REHVA

Hygiene in potable water installations in buildings - Requirements for design, deployment, operation and maintenance

Dr. Christian Schauer

Hygiene in potable water installations in buildings

Authors:

- C. Schauer (Dr., Viega Technology GmbH & Co. KG, Head of Drinking Water department, **Germany**)
- K. Dinne (Belgian Building Research Institute, Head of Laboratory Microbiology and Health, **Belgium**)
- W. van der Schee (Concept developer, Croonwolter & Dros, **Netherlands**)
- J. Mampaey (Managing Director, Studieburo Herelixka, **Belgium**)
- I. Gatto (Viega Technology GmbH & Co. KG, Business Manager, **Italy**)
- J. Perackova (Dr., University of Technology Bratislava, Department of Building Services, **Slovakia**)
- D. Petras (Professor, Dr., University of Technology Bratislava, Department of Building Services, **Slovakia**)
- B. Bleys (Belgian Building Research Institute, Head of Laboratory Water technologies, **Belgium**)

Hygiene in potable water installations in buildings

Reviewer:

- Tālis Juhna (Professor, Dr., Vice-rector for Research, **Latvia)**
- Davor Ljubas (Professor, Dr., Univerity of Zagreb, Head of Chair for water and environmental engineering, **Croatia**),
- Mario Cerroni (Dr., National Institute of Health (ISS), Rome, **Italy**)
- Ilari Aho (Uponor, VP New Business Development & CSR, **Finland**)

Hygiene in potable water installations in buildings

Scope:

- **hygiene** means the totality of all efforts and measures taken to prevent direct or indirect impairments of health and well-being (discomfort) in individual users.

- maintaining the proper water quality within the water installation in buildings

Hygiene in potable water installations in buildings

Scope:

- main informations on the design, installation, start-up, use, operation and maintenance of water installations in buildings

- sensitizing of designers and technicians for the topic hygiene in water installations in buildings

- suggestions for the practical work (maintenance, effects on microbiology, potential causes and measures in practical work, checklists)

Hygiene in potable water installations in buildings

Content/Chapters:

- **drinking water directive (98/83/EC): the proposal of revision (risk analysis, WSP)**
- **terms and definitions**
- **abbreviations, designing symbols**
- **fundamentals of hygiene and water quality**

  physico-chemical water quality

  water quality and microbiology – microorganisms/biofilms/VBNC/nutrients

  maintaining water quality

  biostability in networks

Main causes of contamination

- Improper storage and transport of components (damaged packaging of components)
- improper design (over-dimensioning of storage and pipes)
- disuse (empty residences, vacation)
- stagnation (dead legs)
- components infected during inappropriate manufacturing processes (e.g. improper lubricant, hygiene)

Source: Exner u. Tuschwitzki, 1984

Main causes of contamination

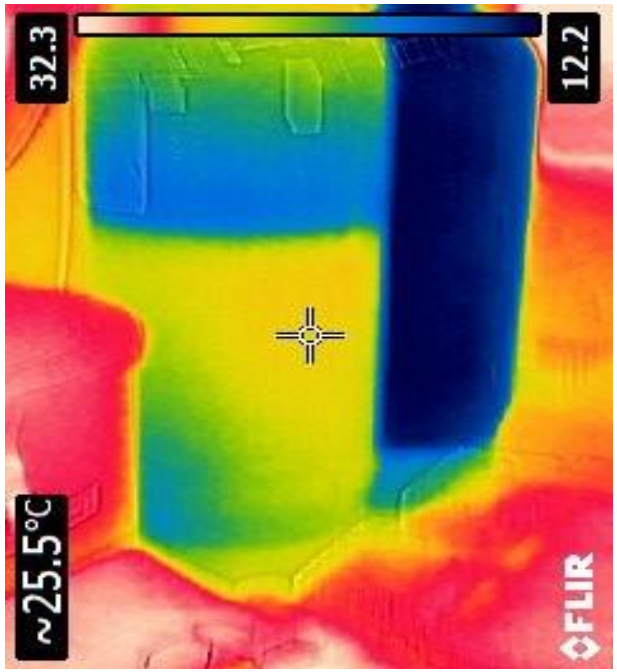
- corrosion damage or significant limescale in the pipes
- temperatures below 55 °C in the hot water system
- temperatures in excess of 25 °C in the cold-water system
- sources for nutrients, e.g. polyphosphate by dosing corrosion inhibitors
- lack of regular inspection and maintenance

