Smart Design and Operation of Water Distribution Networks in the Netherlands

Mirjam Blokker
From Kiwa to KWR

1948

Kiwa N.V. established in 1948 by the Dutch drinking water sector

Joint quality control of water mains’ materials and fittings (Rijswijk)
From Kiwa to KWR

1971: Set up of research department
1972: Joint research programme
1979: Nieuwegein location opened
2006: Splitting of certification from Water Research
2008: Kiwa Water Research becomes KWR
2016: First international shareholder
Drinking water distribution in the Netherlands
Dutch drinking water distribution network

Network:
- 120,000 km
- 50% PVC; 30% AC; 10% CI
- Ca. 3% leakage
- Replacement from 0.5% per year → 1% per year

Research questions:
- Which mains to replace when?
- How to balance investments, performance and risk?
- How to maintain high standards?
- How to work in a busy urban environment?
Typical for Dutch drinking water distribution

**PRACTICE**
- Focus on quality, long term
- Fee covers all cost (ca. €2,- /m$^3$)
- No residual chlorine
- Low leakage
  - <5 %
- Low burst rate
  - 0.08/km/year
- Low number of customer complaints on discolouration
  - <1 per 1000 customers per year

**RESEARCH based vision on:**
- Network design
  - Blueprints
  - Self-cleaning networks
- Network operation
  - Cleaning (flushing)
  - Valves & hydrants maintenance
- Network replacement
  - Failure registration
  - Inspection
  - Models

**Current RESEARCH on:**
- Asset Management:
  - replacement planning for AC pipes
  - failure and inspection data
- Water quantity
  - Demand model (SIMDEUM)
- Water quality:
  - QMRA in the distribution network
  - Biological stable water
  - Sensor placement and interpretation
Typical for Dutch drinking water distribution

**PRACTICE**
- Focus on quality, long term
- Fee covers all cost (ca. €2,- /m³)
- **No residual chlorine**
- Low leakage
  - <5 %
- Low burst rate
  - 0.08/km/year
- Low number of customer complaints on discolouration
  - <1 per 1000 customers per year

**RESEARCH based vision on:**
- Network design
  - Blueprints
  - Self-cleaning networks
- Network operation
  - Cleaning (flushing)
  - Valves & hydrants maintenance
- Network replacement
  - Failure registration
  - Inspection
  - Models

**Current RESEARCH on:**
- **Asset Management:**
  - replacement planning for AC pipes
  - failure and inspection data
- **Water quantity**
  - Demand model (SIMDEUM)
- **Water quality:**
  - QMRA in the distribution network
  - Biological stable water
  - Sensor placement and interpretation

**Bridging science to practice**
No residual chlorine
Best practice

1. Use the best source available:
   - microbiologically safe groundwater,
   - surface water with soil passage,
   - direct treatment of surface water in a multiple barrier treatment;

2. Use a preferred physical process treatment (such as sedimentation, filtration and UV-disinfection). If necessary, also oxidation can be used by means of ozone or peroxide, but chlorine is avoided;

3. Prevent ingress of contamination during distribution;

4. Prevent microbial growth in the distribution system by production and distribution of biologically stable (biostable) water and the use of biostable materials;

5. Monitor for timely detection of any failure of the system to prevent significant health consequences.

barriers against ingress of microbial contaminants
Typical for Dutch drinking water distribution

**PRACTICE**
- Focus on quality, long term
- Fee covers all cost (ca. €2,- /m³)
- No residual chlorine
- Low leakage
  - <5 %
- Low burst rate
  - 0.08/km/year
- Low number of customer complaints on discoloration
  - <1 per 1000 customers per year

**RESEARCH based vision on:**
- **Network design**
  - Blueprints
  - Self-cleaning networks
- **Network operation**
  - Cleaning (flushing)
  - Valves & hydrants maintenance
- **Network replacement**
  - Failure registration
  - Inspection
  - Models

**Current RESEARCH on:**
- **Asset Management:**
  - replacement planning for AC pipes
  - failure and inspection data
- **Water quantity**
  - Demand model (SIMDEUM)
- **Water quality:**
  - QMRA in the distribution network
  - Biological stable water
  - Sensor placement and interpretation
The story of water quality and asset management

Once upon a time......

