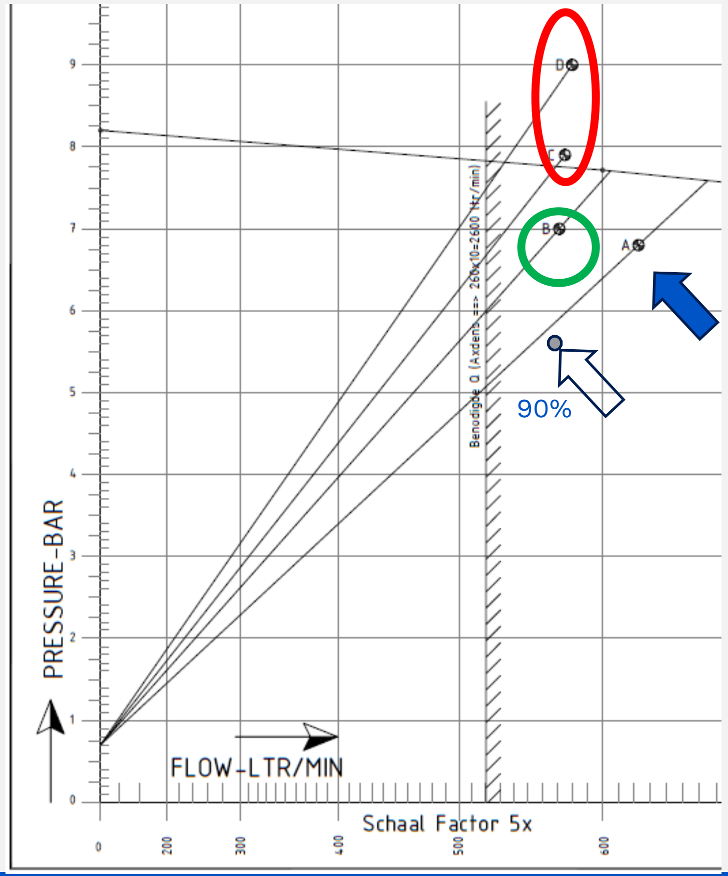

Monitoring of aged sprinkler installations

Wim van Bijsterveldt

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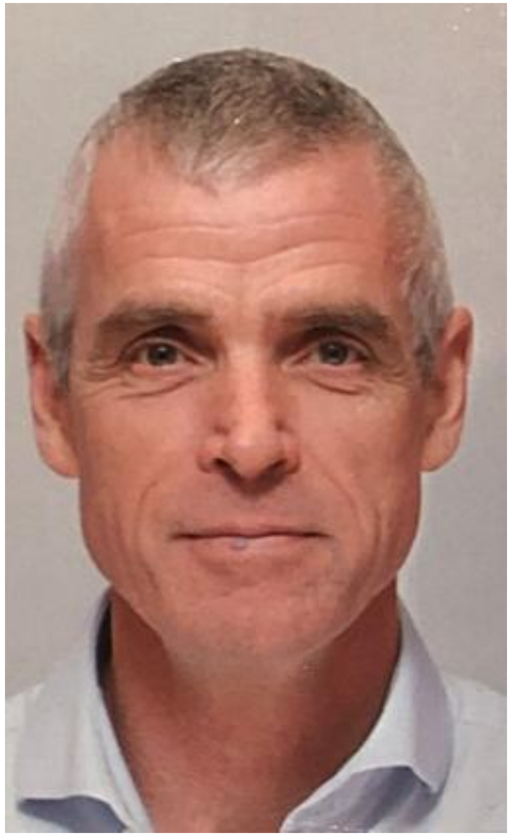
Wim van Bijsterveldt



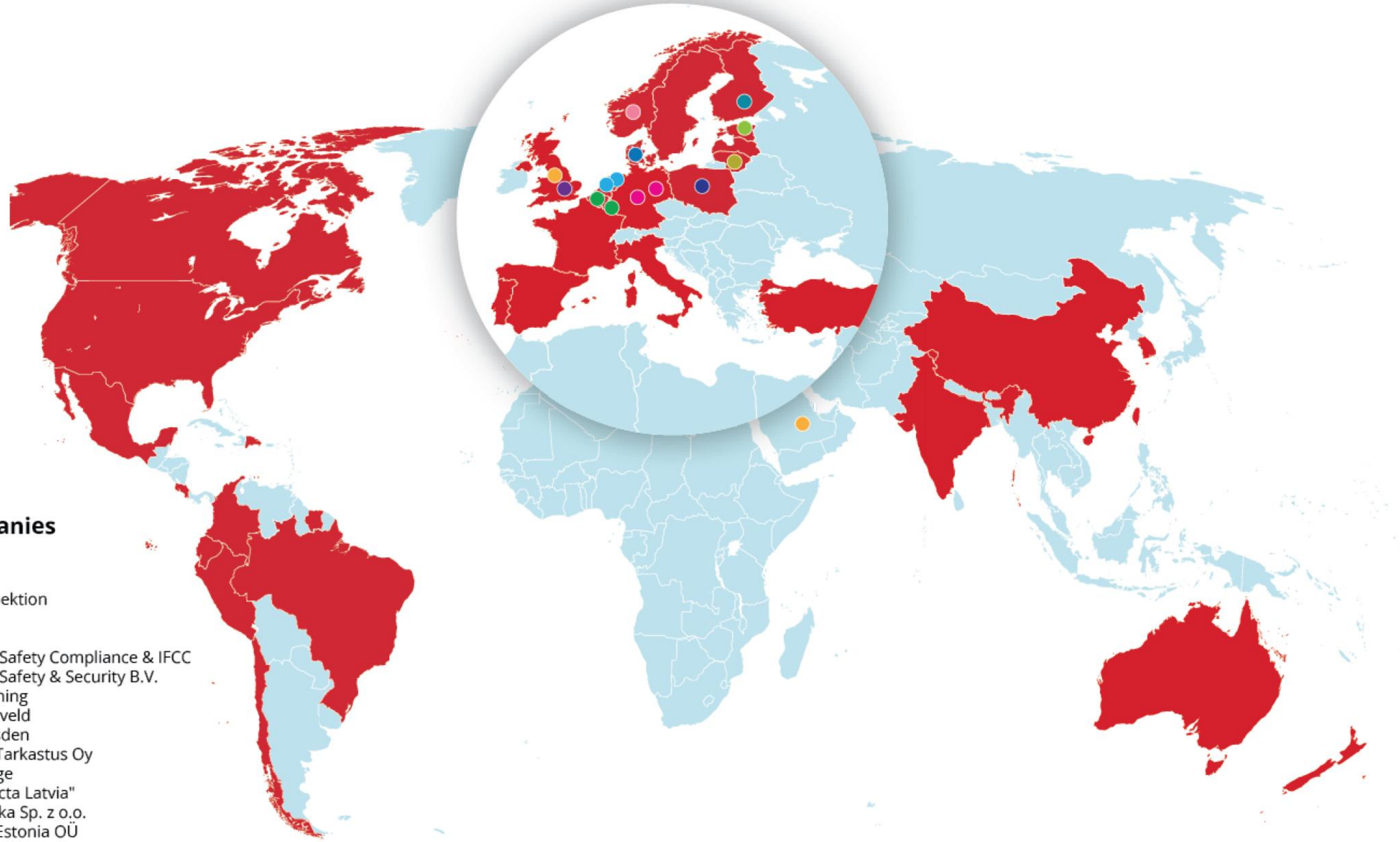
Manager Fire Safety & Security

Kiwa Fire Safety & Security

Zaltbommel

The Netherlands

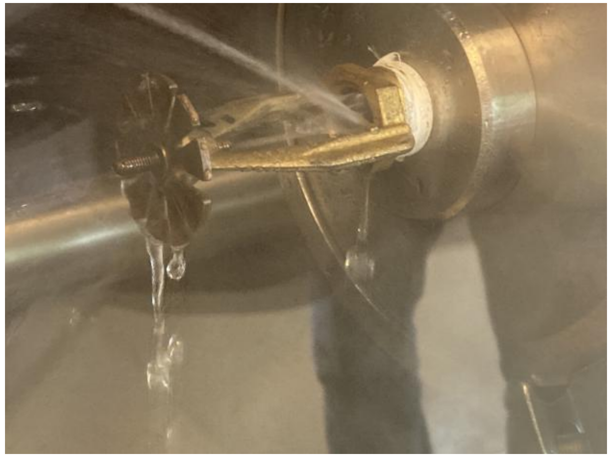
The Kiwa Group



Kiwa Family of Companies

Belgium	Vincotte
Luxembourg	Vinçotte
Denmark	RMG-Inspektion
United Kingdom	BASEC
UAE	BASEC
United Kingdom	Kiwa Fire Safety Compliance & IFCC
Netherlands	Kiwa Fire Safety & Security B.V.
Netherlands	Kiwa Training
Germany	Kiwa Wijnveld
Germany	MPA Dresden
Finland	Inspecta Tarkastus Oy
Norway	Kiwa Norge
Latvia	AS "Inspecta Latvia"
Poland	Kiwa Polska Sp. z o.o.
Estonia	Inspecta Estonia OÜ

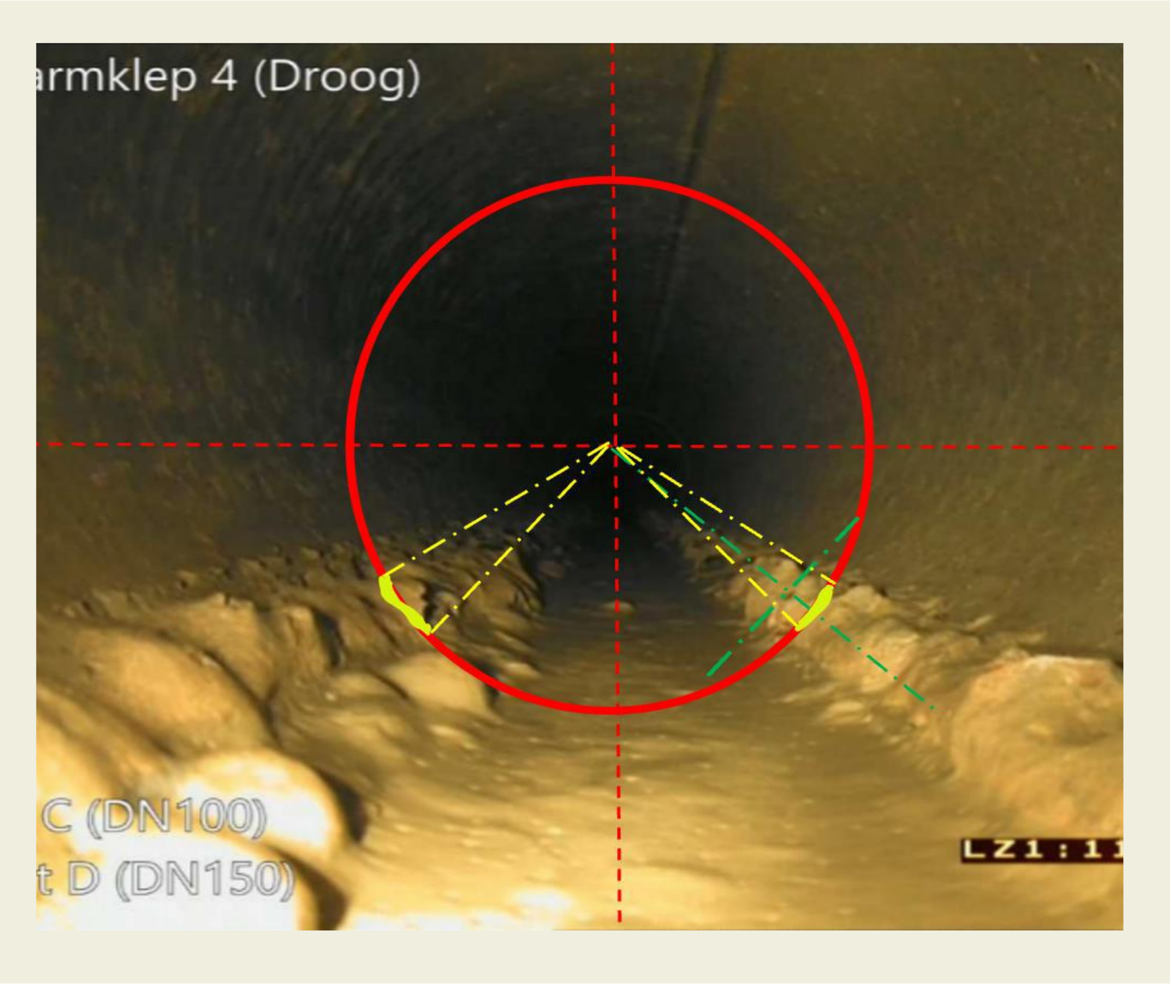
Our services



Monitoring of aged sprinkler installations

Topics

- Method according Dutch Inspection protocol
- Quantification of the Hazen Williams C Factor
- Quantification of Diameter Loss
- Testing of aged sprinklers