Technical deficiencies

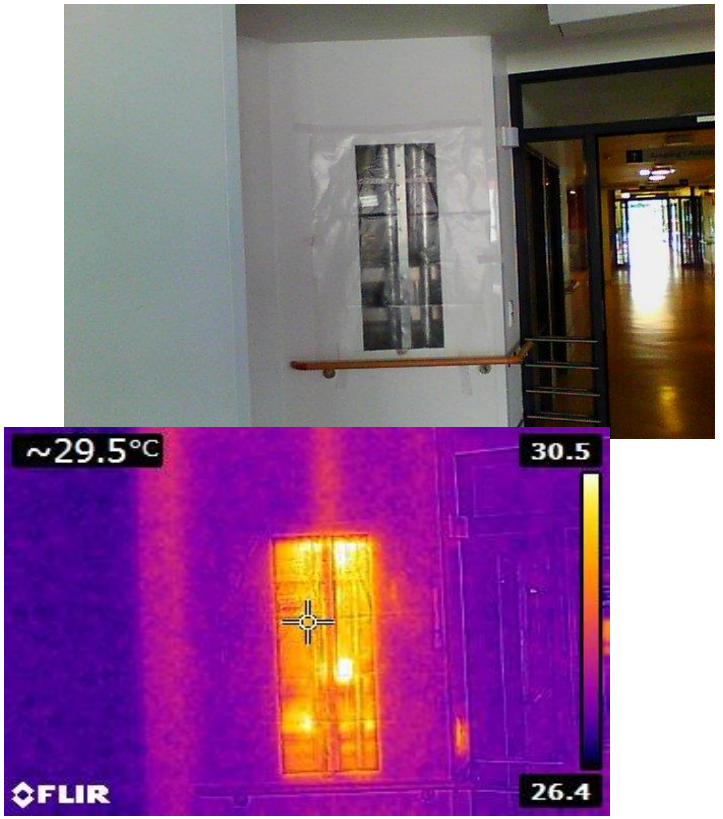
transportation to the construction site

Hygiene at the construction site?

Technical deficiencies

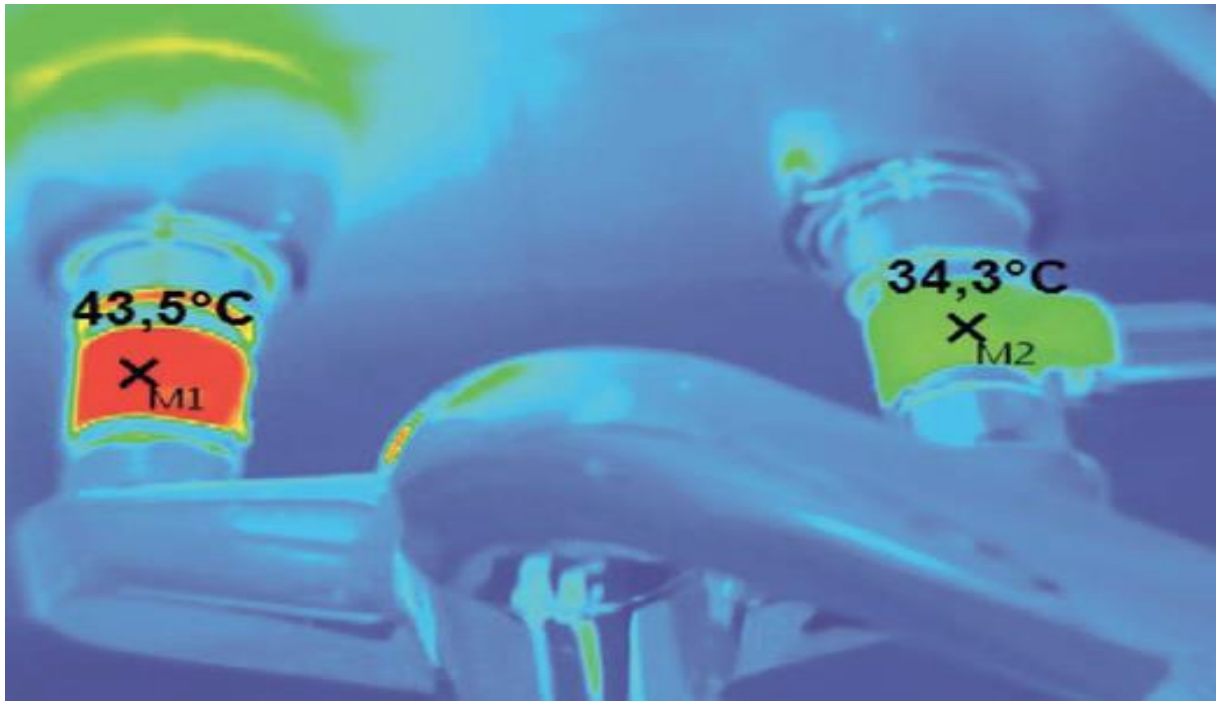


Room temperature higher than 25 °C – softener before dialysis (medical centre)