There was a water quality problem

With an obvious cause
However....

There is so little cast iron
Consequences of particle related processes

- Discolouration only occurs in the presence of sediment: Controlling the sediment = controlling the discolouration
- Balance between incoming and outgoing sediment indicates the sediment build-up
- Hydraulic processes govern the deposition and resuspension
Self-Cleaning Network

Normal network

\[ v_{\text{max}} = 0.07 \text{ m/s (normal)} \]

\[ v > 0.4 - 1.5 \text{ m/s (disturbed)} \]

Self-cleaning network

\[ v_{\text{max}} \geq 0.2 \text{ m/s, unidirectional (normal)} \]

\[ v > 0.4 - 1.5 \text{ m/s (disturbed)} \]

- Unidirectional flow \( \Rightarrow \) branched structure
- Velocity 0.2 m/s once a day \( \Rightarrow \)
- Reducing diameter to the end (110, 63, 40 mm) & flowing ends
- No corroding pipe material \( \Rightarrow \) PVC
- Enough head available at max water use

Brown water complaints

No brown water complaints
Self cleaning networks

Characteristics

Self-cleaning networks:
• Last part of the network
• Unidirectional flow, no stagnant zones
• Minimum flow at peak hour

Leading to
• Shorter lengths (no loops) and smaller pipe diameters → cheaper network
• Less discolouration incidents (no flushing)
• Good security of supply
• Smaller hydrant capacity

Typical for Dutch drinking water distribution

**PRACTICE**
- Focus on quality, long term
- Fee covers all cost (ca. €2,- /m$^3$)
- No residual chlorine
- Low leakage
  - <5%
- Low burst rate
  - 0.08/km/year
- Low number of customer complaints on discolouration
  - <1 per 1000 customers per year

**RESEARCH based vision on:**
- **Network design**
  - Blueprints
  - Self-cleaning networks
- **Network operation**
  - Cleaning (flushing)
  - Valves & hydrants maintenance
- **Network replacement**
  - Failure registration
  - Inspection
  - Models

**Current RESEARCH on:**
- **Asset Management:**
  - replacement planning for AC pipes
  - failure and inspection data
- **Water quantity**
  - Demand model (SIMDEUM)
- **Water quality:**
  - QMRA in the distribution network
  - Biological stable water
  - Sensor placement and interpretation

KWR Watercycle Research Institute
AM: replacement planning of AC pipes

Current research (1)

Combining information:
• Pipe degradation mechanisms: strength lost due to internal / external cement leaching
• Failure registration data (USTORE)
• Exit assessment on leaching (phenolphthaleine staining)
• Inspection with Georadar, Echo pulse

Registration of bursts with USTORE

- 8 drinking water companies
- 18,000 bursts

Developments:
- Quality system
- Belgium companies joining

Storingsfrequentie AC leidingen

Bathtub curve PVC,
- Younger mains: joints
- Older mains: joints and pipes
Typical for Dutch drinking water distribution

**PRACTICE**
- Focus on quality, long term
- Fee covers all cost (ca. €2,- /m³)
- No residual chlorine
- Low leakage
  - <5 %
- Low burst rate
  - 0.08/km/year
- Low number of customer complaints on discolouration
  - <1 per 1000 customers per year

**RESEARCH** based vision on:
- Network design
  - Blueprints
  - Self-cleaning networks
- Network operation
  - Cleaning (flushing)
  - Valves & hydrants maintenance
- Network replacement
  - Failure registration
  - Inspection
  - Models

**Current RESEARCH** on:
- Asset Management:
  - replacement planning for AC pipes
  - failure and inspection data
- Water quantity:
  - Demand model (SIMDEUM)
- Water quality:
  - QMRA in the distribution network
  - Biological stable water
  - Sensor placement and interpretation

Bridging science to practice
Drinking water

- That looks good
- That tastes good
- Is always available
- Is not expensive