Method according Dutch Inspection protocol

Dutch Inspection scheme

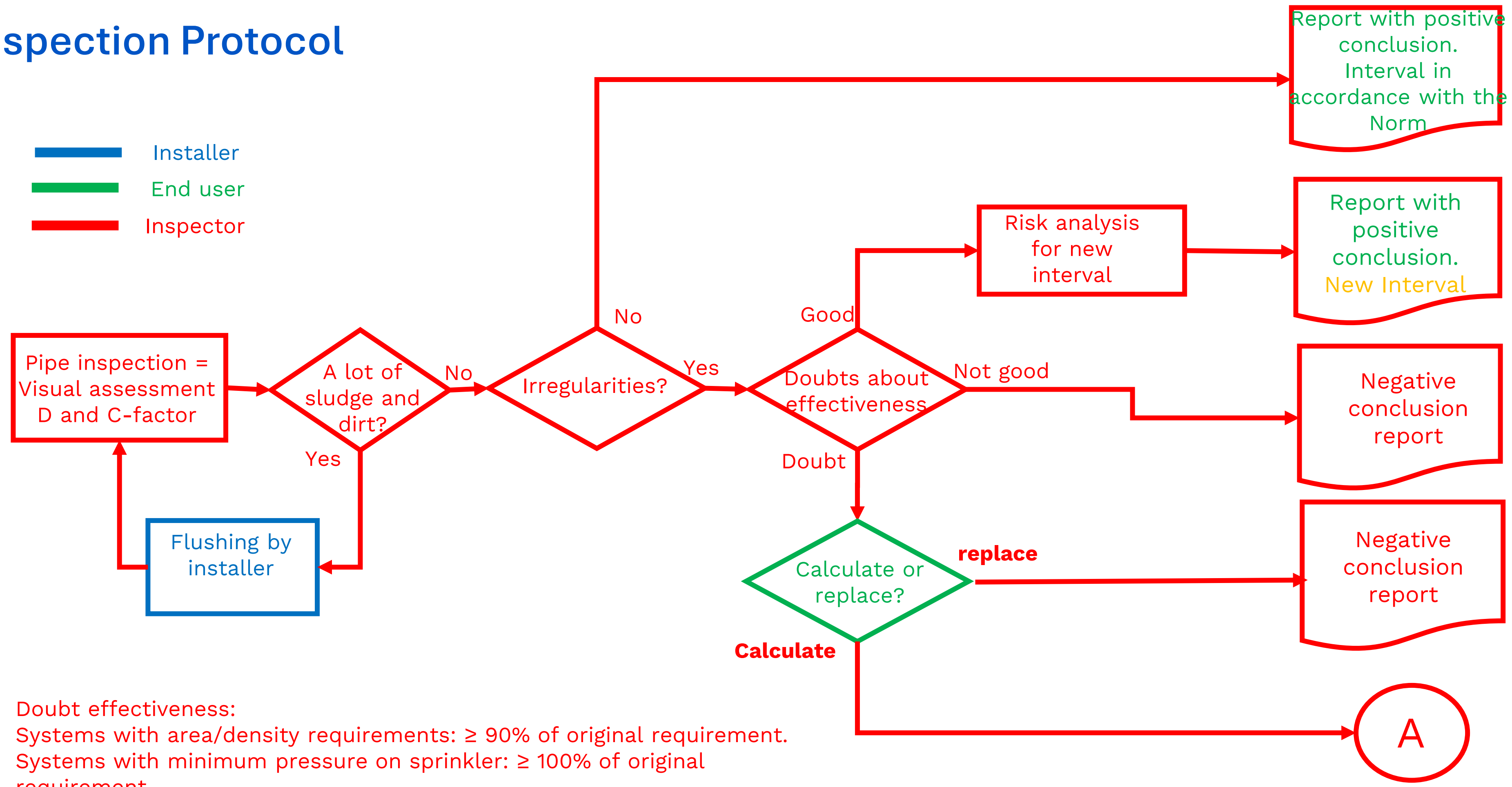
- Mandatory inspection method in The Netherlands (Building legislation);
- A harmonized inspection method to determine if the sprinkler system can extinguish a fire that might occur in the premises (based on ISO17020: General requirements).

The internal condition of the pipes (contamination, k-line system) has no negative impact on achieving the hydraulic performance requirements.

How can we quantify the hydraulic effect of corrosion and contamination of sprinkler pipes.

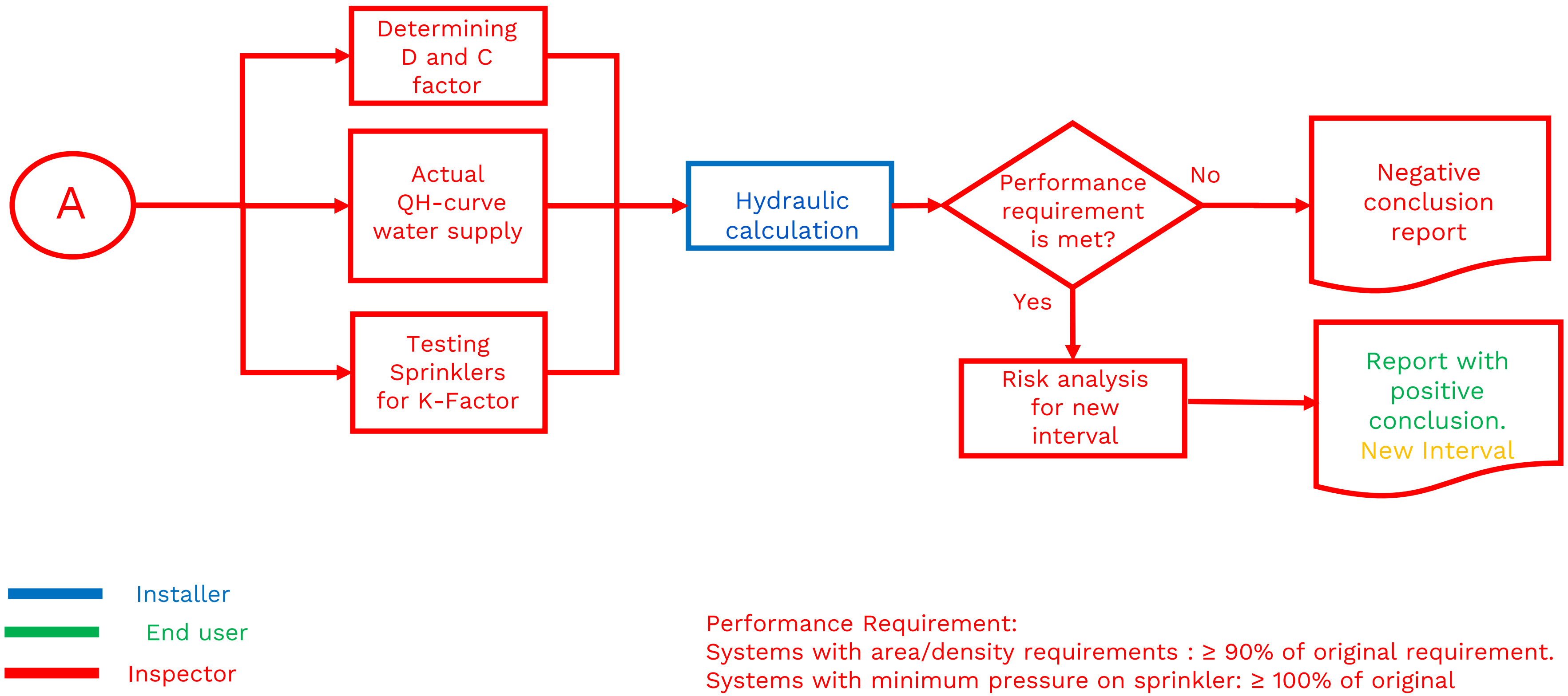
As an Inspection body, we need pass/fail criteria.

Inspection Protocol



Doubt effectiveness:
Systems with area/density requirements: ≥ 90% of original requirement.
Systems with minimum pressure on sprinkler: ≥ 100% of original requirement.

Inspectie Protocol



Performance Requirement:
Systems with area/density requirements : ≥ 90% of original requirement.
Systems with minimum pressure on sprinkler: ≥ 100% of original requirement.

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Inspection Protocol

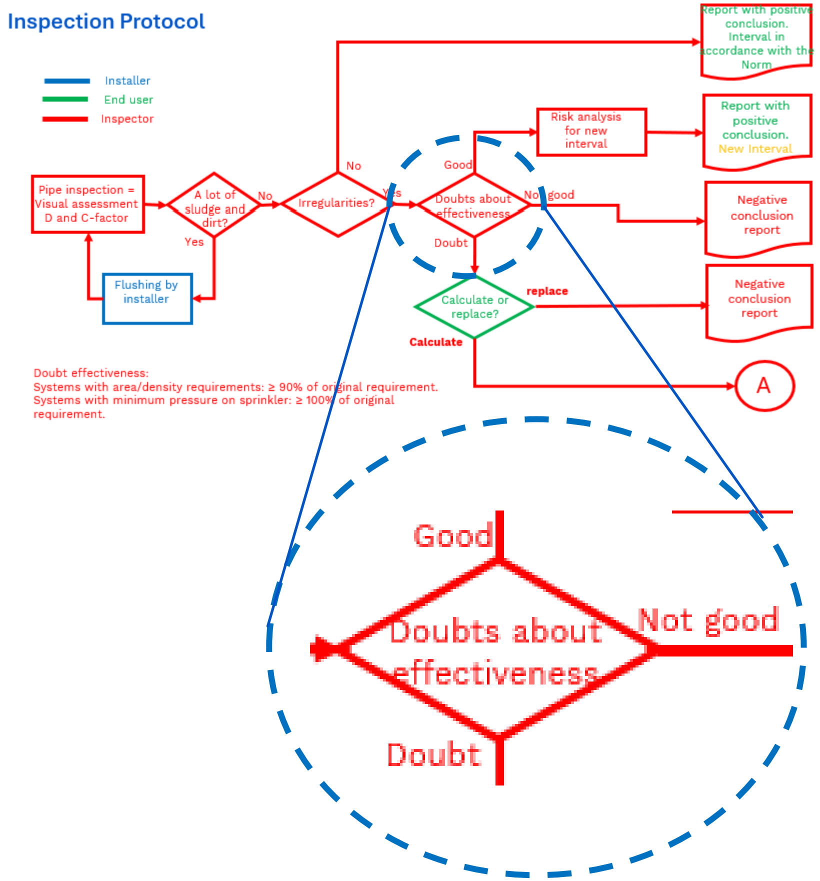
Pass/fail criteria

1e protocol (2022):

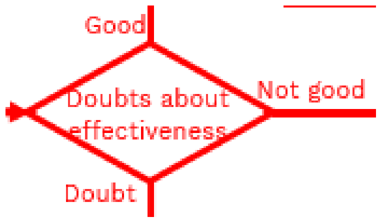
- Diameter reduction >10%

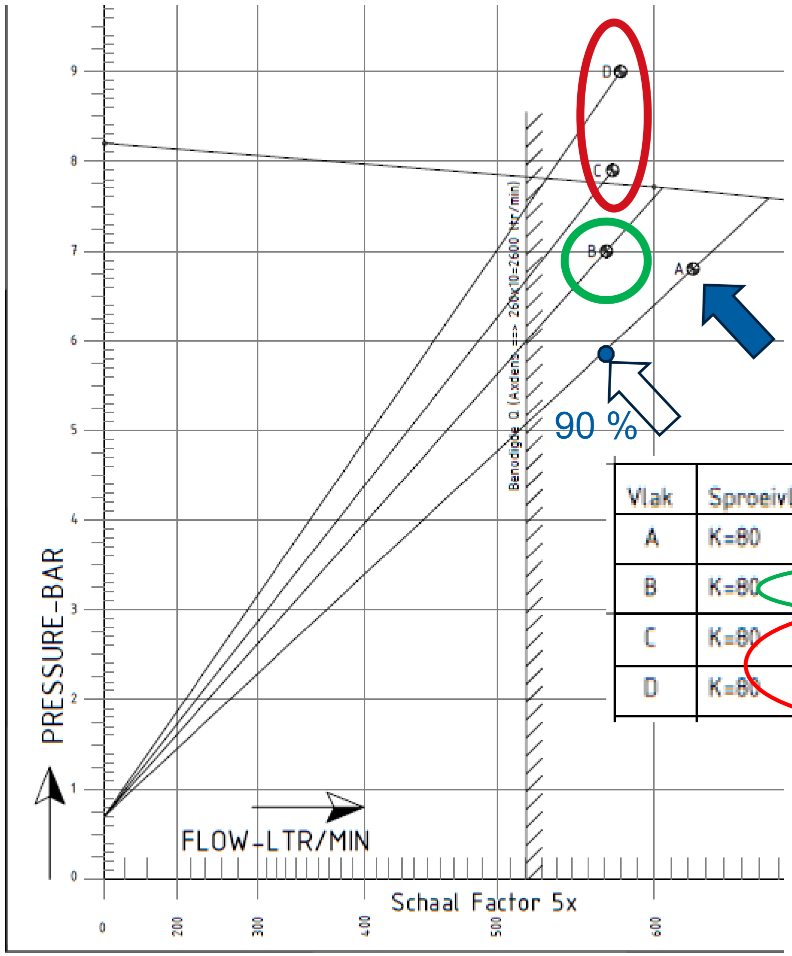
2e protocol (2024):

- Area density systems: ≥ 90 % of required density (design)
- Min. pressure on sprinkler: original design pressure



Example of HSS 10



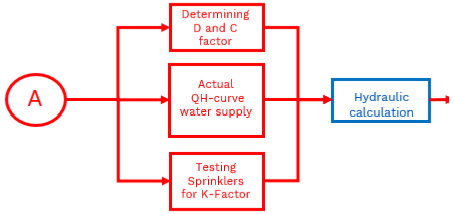


Vlak	Sproeivlak	P req.	Q
A	K=80 Diameter -0% C=120 Dens. 10 mm/min (100%)	6.81	3134
B	K=80 Diameter -10% C=120 Dens. 9 mm/min (90%)	7.0	2855
C	K=80 Diameter -15% C=120 Dens. 9 mm/min (90%)	7.9	2876
D	K=80 Diameter -20% C=120 Dens. 9 mm/min (90%)	9	2900

$$p = \frac{6.05x10^5}{C^{1.85}\ x\ d^{4.87}}\ x\ L\ x\ Q^{1.85}$$

Quantification of the Hazen Williams C Factor:

- Research project



Inspection Protocol

To determine the hydraulic capabilities of the system, we focus on:

1. Diameter(s) of the pipes
2. C-factor(s) of the pipes
3. Average K-factor of the sprinklers.
4. Currently available pressure of the water supply (QH-curve).