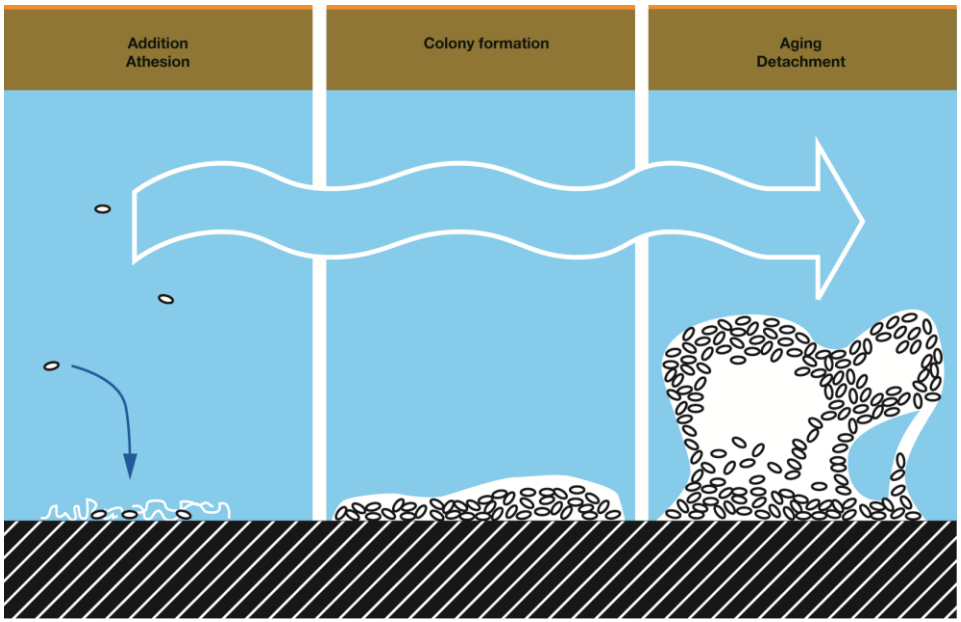


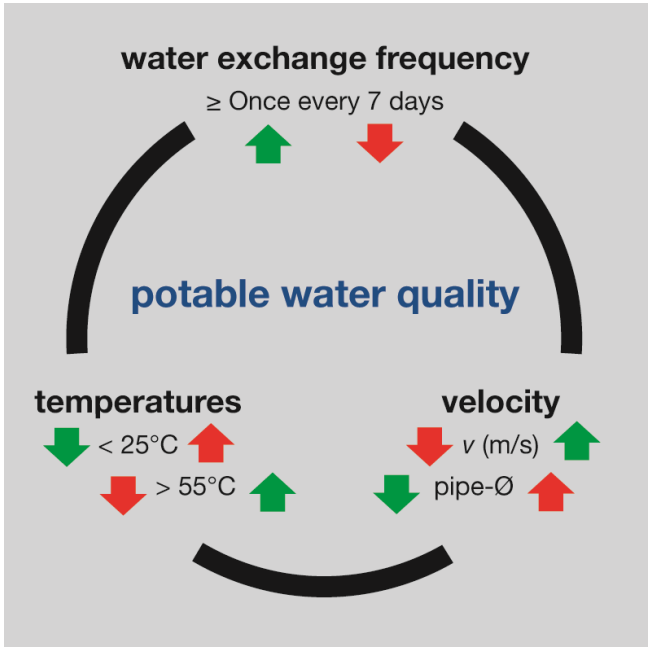
Heat from PWC-H circulation to the wall – danger for PWC

