening Ground Microphone

https://www.youtube.com/watch?v=6uaKB3AIhptU
Location - Effect of Pressure on Leakage

High Pressure

Low Pressure
Location – Correlating Noise Loggers

- Shut valve
- District Meter
- Noise logger

Accelerometer

Hydrophone
## Location – Cross Parameter Incident Alerts

**Incidents**

<table>
<thead>
<tr>
<th>Type</th>
<th>Station Description</th>
<th>Action</th>
<th>Incident Date</th>
<th>Reported Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meter Head</td>
<td>Upper Cross Rd East Stn 20</td>
<td></td>
<td>8 months ago</td>
<td>3 months ago</td>
</tr>
<tr>
<td>Valve Head</td>
<td>140 Marine Parade Road Stn 33</td>
<td></td>
<td>8 months ago</td>
<td>3 months ago</td>
</tr>
<tr>
<td>Valve Head</td>
<td>Changi Village Rd Stn 13</td>
<td></td>
<td>8 months ago</td>
<td>3 months ago</td>
</tr>
<tr>
<td>Water Quality</td>
<td>Upper Thompson Rd Stn 36</td>
<td></td>
<td>8 months ago</td>
<td>3 months ago</td>
</tr>
<tr>
<td>Water Quality</td>
<td>Serangoon Junction Stn 48</td>
<td></td>
<td>8 months ago</td>
<td>3 months ago</td>
</tr>
<tr>
<td>Water Quality</td>
<td>ERL 5 Farrer Rd Stn 11</td>
<td></td>
<td>8 months ago</td>
<td>3 months ago</td>
</tr>
<tr>
<td>Water Quality</td>
<td>Serangoon Ave Stn 33</td>
<td></td>
<td>8 months ago</td>
<td>3 months ago</td>
</tr>
<tr>
<td>Valve Head</td>
<td>Pasir Ris Dr 1 Stn 16</td>
<td></td>
<td>8 months ago</td>
<td>3 months ago</td>
</tr>
<tr>
<td>Water Quality</td>
<td>Tampines St 11 Dr 18</td>
<td></td>
<td>8 months ago</td>
<td>3 months ago</td>
</tr>
</tbody>
</table>

**Map**

The map shows various locations with incident alerts indicated by different symbols and colors. The locations are categorized by type (e.g., Meter Head, Valve Head, Water Quality) and are marked with specific incident details.
Using Digital Technology to Detect Leaks
Repair
Repair

1. Location
2. Type of leak
3. Main size
4. Main material
5. Main location
6. Main depth
7. Valves to be closed for shut down
8. Customers affected by shut down
Case Study – Implementation of View™ by Yorkshire Water, UK

**Pilot ambition**

- 20% reduction in leakage
- 50% reduction in visible leakage
- 50% reduction in supply interruption
- 25% reduction in mains breaks

https://wwtonline.co.uk/webinars/xylemview
Summary – The NRW Treadmill
Using Digital Technology to Identify Transients to Prevent Bursts
Using Digital Technology to Identify Transients to Reduce Bursts

1. What are transients?
2. Identifying transients
3. Sources of transients
4. Locating transients
5. Mitigation of transients
6. Detection and location of bursts using transients
What Are Transients?

- **A momentary** or temporary event
- **For our purposes**- a temporary and sudden change in pressure
- **Sudden** - Where the transient onset is “rapid” relative to the characteristic of the pipe, typically seconds.
- **Water hammer!**
What Are Transients?

- Pressure wave - Wave speed depends on pipe material, size, fittings, elevation, anchoring, dissolved gas
- Wave Speed can be 300-1400 m/s - Very fast, can transition along pipe in seconds to minutes
- Rule of thumb is Joukowski’s equation:
- Where the wave speed is 1000m/s (e.g. concrete) the change in pressure for a 1m/s change in velocity is 100m/140psi!!!
Why Do We Care?

- Damage to pipes!
- Either instantaneous or through cumulative stress
- Can be a symptom or a cause of pipe failure
- Awareness-Location-Solution

![Diagram showing pump, valve open and valve closed with water flow](image)
Types

- With a = 1000 m/s for a concrete pipe, the change in head for a 1m/s change in velocity is 100m/140psi!!!
- Can be negative and positive transients can occur at the same time.
- Can be frequent and persistent.
- Causes pipe collapse! If sufficiently low, can draw water into the pipe.
- Causes pipe splits and breaks.
Types

- Overactive pumps
- Un-necessary surges
- Zero pressures
Sources of Transients

- **Pumps starts and stops**
  - Pump check valves
  - Power failure
- **Valve closing and opening**
  - Manual
  - Automatic
  - Customer demands
- **Air valves**
  - Sudden closure during pipe filling
  - Normal venting
- **Bursts!**
Identifying Transients-Awareness

- Not possible with traditional sensing equipment/SCADA systems
- High resolution recording is required - fractions of a second.
- High resolution requires AI to interpret in real-time - Too much data!
- 256Hz is ~1GB per month of data. 230,000 times more than 15 minute resolution
- AI can classify into transient types, and locate their likely origins
- Collected data can further feed into pipe risk models
Locating Transients

*Numbers indicate relative time of transient detection*
Locating Transients

Pressure Sensor
(pressure abnormalities, burst transients, operational transients)

Hydrophone
(acoustic energy)
Locating Transients

- Transient modelling
- Uses known pipe details and recorded pressure data
Mitigation of Transients

- Variable speed drives, soft starters, fly-wheels
- Surge vessels or accumulators
- Automated pump control valves
- Right sized equipment
- Air valves
- Manual valve operating procedures.
- Pipe re-design and replacement
Early Warning

First alarm sent on 3rd September, 23:31
Transient of 6m recorded at 22:45

Second alarm sent on 4th September, 03:36
Transient of 11m recorded at 02:54

30 second interval data

Max resolution, high rate data

6m drop 22:45
11m drop 02:54

Let's Solve Water
Summary

• Transients can be hard to identify with traditional methods
• Digital technology can quickly identify, classify and locate transient issues
• Early identification can lead to proactive maintenance, resource prioritization and design of mitigations
• Monitoring for transients can also identify pipe bursts in realtime
Session Conclusion

1. Digital technology has arrived

2. Machine learning and artificial intelligence will further improve our ability to reduce water loss in the future

Let’s Solve Water