K-factor : based on lab tests in accordance with EN12259-1.

Currently available pressure: based on recent capacity test

Question: **How to determine the diameter and C-factor of the pipes based on visual inspection?**

Research project

A joint effort by:

- Fontys University of Applied Sciences
- Kiwa FSS

Research Question:

- To what extend can the Hazen-Williams C factor Coefficient of corroded fire sprinkler pipes be quantified?

Focus area of our research

Most common corrosion phenomena that directly affects Head loss

Tuberculation

Narrowing of Diamete

Research approach

1. Process

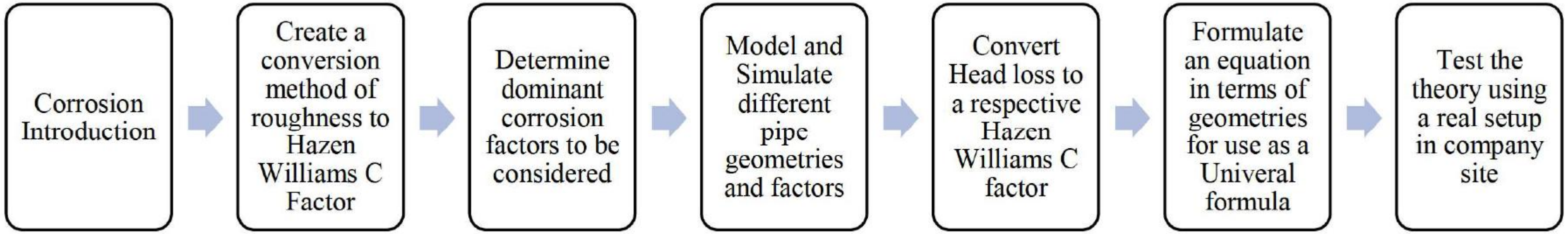


Figure 1 Problem Solving Process Flow Chart

Hazen-Williams aquation

- Diameter has a larger effect than the change in the C factor.
- The change of the C factor is dictated through generated low-pressure areas

The approach of mainly changing the Diameter does not consider losses due to generated low pressure areas

$$p = \frac{6.05x10^5}{C^{1.85}\ x\ d^{4.87}}\ x\ L\ x\ Q^{1.85}$$

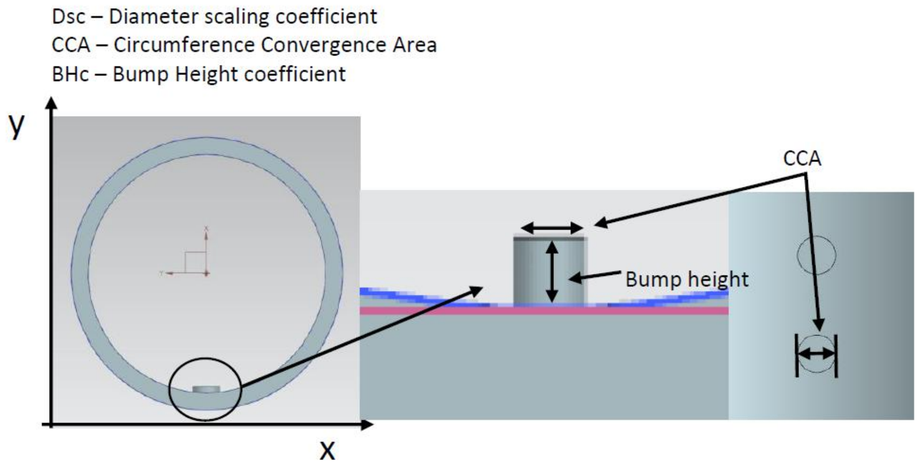
Research

What's causing the head losses?

Quantification of the Hazen Williams C Factor through a geometric approach

On geometrical basis:

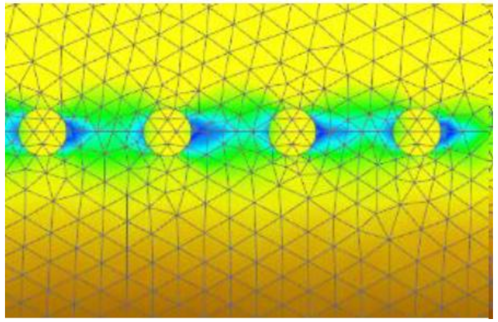
1. 1. Bump Height
2. 2. Surface Area
3. 3. Pipe Diameter
4. 4. Profile length

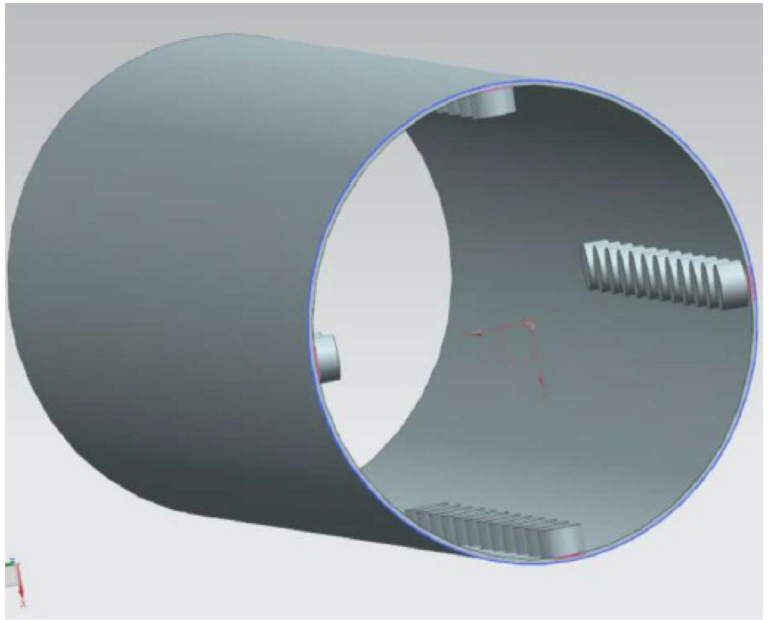


Research

An example of a CFD pipe model.

By changing tubercle dimensions, shape and positioning, the individual effect of these changes on the head loss became clear.





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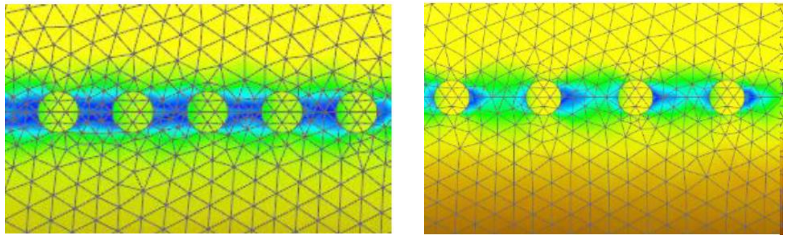
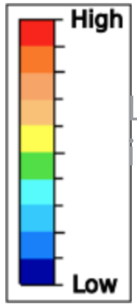
Research

Other elements included such as:

On geometrical basis:

1. Distances between tuberculation
2. Staggered layout
3. Number of Rows
4. Streamlining

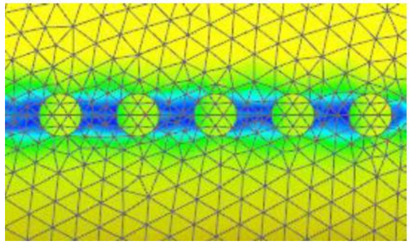




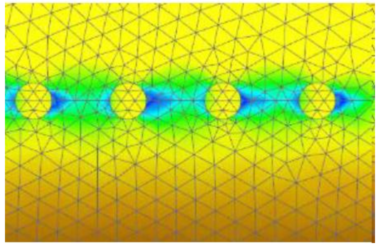
Low pressure = high impact on head loss

Research

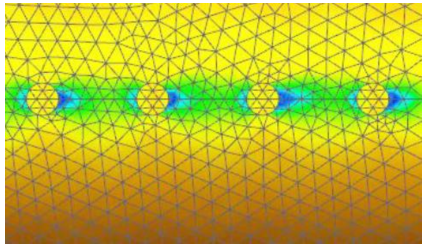
DN50 pipe



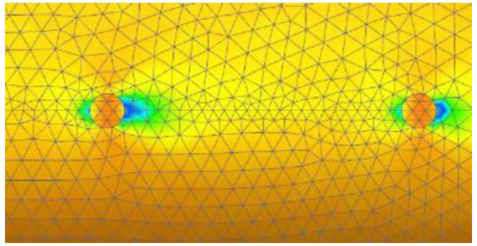
Distance = 2,5mm



Distance = 5mm



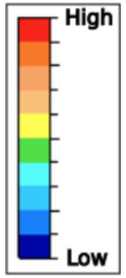
Distance = 7,5mm



Distance = 25mm

Tubercle height = 1,5mm

Tubercle diameter = 6,3mm

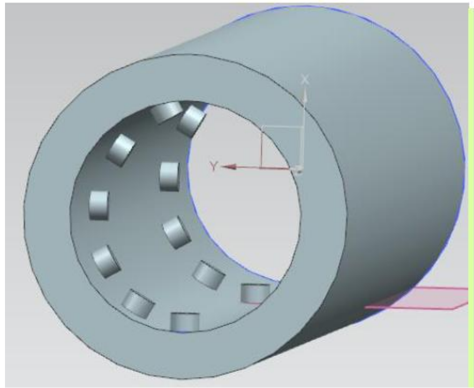


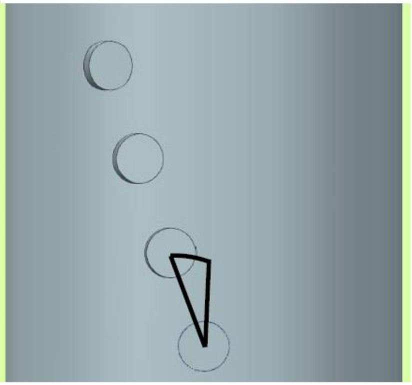
Low pressure = high impact on head loss

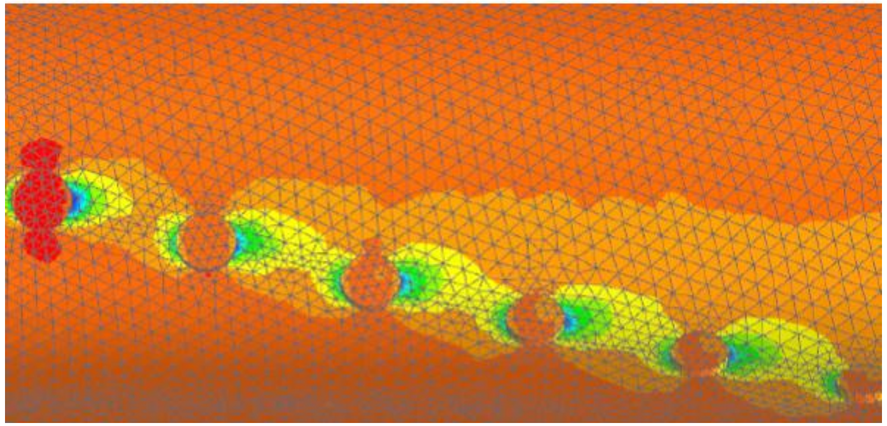
Research

Staggered Layout

Low pressure areas are less than linear tuberculation





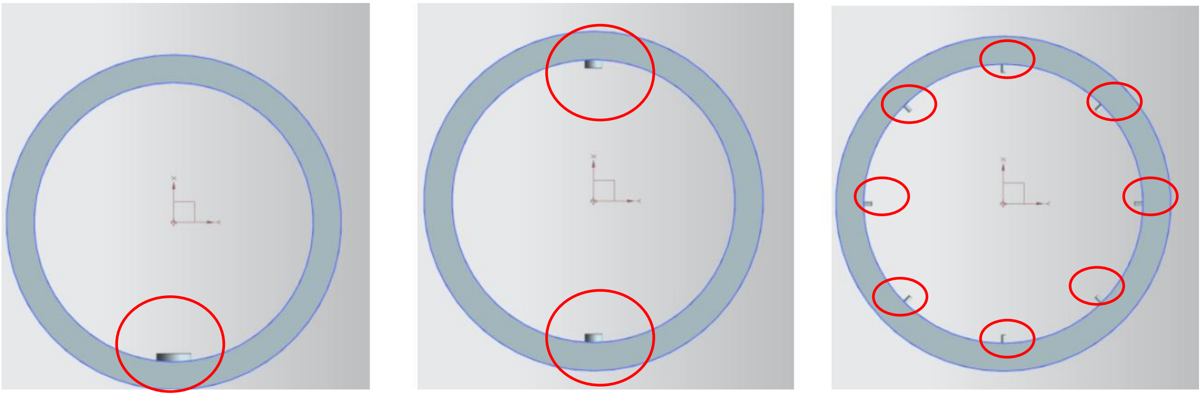


Research

Number of Rows

Generally, the behavior of the C factor is similar except at tubercle distances lesser than 15mm.

Generally, higher number of rows indicate greater head losses up to a certain degree



Quantification of the Hazen Williams C Factor

The simulations are modeled and formulated to determine the Hazen Williams C Factor

A calculation tool is provided for simplicity

The algorithm is tested through case studies through computer simulations

The algorithm is validated by real-life testing.