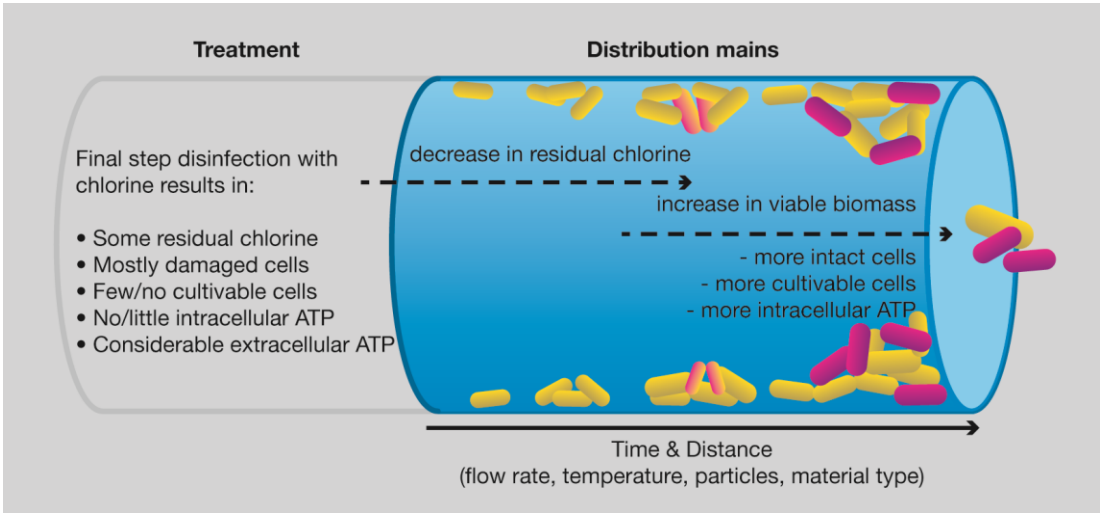
Technical deficiencies



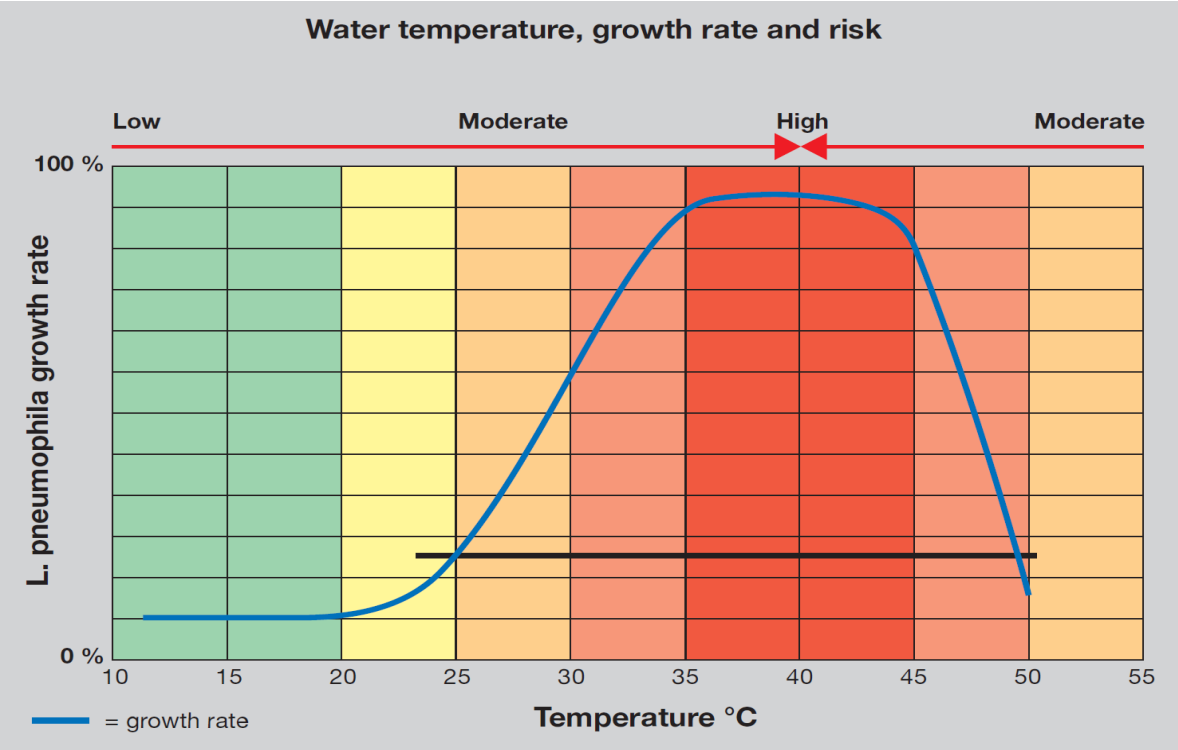
Heat transfer from PWH to PWC via extraction fitting – direct connection to the circulation


Addition
Athesion
Colony formation
Aging
Detachment


water exchange frequency
≥ Once every 7 days
potable water quality
temperatures
< 25°C
> 55°C
velocity
v (m/s)
pipe-Ø


Treatment
Distribution mains
Final step disinfection with chlorine results in:
• Some residual chlorine
• Mostly damaged cells
• Few/no cultivable cells
• No/little intracellular ATP
• Considerable extracellular ATP
decrease in residual chlorine
increase in viable biomass
- more intact cells
- more cultivable cells
- more intracellular ATP
Time & Distance
(flow rate, temperature, particles, material type)

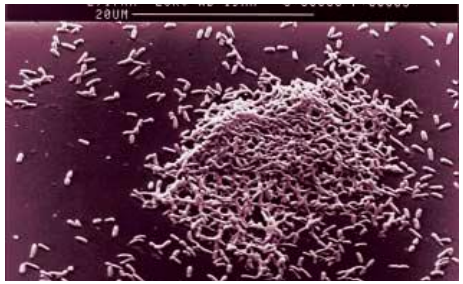
Legionella - Growth temperature



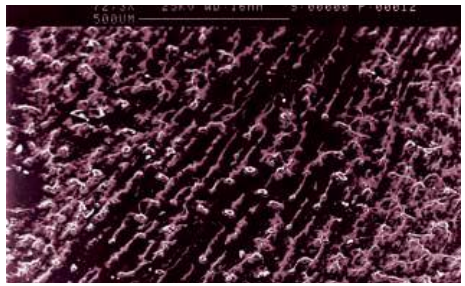
Water temperature and legionella growth rate (according to *Exner M. 2009*): Colors in the diagram represents the relative health risk from red (high) to green (low); Black line defines the temperature range of the best legionella growth rate.

Sufficient flow - Biofilm

- Stagnation - loose biofilm
- **Sufficient flow - stable biofilm**
- Strong change in flow velocity after several years of use: Biofilm can be pull off, bacterial contamination is possible!



Pseudomonas-Biofilm 0,03 m/s



Pseudomonas-Biofilm 1 m/s

VBNC - viable but not culturable

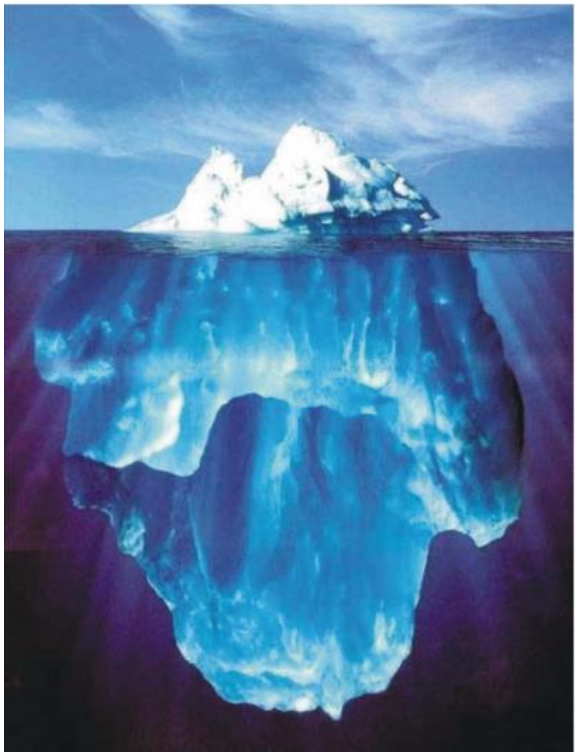
- Slower growth rates of bacteria in the biofilm. The bacteria partially show a reduced metabolism - **survival strategy** (known since 1991)

- **stressors for the cells**:
  lack of nutrients, high temperature, osmotic pressure, presence of biocides, lack of oxygen, pH value, radiation

VBNC - viable but not culturable

- **overestimation of effectiveness of disinfection**

- suitable conditions are generated again: **bacteria can reproduce again**, i.e. they can be cultivated and can be infectious.



Source: *H.-C. Flemming 2010*

Hygiene in potable water installations in buildings

Content/Chapters:

- **design, assembly and start-up:**
  design rules (sanitary room book)
  structural requirements – avoiding hot spots/PWC
  dimensioning and pipe routing
  selection of materials
  corrosion and scaling
  operating instructions, maintenance plans
  monitoring of parameters
  transport, storage and construction
  assembly, leak-test and start-up

Sanitary room book

Room Book:

Construction section:	Construction phase 3
Level:	1st upper floor
Room:	126
Name of room:	Doctor's consulting room
Type and frequency of use:	Medical examination of patients; washbasin for the doctor. Used one to five times a day, never in the weekends.
Equipment:	Washbasin: ceramic washbasin, standard 1 pc single lever wall fitting, 1 pc (PWC 0.07 l/s, PWH 0.07 l/s)

Minimum consumption to be expected:

n	PWC	PWH	PWC	PWH
1/day	Litres	Litres	Litres/d	Litres/d
Washbasin 2	1.0	1.0	2.0	2.0
Total water-consumption, min.			2.0	2.0

	The daily water exchange is guaranteedby the WC system of the staff
Design of the installation:	
Potable waten cold:	Connection via double wall plate
Potable water hot:	Ejection via double wall plate, nominal pipe diameter 16 x 2.2 mm as series installation, ejection time < 10 seconds / >55°C
Notes on maintenanoe:	The flow control at the washbasin wall tap must be checked/replaced once per year