Hazen Williams C factor Calculation Algorithm

Parameter Inputs

Circumference coverage area %	Tubercle diameter [mm]	Tubercle height [mm]	Pipe Diameter [mm]	Helical	Gs	length of geometry	separation	Rows	Diameter scaling factor (DSF)
0,1	0	1	150	0	1	10	10	1	90,0000

Results

118,9547748	121,0737748
97,547188	
95,428188	

Algorithm

For diameters:	Pre calculation look up table		Diameter scaling factor (DSF)	Bump height-Diameter (%)	Bump height scaling coefficient	Z factors
<25	0	157,6	16			
<50	25	134	33,5			
<100	50	113,9	79,73			
<200	100	96,815	89,5575			
> = 200	200	82,3	85,3875			
	400	69,95				

Legend

DSf = Diameter Scaling Factor
CCA = Circumference Coverage Area
BHc = Bump height scaling coefficient

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Quantification of Diameter Loss

Determination of Diameter Loss

Easiest Method : Measurement!

By removing the pipe, we can measure the height of the buildup from the edge of the pipe.

Quantification of Diameter Loss

Determination of Diameter Loss

Aggregate height of Diameter

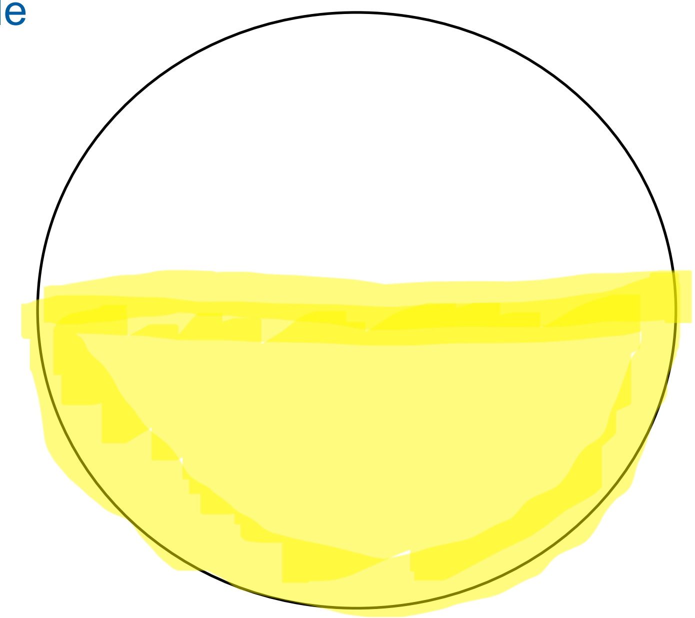
We can base our assessment on the narrowest area of the constriction. In this way, the maximum expected headloss, and therefore Risk, is assessed.

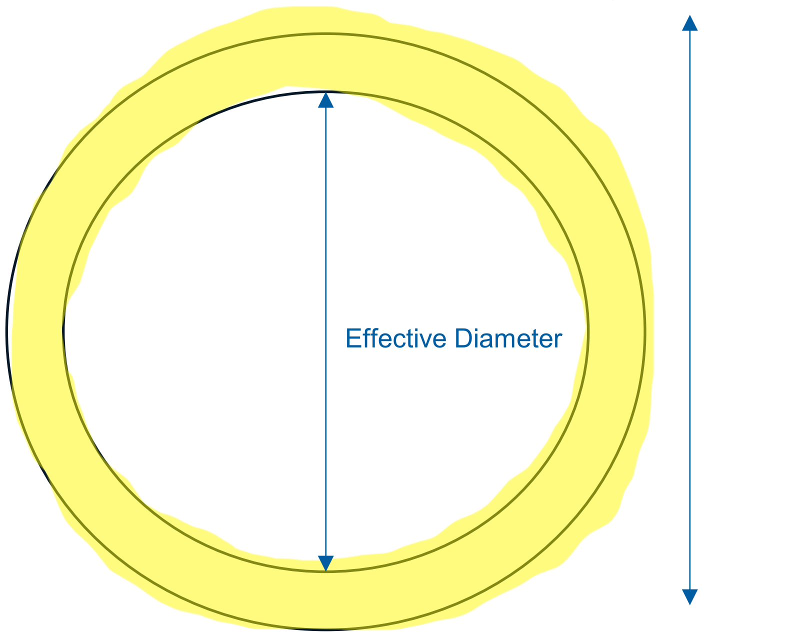
Quantification of Diameter Loss

Back to Basics:

Surface Area of a Circle

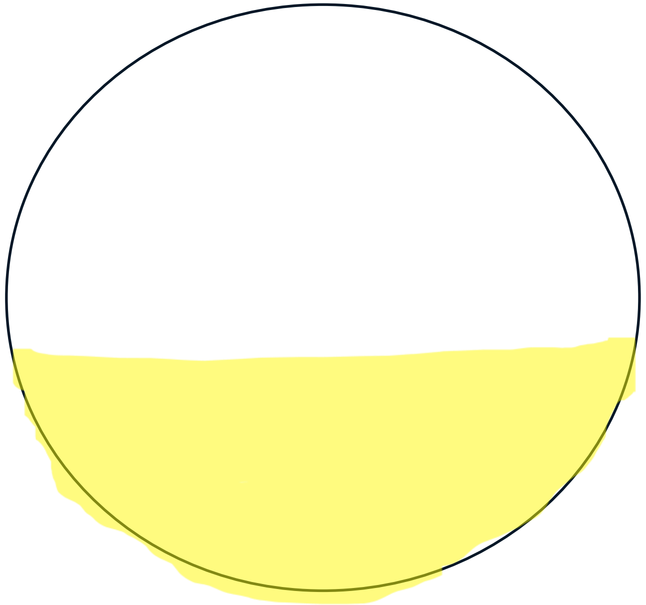
$$A = \pi r^2$$

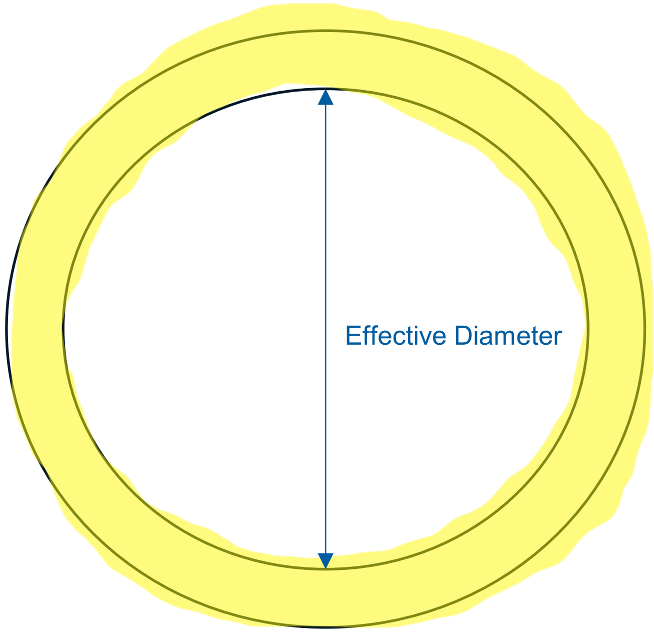




Quantification of Diameter Loss

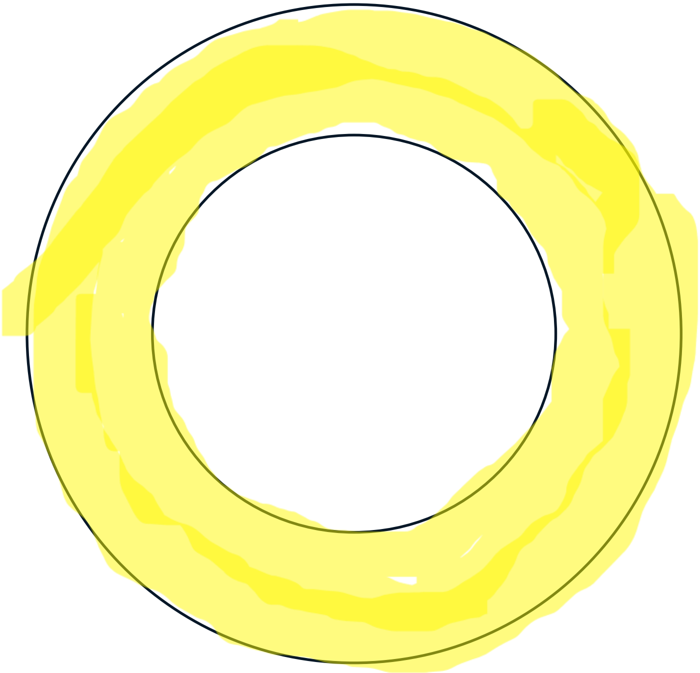
Examples





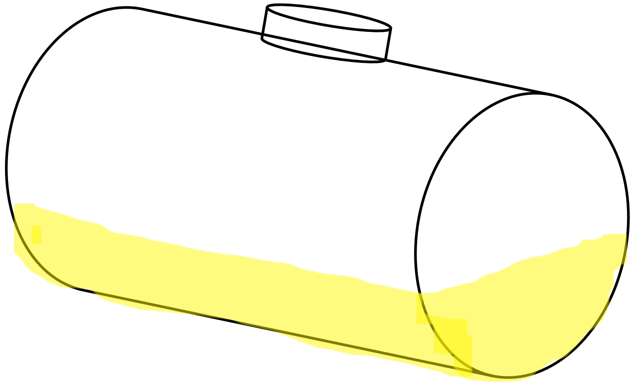
Quantification of Diameter Loss

Examples



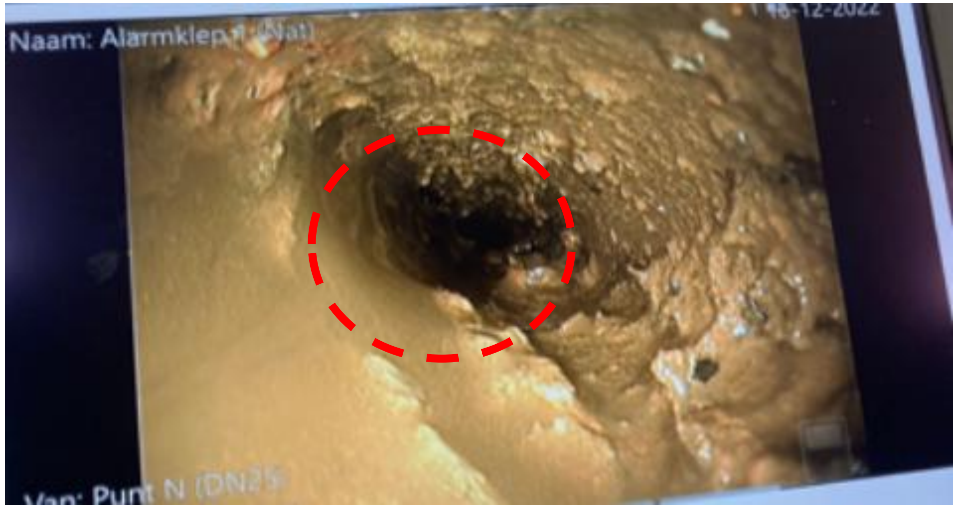
Quantification of Diameter Loss

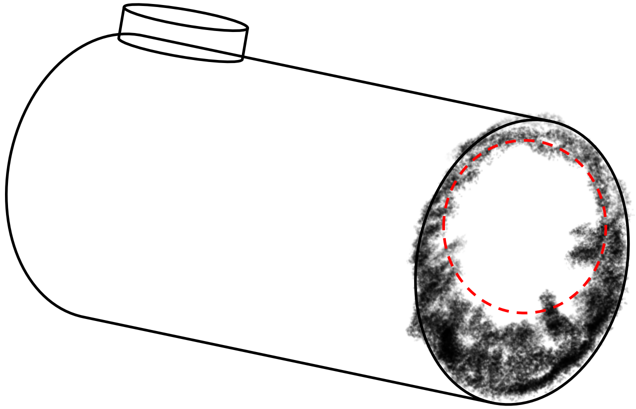
Examples



Quantification of Diameter Loss

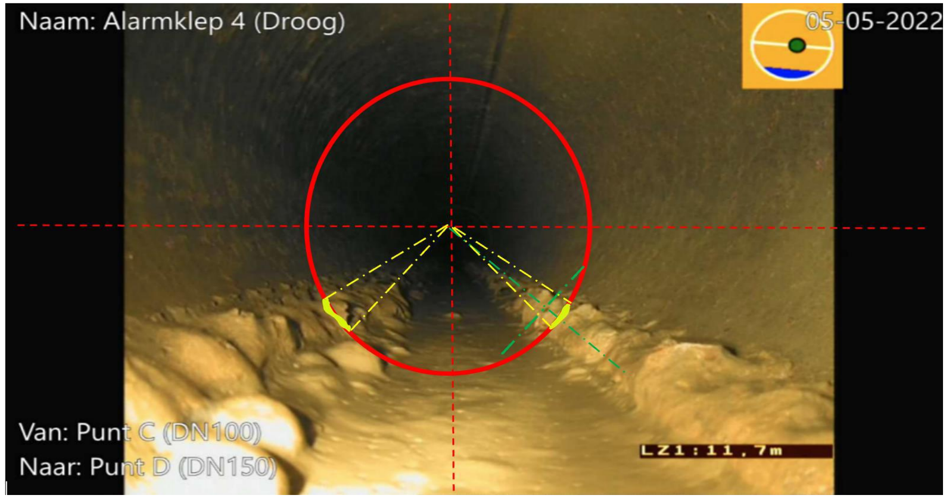
Examples





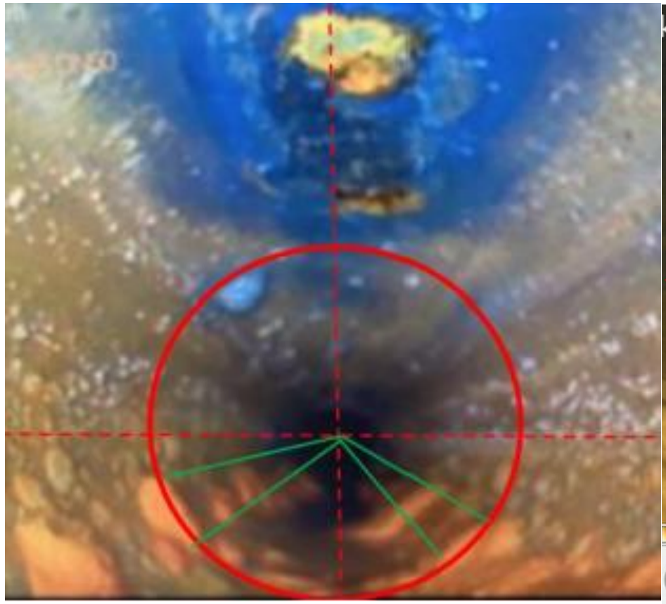
Quantifying Tubercles

Example



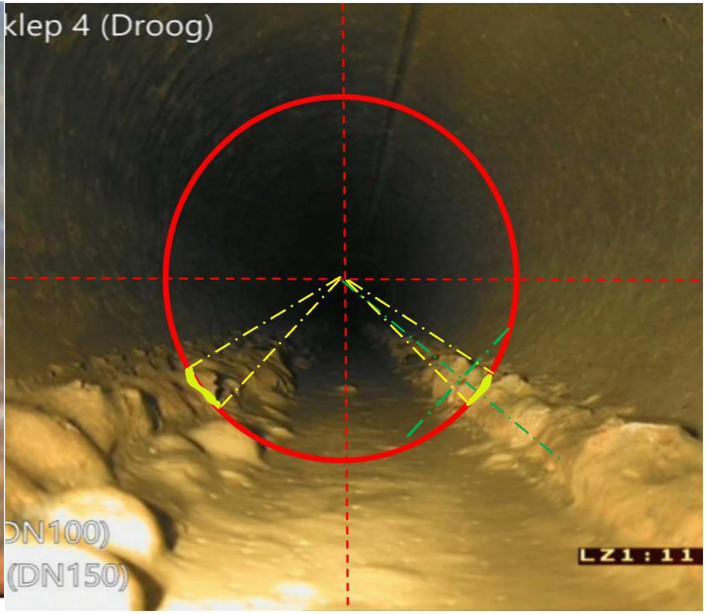
Parameter	Value
Diameter	100
Circumference Coverage Area	7%
Tubercle Height	5-7mm
Rows	2
Streamlining Gs	1