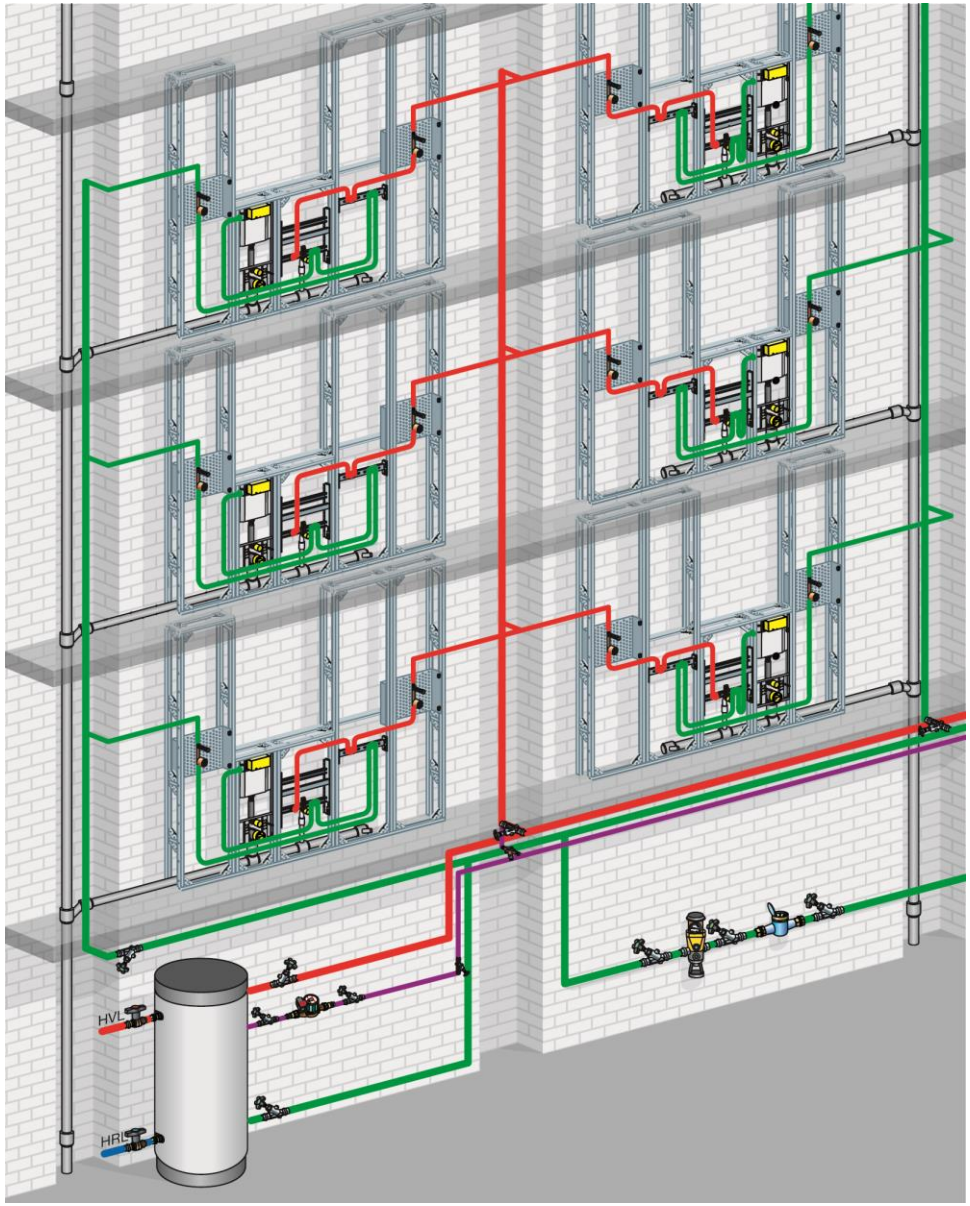
Protection of potable water

Category 1	Water for human consumption withdrawn directly from a potable water installation - no protection required
Category 2	Liquid which poses no risk for human health. Liquids which are suitable for human consumption, including water from a potable water installation which may exhibit changes in terms of taste, smell, colour, or temperature (temperature increase or reduction) - as a minimum, a testable backflow preventer type EA (e.g. in the house inlet installation)
Category 3	Liquid which poses a risk to human health due to the presence of one or more harmful substances - system divider of type CA
Category 4	Liquid which poses a risk to human health due to the presence of one or several toxic or very toxic substances or one or several radioactive, mutagenic, or cancerogenic substances - system divider of type BA
Category 5	Liquid which poses a risk to human health due to the presence of microbial or viral pathogens of transmissible diseases - free outlet of type AA or type AB

Plumbing materials

Material pipe system	Reference documents
Copper	Pipes: EN 1057 Fittings: EN 1254
Stainless steel	Pipes: EN 10312
Galvanised steel	Pipes: EN 10255 + EN 10240 Fittings: EN 10242
PE	Pipes and fittings: EN 12201
PVC-U	Pipes and fittings: EN ISO 1452
PVC-C	Pipes and fittings: EN ISO 15877
PEX	Pipes and fittings: EN ISO 15875
PP	Pipes and fittings: EN ISO 15874
PB	Pipes and fittings: EN ISO 15876
Multilayer	Pipes and fittings: EN ISO 21003

Example for a potable water installation with horizontal distribution lines and separated shafts for potable water hot (PWH) and cold (PWC); red lines: potable water hot PWH; purple line: potable water cold PWH-C; green lines: potable water hot circulation PWH-C; HVL: feed line of the heating system; HRL: return line of the heating system [Schauer et al. 2018].