C-factor



DN50

C=91



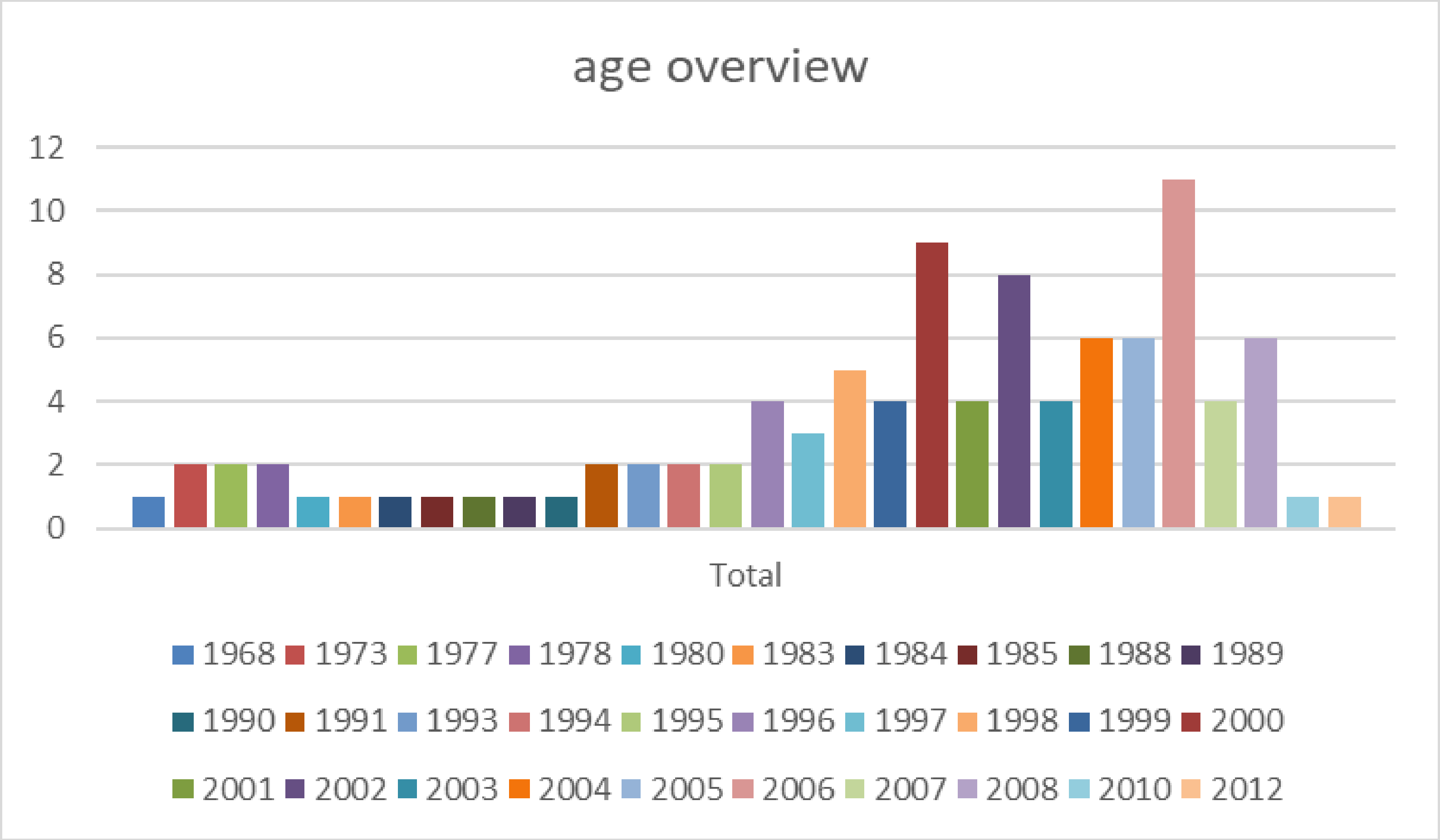
DN100

C=81

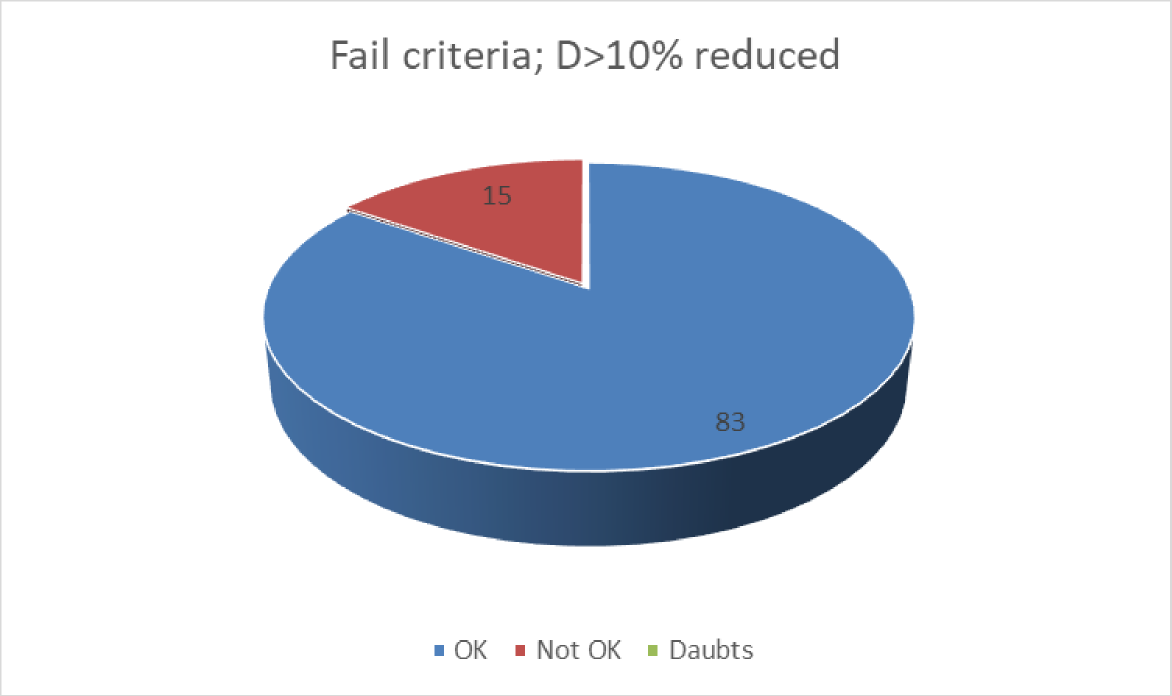
DN32

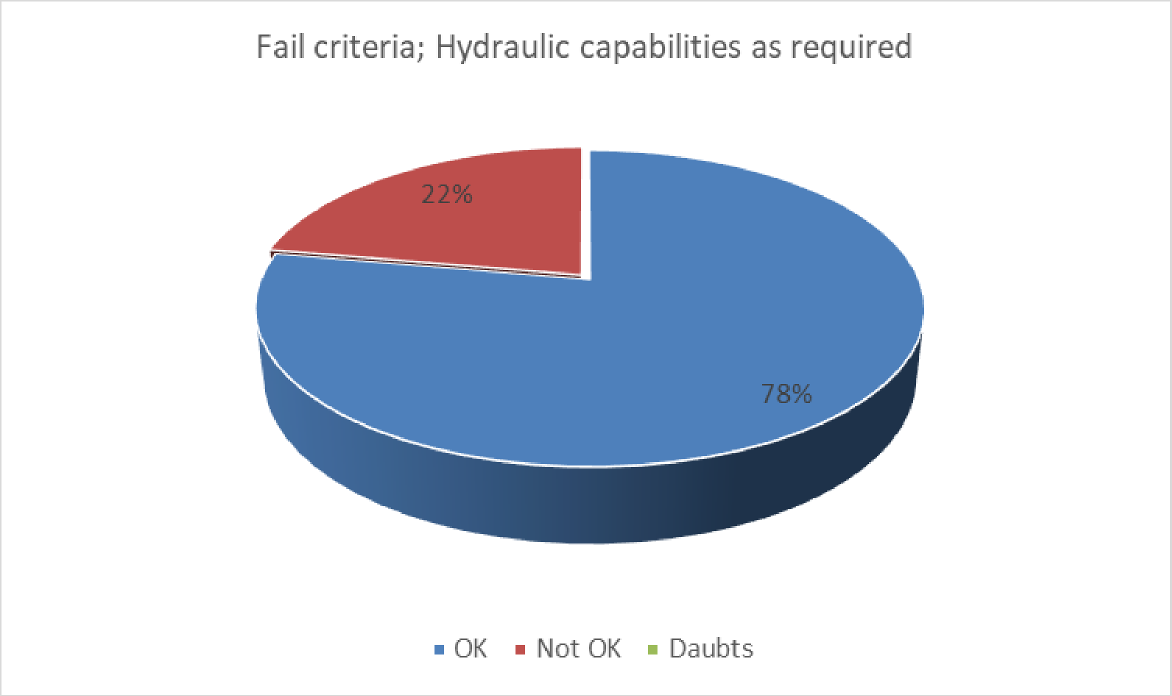
C=70

Inspection results

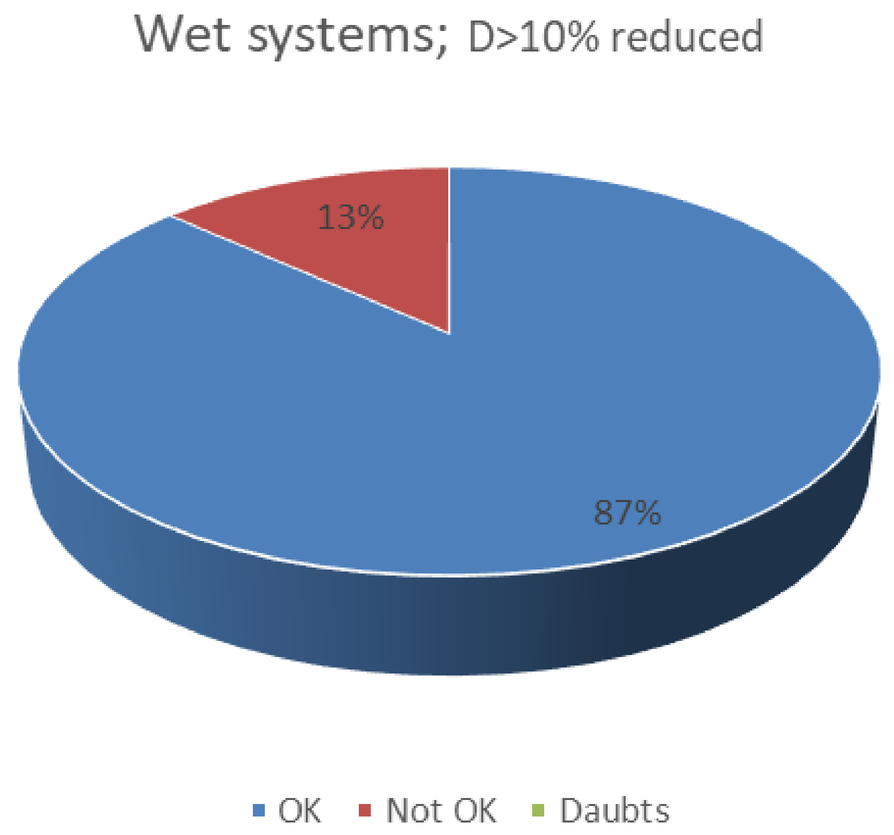


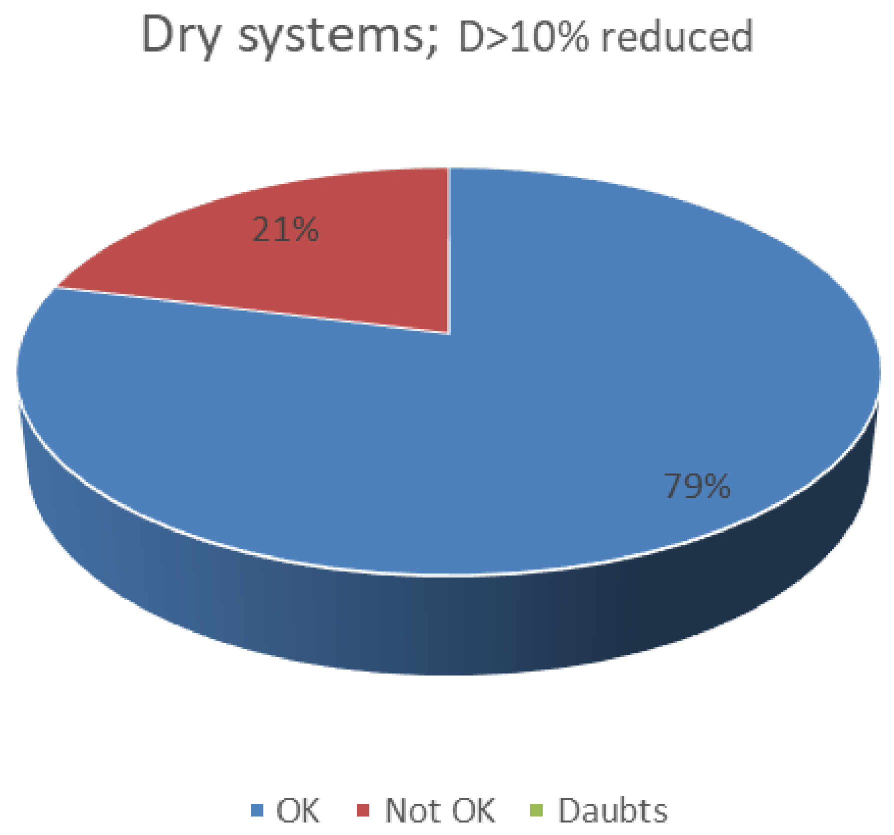
Inspection results





Inspection results





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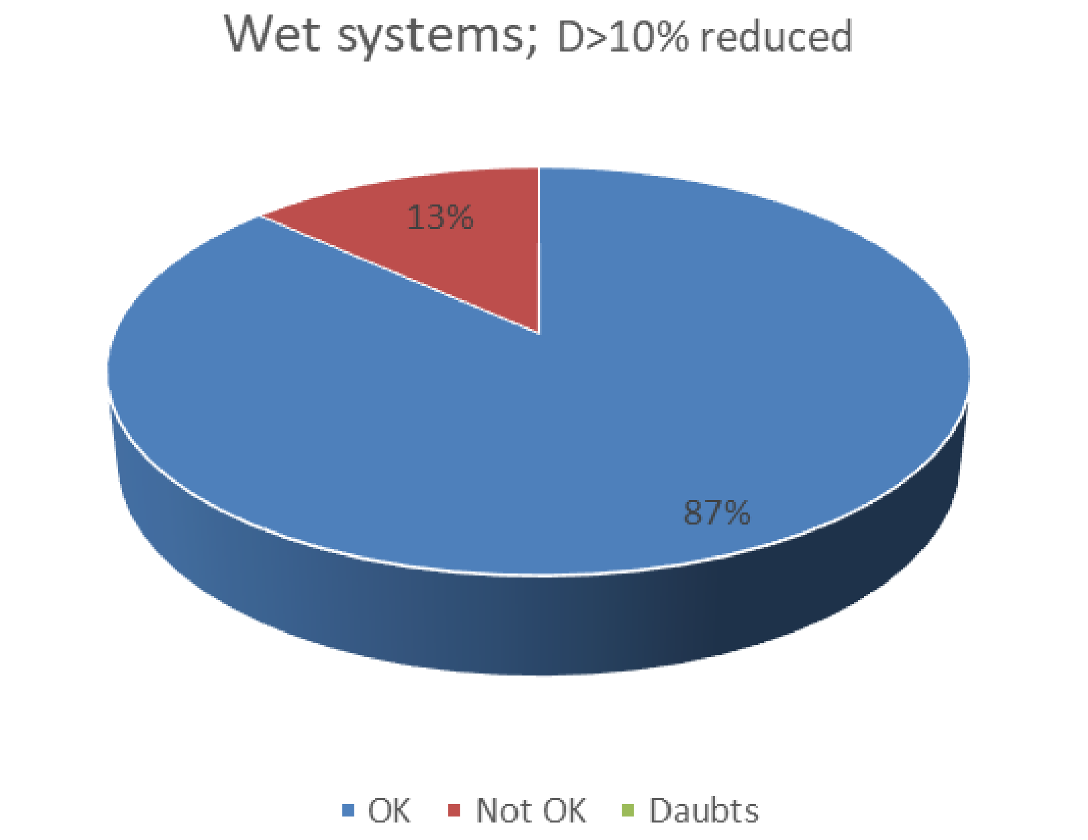
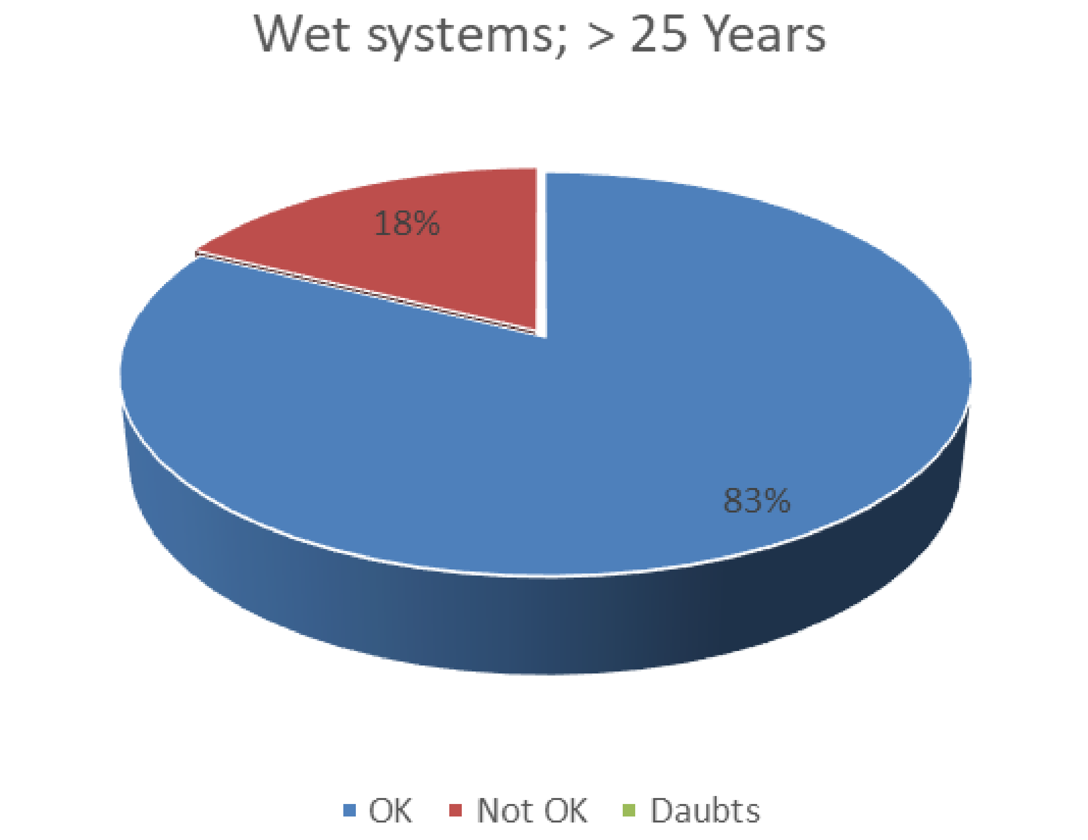
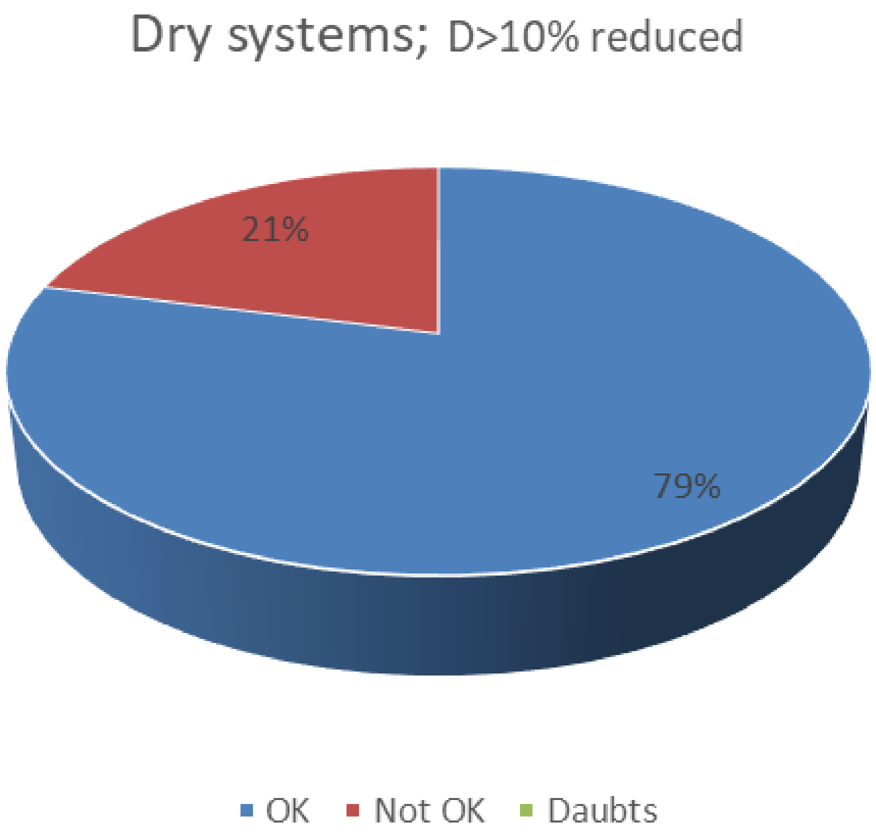
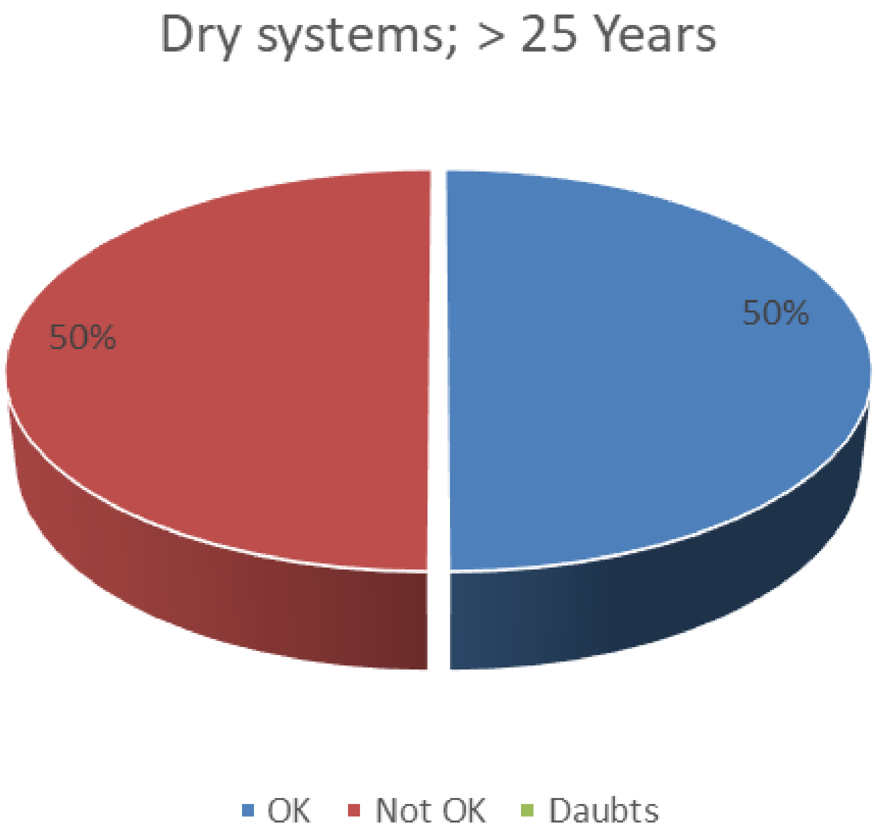
Inspection results