Hygiene in potable water installations in buildings

Content/Chapters:

- **use and mode of operation:**

  measures in case of interruptions

  of operations, sampling (control points), disinfection
- **maintenance**

  preventive maintenance, inspection, corrective maintenance, improvement

  engineering and hygienic deficiencies

  refurbishment
- **checklists** (maintenance, hygiene plan, measures, hygienic working)

Intended operation

Duration of the interruption of operation	Measures at the start of the interruption	Measures at return (end of interruption)
≥ 4 hours to 3 days	None	Allow stagnant water to drain until the temperature is constant
	Interruption of operation	
Up to max. 4 weeks	Closing the shut-off valve downstream of the water meter system	At recommissioning, full water exchange at all draw-off points by flushing with water
> 4 weeks	At closing, leave the shut-off systems filled (do not drain!)	Recommissioning by specialist companies, flushing with water*
	Closing the shut-off valve	
> 6 months	At closing, leave the shut-off systems filled (do not drain!); drain in case of imminent frost	Recommissioning by specialist companies, flushing with water*, microbiological control examinations (potable water, hot and cold) and for *Legionella* (potable water, hot and cold)
> 1 year	Disconnection of the connection lines directly at the supply line by a specialist, report to the water supplier	
	Conversion: Removal of now redundant parts of the potable water installation by dismounting them directly at the supply line where flow-through will still be present in intended operation.	
	Reconnection by a contractor	

Technical deficiencies

Type of deficiency	Deviation from	Potential effect on the microorganisms [a]						Comment
Use of unsuitable components	Technical rules (e.g. EN 806, EN 1717)		2	3	4	5	6	Depending on the type of unsuitable component
Defective components (e.g. hot water tank with decomposing coating, safety and safeguarding fittings)			2	3		5	6	With temperatures > 60 °C, the abnormality has no negative effects on microbiology
Connection to non-potable water systems	EN 1717		2	3	4	5		Exposure of the potable water to risks depending on the non-potable water connected to the installation
Critical temperature range (cold potable water > 25 °C, heated potable water in the circulation system < 55 °C)	CEN/TR 16355, EN 806-2		2				6	Lack of hydraulic balancing of the pipes in the circulation system, lack of thermal insulation of the pipes for cold or heated potable water, e.g. in the circulation system
Use of unsuitable materials	EN 16421		2	3		5	6	Depending on the type of unsuitable material
Missing or improper labeling of the pipes; disturbances	EN 806-4	1						There is the risk of impermissible connections with non-potable water systems, resulting in the following microbial disturbances
Non-intended use, stagnation, lack of regular flow-through of the pipelines	EN 806-2, EN 1717		2	3	4	5	6	Subsequent modifications to the potable water installation, e.g. excessively low consumption, water saving measures, stagnation
Slimy-sludgy coatings	EN 16421		2	3		5	7	Material not suitable for potable water
Connection of firefighting water or emergency water supply	DIN 1988-600		2	3		5		Insufficient water exchange, retroaction
Connection of eye and body showers	EN 1717		2	3		5		Insufficient water exchange, retroaction
Missing, defective, or improper safeguarding devices	EN 1717		2	3		5	6	Hazards for the potable water quality due to non-potable water and other factors
Unused pipelines, „dead legs“	EN 806		2	3		5	6	Extraction point has been removed

[a] Explanation on the table: 1 = none, 2 = heterotrophic plate counts, 3 = coliform bacteria, 4 = E. coli, 5 = Pseudomonas aeruginosa, 6 = Legionella spec., 7 = fungi and protozoa

Deficiency evident from:	Acute health risk	Comment	Immediate measure required
Use of unsuitable components	Possibly yes	Health risk depending on type of effect	Replace unsuitable components
Use of unsuitable pipeline components	Possibly yes	Depending on chemical or bacteriological examination	Restricted use because immediate measures are not available
Defective components (e.g. hot water tank with decomposing coating, safety and safeguarding fittings)	Possibly yes	Safety and safeguarding fittings must be operative	Replace defective components
Connection to non-potable water systems	Yes	Carry out bacteriological examination	Disconnect the systems
Missing or improper marking of non-potable water systems	No	Depending on other supply lines in the building	Attach markings
Critical temperature range (cold potable water > 25 °C, heated potable water in the circulation system < 55 °C)	Possibly yes	Depending on bacteriological examination	Temperature adjustments are required; increase the water exchange in cold water, carry out a hydraulic adjustment
Non-intended use	Possibly yes	Identify the type of deviation	Ensure use as intended
Stagnation No regular flow through the pipes	Possibly yes	No evaluation possible without a detailed examination and recording of the user behaviour	Disconnect the pipeline, or provide for regular and sufficient water exchange
Connection of potable water to the firefighting water system	Possibly yes	Clarify if necessary	Provide for regular and sufficient water exchange; separation of potable water/ fire extinguishing system
Missing or improper safeguarding device	Yes	Clarify extraction situation	Adjust the safeguarding device
Unused pipelines (dead legs)	Possibly yes	Extraction points removed	Disconnect the pipelines at the branch