Inspection results





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Testing of aged sprinklers

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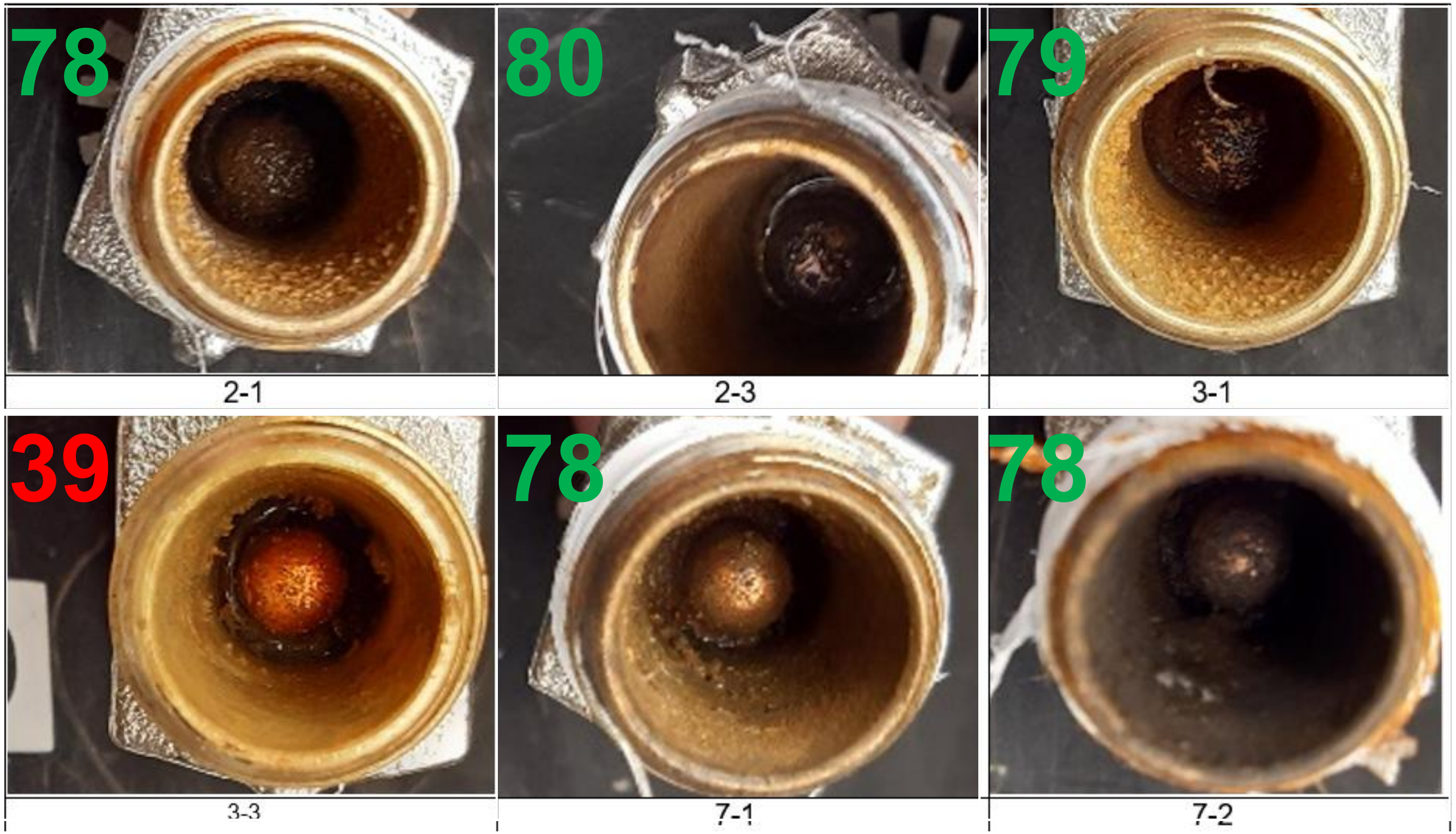
Dutch Inspection scheme

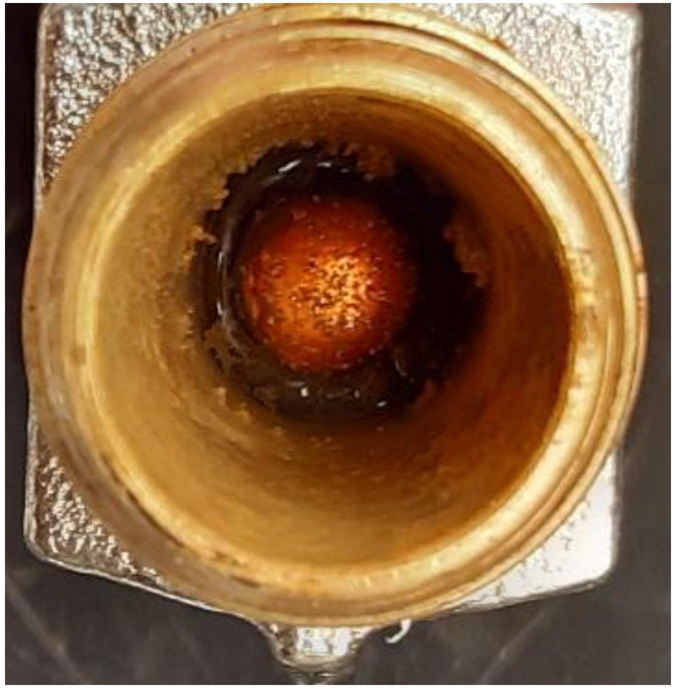
7.3.2.11	A3*	A3	Er is documentatie beschikbaar waaruit blijkt dat sprinklers/sproeiers op fabrieks-specificaties of in de frequentie volgens de van toepassing zijnde norm worden getest en eventueel worden vervangen.
	*Indien het een bestaande installatie betreft.		

Documentation shall be available demonstrating that sprinklers are tested to factory specifications or at the frequency specified by the applicable standard and replaced as necessary.

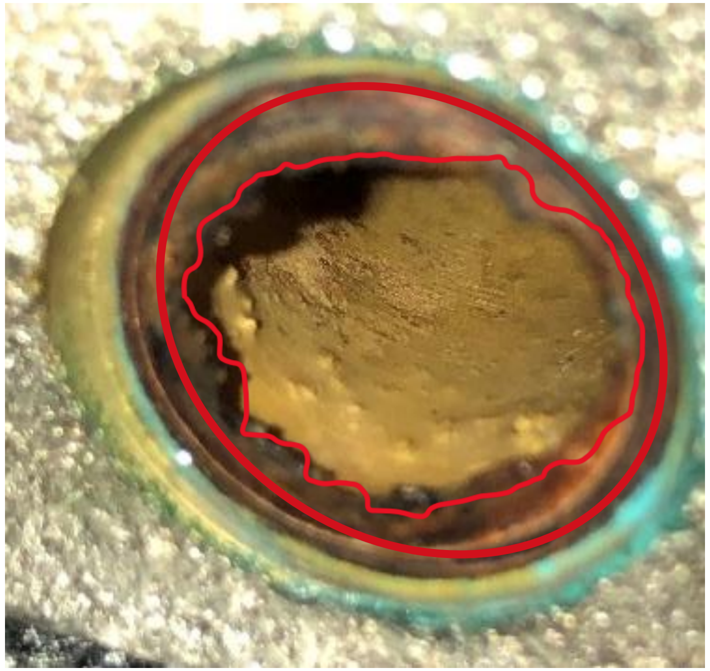
Why testing?

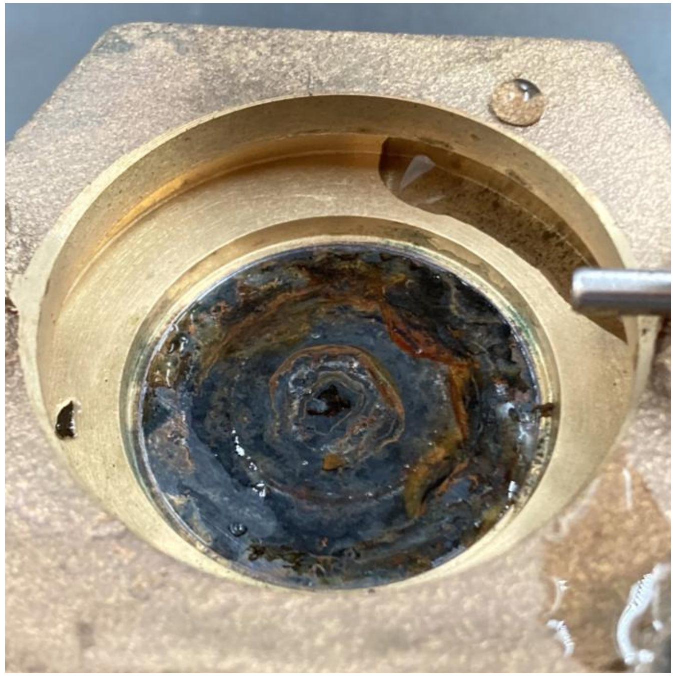


Why testing?



#3-3 (K80)





ESFR K202 (K14)

Field Service Test

- How to test

Field Service Test of sprinklers based on:

- EN 12259-1; Fixed firefighting systems - Components for sprinkler and water spray systems - Part 1: Sprinklers

Sprinklers in EU have been tested by this norm (CE-requirements). By using the same tests we can compare the results.

Possible test methods:

- **VdS2091**
  - VdS ratings and criteria (much broader than type approval)
  - batch sampling: 20% liquid bath (ESFR>20% RTI) and 80% functional and water flow test
- **Nordics** (sample rate 25 per 5000 installed sprinklers)
  - VdS ratings and criteria for openings temperature, functionality and water flow
  - NFPA 25 criteria for thermal sensitivity (RTI)
  - batch sampling: 4 spr. liquid bath; 16 spr. functional and water flow test and 5 spr. RTI.
- **Specific customer requests**

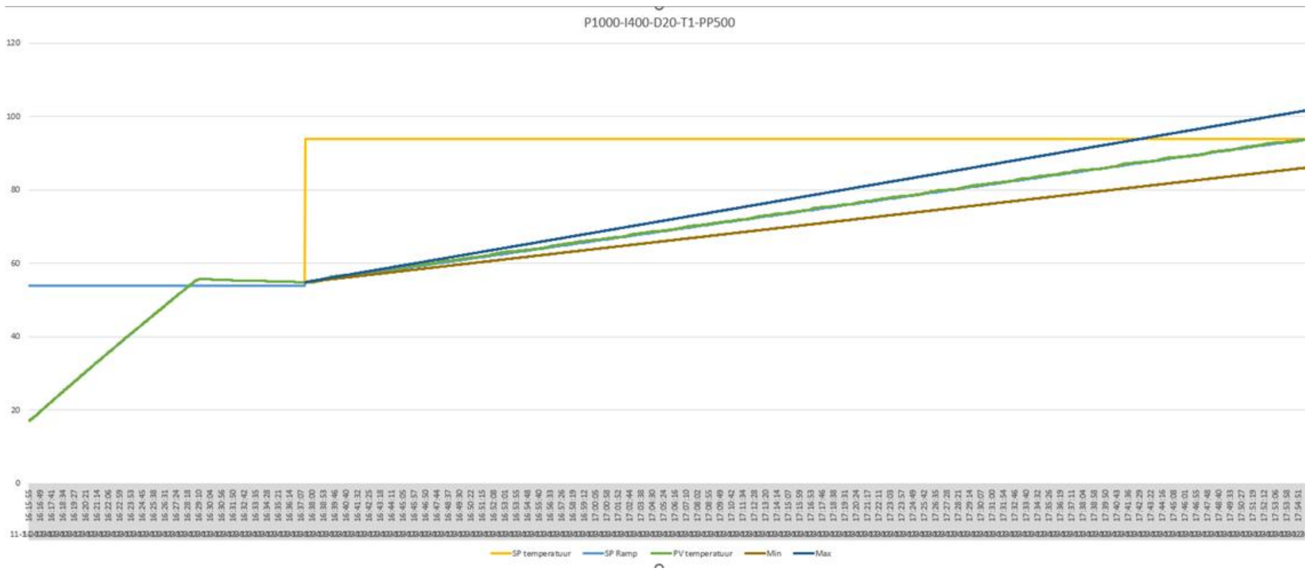
Scope of Tests

- Field Service Test
  - Operating temperature (Annex B)
  - Functional test (Annex E)
  - Water flow test (Annex C)
  - Thermal response tests (Annex N)
  - Water distribution test (Annex D) (construction facility started)
  - All others @ Kiwa Apeldoorn

Test Operating temperature

EN 12259-1 Annex B

- Test to determine operating temperatures of fusible link
- sprinklers and glass bulb sprinklers



Functionele test

Enclosure with heat gun to increase the temperature at the sprinkler at a rate equivalent to 400ºC in not more than 3 min.

- Visual findings:
  - Activation
  - Blockage
  - Lodgement

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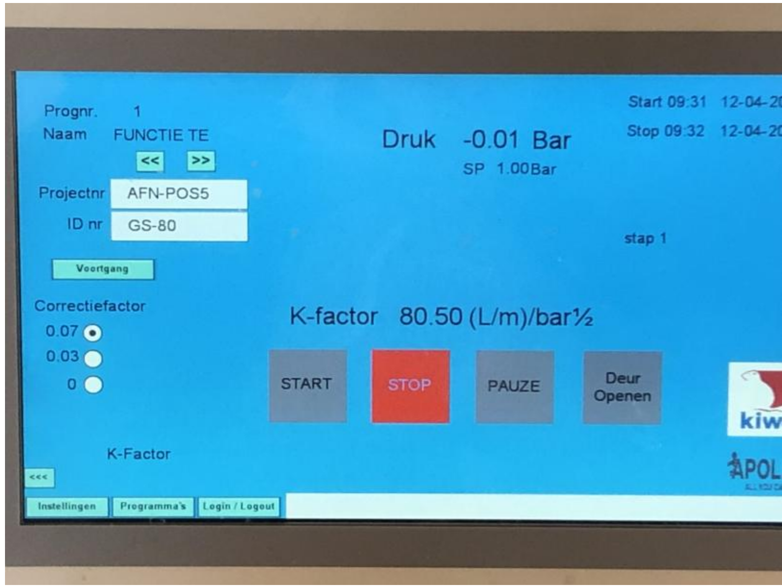
Water flow test

EN 12259-1 Annex C

- Measuring Flow and Pressure to calculate Flow constant by:

- K=Q/√P
  - Q [l/min]
  - P [bar]



Thermal response tests

EN 12259-1 Annex N

Wind tunnel

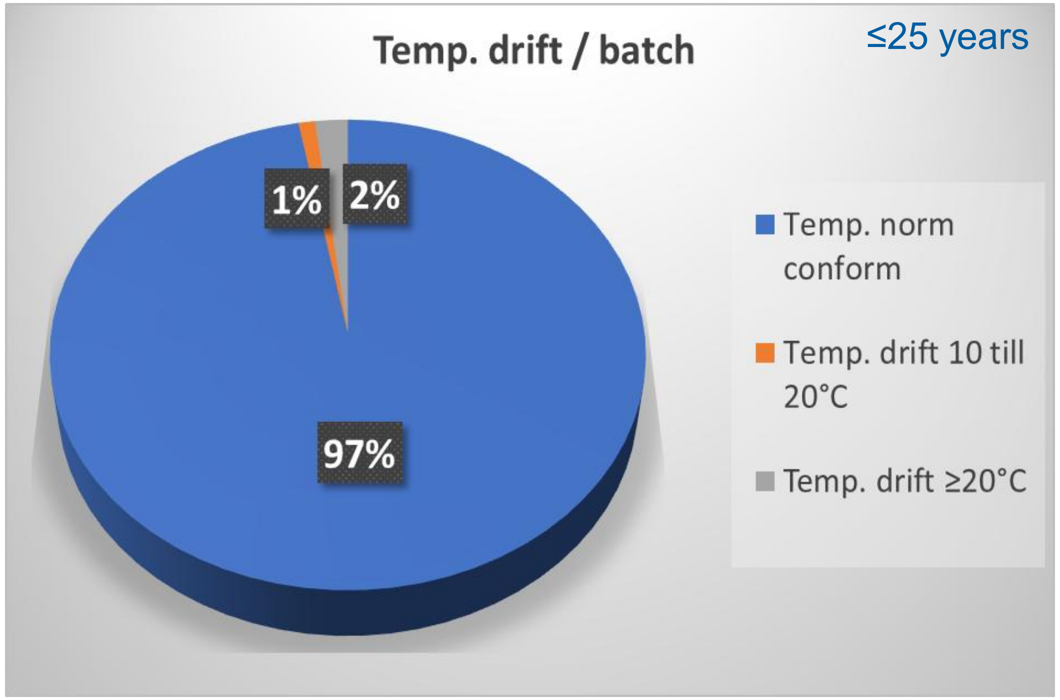
Activation of sprinklers by plunging the sprinklers into a hot air flow.

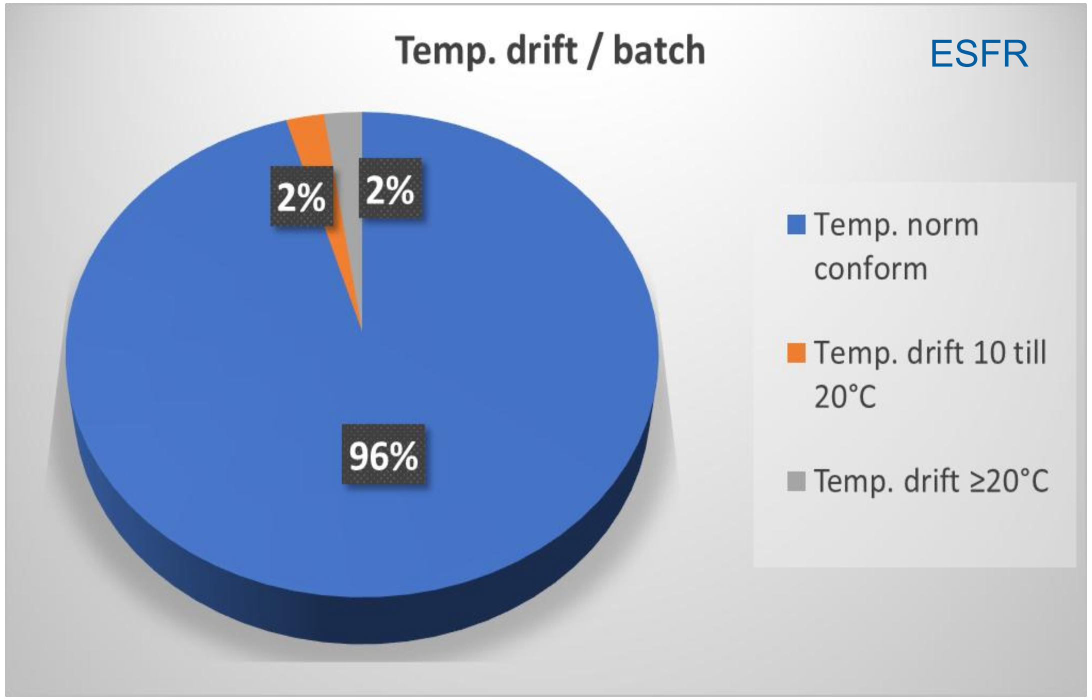
Measuring the time of activation and calculate RTI.

Accredited service

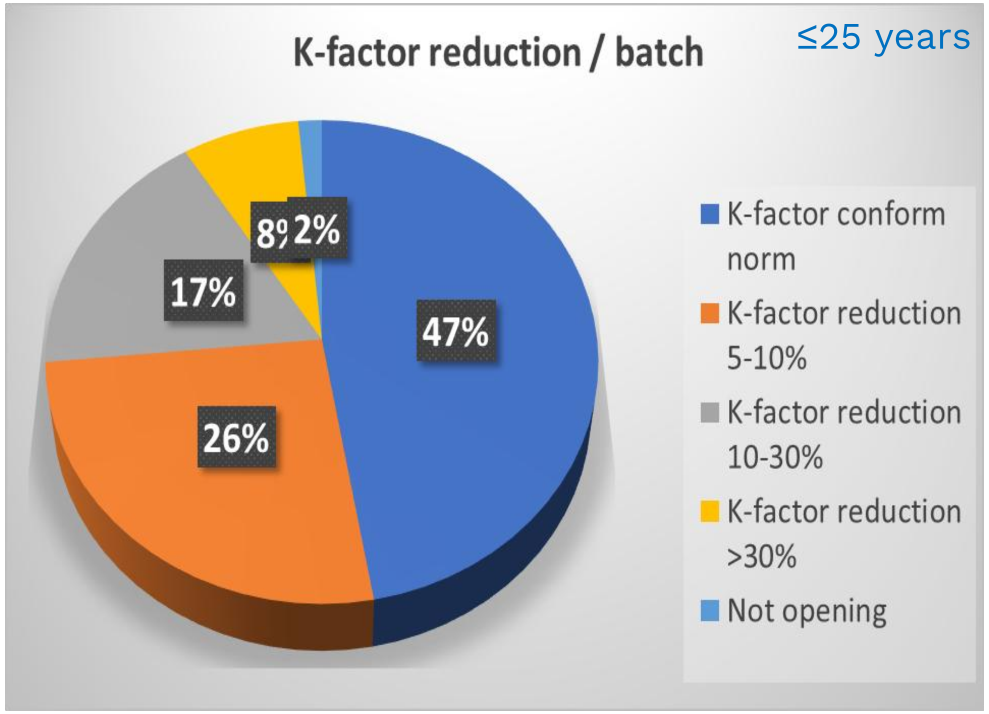
No.	Material or product	Type of activity[1]	Internal reference number	Location
h.	Fire safety components and materials Early suppression Fast Response sprinkler (ESFR) Fast-response sprinkler Special-response sprinkler Standard-response sprinkler	IRN 701, IRN 702, IRN 703, IRN 704, IRN 705, IRN 706	ISO 6182-1 ISO 6182-1: 2014 ISO 6182-1; 2004 ISO 6182-1: 2021 ISO 6182-7 ISO 6182-7; 2020 ISO 6182-7; 2004 EN 12259-1, EN 12259-1; 1999+A1; 2001, A3: 2006, EN 12259-1; 1999+A1; 2001, A2: 2004, EN 12259-1; 1999+A1; 2001, EN 12259-1; 1999 VdS 2091	ZA

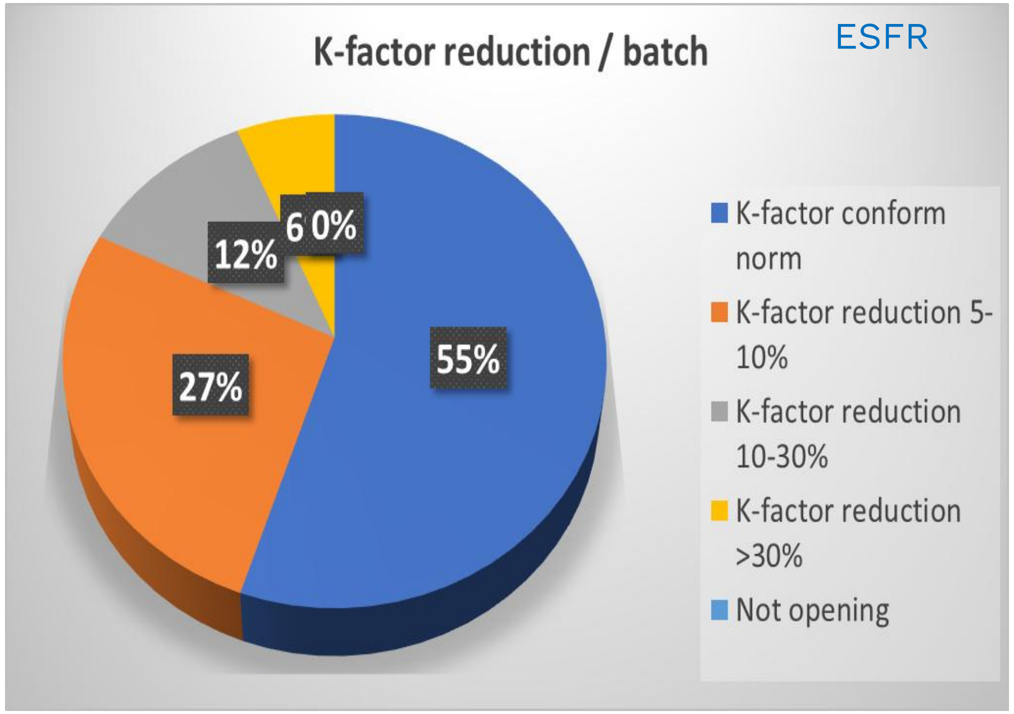
Test results opening temperature



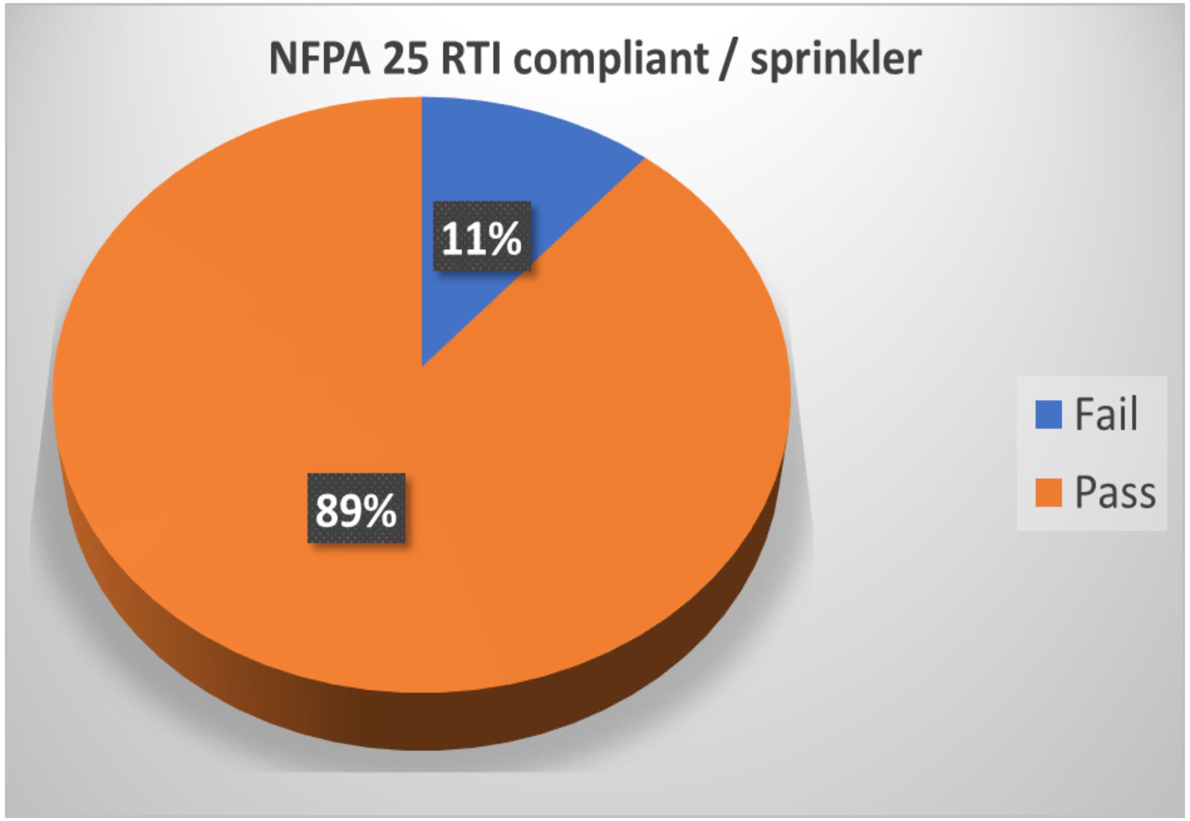


Test results K-factor reduction per batch





Test results sensitivity



Take away from this presentation

- Internal monitoring of aged sprinkler installations is necessary to identify issues in time.
- Dry systems degrade faster than wet systems.
- Visual inspections of sprinklers is not sufficient to identify function loss.
- Severe K-factor reduction is a worrying problem for aged sprinklers
- O-ring sprinklers need extra attention, on monitoring there functionality.
- When performing internal inspection and sprinkler testing, clear sampling rates, sampling volumes and pass/fail criteria are necessary.

Short video on sprinkler testing

Questions

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