Measures	*Legionella*	*Pseudo-monas aeruginosa*	Coliform count at 22 °C and 36 °C	Faecal load (*E. coli* and *enterococci*)
Operational				
Temperature level according to CEN/TR 16355 (potable water heater, piping system)	●	✖	✖	✖
Hydraulic balance (PWH-C)	●	✖	✖	✖
Ensuring use as intended, preventing stagnation	●	●	●	✖
Process-related				
System cleaning [C] Cleaning (with water or water/air mix)	✔ 🕘	✔ ●	✔ ●	✔ ●
Water exchange	O	O	O	●[A]
Chemical disinfection:				
System disinfection [D]	✔ O	✔ O	✔ O	●[A]
Potable water disinfection	🕘	O 🕘	O 🕘	● 🕘
Thermal disinfection System disinfection	✔	?	?	?
Final-stage filtration (bacteria-proof filter) [B]	🕘	🕘	🕘	🕘
Structural				
Downsizing the system to the required minimum dimensions ("lean system")	●	O	O	✖
Change of the pipe arrangement and dimensioning	●	✖	O	✖
Removing dead legs	●	●	●	✖
Thermal insulation	●	✖	O	✖
Replacement of system sections	O	●	O	✖
Removal of contaminated sources	O	●	O	✖
Compliance with EN 1717 (e.g. keeping potable water installations separate from non-potable water installations)	✖	✖	●	●

● = mandatory measure
O = suitable as a supportive measure
🕘 = intermediate measure for safeguarding the potable water quality
✔ = preparatory measure for refurbishment or for disinfection of the system or the potable water
✖ = unsuitable or impractical
? = effect unknown

[A] after successful refurbishment of the external contamination source
[B] under compliance with manufacturer's specifications regarding service life, replacement, handling, intended use, resistance to chemicals, validated for the intended use
[C] mandatory measure when preparing for system or potable water disinfection
[D] precondition when preparing for potable water disinfection

Maintenance

- **Preventive maintenance**: all measures (exchanging, cleaning, etc.) intended to retain the specified condition of an item so as to prevent any defect and avoid potential hazards.

- **Inspection**: all measures serving to establish and assess the ac-tual condition of an item

Maintenance

- **Corrective maintenance**: all measures (changing, repairing, refitting, cleaning, replacing) intended to restore the specified condition of an item.

- **Improvement**: only such measures as improve the hygiene condition of the potable water installation, rather than measures improving comfort.

Potential causes and remedial measures in practical work

Cons. no.	System component	Causes	Measures
1	Pipe internal surfaces	Incrustation, scale formation	a) Intermittent flushing b) Replacement of the pipelines
	Fittings and pipelines that have become obsolete	Stagnant sections	Remove
	Pipelines with stagnant water	Stagnant section (little used and longer than 10 x DN)	Remove or include as a series or ring system
	Potable water pipelines cold, hot, and closed circuit	Temperatures more than 25 °C less than 55 °C	Temperature measurements with temperature sensor a) Forced flushings b) Intended use c) Hydraulic balancing
2	Thermal insulation of cold, hot, and circulation pipes	Missing or insufficient insulation	Addition or refurbishment of insulation
3	Main service connection	No backflow preventer	Retrofit
		Bypass lines without regular flowthrough	Remove
4	Water treatment systems (e.g. filter, water softening, UV, ultrafiltration)	No filter	Retrofit
		Soiled filter	Backflush, or replace filter insert
		Dosing system Water softening unit Limescale protection unit	Monitoring the function e.g. piston dosing pump, dosing agent, regeneration, inspection, maintenance, repair

Next REHVA- guidebook ...

Proposal for the task force:

Energy efficiency in buildings - ventilation, heating, potable water heating and cooling

- **Existing publications:** REHVA-guidebooks 2, 7, 9, 12, 15, 17, 18, 22, 26, 29, 30;
- **Type of publication:** REHVA-Guidebook, printed book
- **Target groups:** researchers, industry, designers / Europe and USA/Australia

Thank you for your attention !