REHVA-guidebook No. 30: Hygiene in potable water installations in buildings

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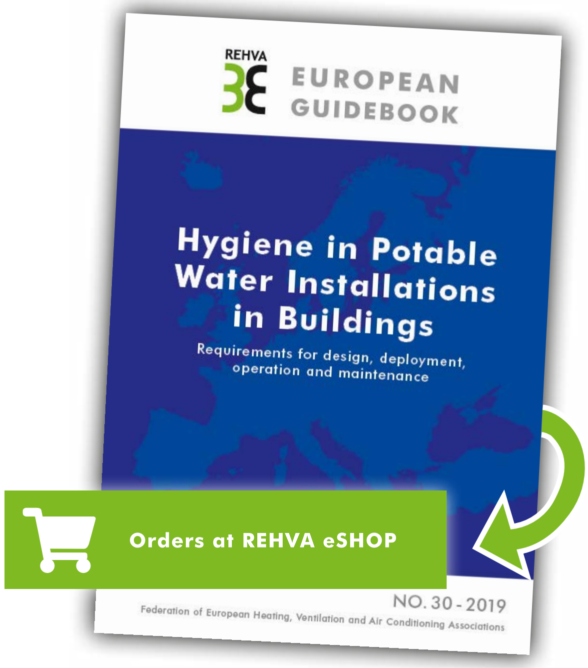
The interrelationships between water quality, health and the well-being of users require that all parties involved have a specific responsibility for aspects of hygiene in specifying the requirements for potable water installations in buildings. This guidebook gives an overview about the fundamentals of hygiene and water quality and contains the main information on the design, installation, start-up, use, operation and maintenance of potable water installations in buildings. It gives also suggestions for the practical work (maintenance, effects on microbiology, potential causes and measures in practical work, checklists). It is a useful guide for hygienic planning of water piping systems inside buildings. All requirements described in this guidebook apply equally to existing buildings, particularly in the case of conversions, extensions and demolition.

Statistics generated by the World Health Organisation (WHO) show that globally people cannot assume that these standards for potable water are being met. Diseases related to contamination of water cause a significant burden in human healthcare. Interventions to improve the quality of water provide significant benefits to health. Even in the European WHO sector, many people suffer with discontinuous supplies of water as well as aesthetic-related and health-related quality issues for potable water. The most significant worldwide contributory factor is microbiological contamination of water (that, in particular, causes infection of the gastrointestinal tract), which mean that its control must always be of paramount importance.



The most effective means of consistently ensuring the safety of drinking water supplies is through the use of a comprehensive risk assessment and risk management approach incorporated in a Water Safety Plan (WSP) that applies to all steps of a water supply, including the distribution system. In the case of distribution systems, it is assumed that water is safe to drink at the point of entry, so the aim becomes to maintain safety by preventing contamination after treatment. In simple terms, this includes:

- constructing systems with materials that will not leach hazardous chemicals into the potable water;
- maintaining integrity to prevent the entry of external contaminants;
- maintaining the supply of potable water to consumers; and
- maintaining conditions to minimize the growth of microbial pathogens (e.g. *legionella*) and biofilms, scaling and accumulation of sediments.

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. The goal is to maintain proper water quality within the building's water installations. The REHVA-guidebook applies to all water installations on sites, in buildings and on ships (sanitary distribution system). A high standard of water quality has been taken for granted as something that can be relied on for many decades. It is generally expected that water may be used at anytime and anywhere and without endangering our health – if possible, for drinking but also for other purposes such as washing, cooking, cleaning, sport etc. Central waterworks supply over 95% of the population with potable water round the clock and with virtually no interruptions. Potable water is available to us at home and at work wherever we need it.

In most cases, under poor conditions, a multiplication of all microorganisms including pathogenic bacteria results in hygiene issues that are attributable to technical deficiencies. The growth of the biofilm plays a decisive role here, in particular regarding the subsequent removal of the microbiological contamination. The following examples list technical deficiencies which may pose hazard factors that exacerbate microbiological contamination (bacterial growth, release of microorganisms relevant for hygiene) in the cold and hot water systems of buildings:

- Improper storage and transport of components (damaged packaging of components)
- improper design (over-dimensioning of storage and pipes)
- improper commissioning (delays between filling and use)
- stagnation (disuse, dead legs)
- use of unsuitable materials and components (hoses and uncertified materials and components)
- incorrect material combination (corrosion, dezincification)
- defective system components (e.g. heat exchanger, circulation pumps)
- pump capacity and balancing valves not adjusted
- 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
- insufficient thermal insulation of pipes
- hygienic deficiencies at the taps (e.g. aerators)
- sources for nutrients, e.g. polyphosphate by dosing corrosion inhibitors
- lack of regular inspection and maintenance

The concentrations of the metals lead, copper, and nickel in potable water samples taken from the consumer's extraction point ("tap") primarily depend on the following influencing factors:

- materials employed in the water installations in buildings,
- design of the water installations in buildings, operating conditions (flow and stagnation times, consumer behaviour),
- age of the potable water installation,
- chemical and physical properties of the potable water.

Maintaining potable water quality

For maintaining water quality basic requirements that should be applied to potable water installations in buildings:

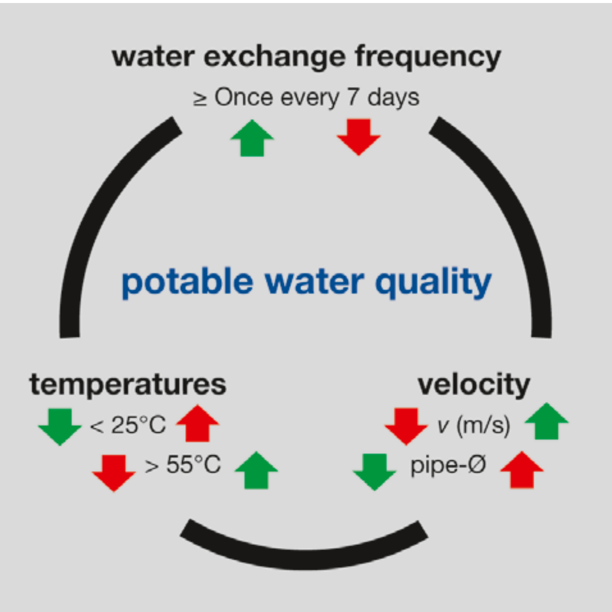
- Suitable pipe materials
- Delivering potable water
- Matching demand (comfort) – water quantity, temperature and noise control (avoidance of excessive flow velocities)
- Reliable system operation and good value – safe, sustainable, energy-efficient

These requirements are the classical goals, while the last one - energy-efficiency in relation to hygienic water quality - only came into focus in recent years.

Cold water should flow from an outlet with a temperature of less than 25°C. It is assumed that for the normal water consumption no critical growth of microorganisms takes place below this temperature. *Legionella* bacteria rank among the most important sources of environmental infections in all buildings, especially in installations with a centralised water heating system (but also decentralized). Their preferred habitat is heated, stagnant water, e.g. in pipes and stores, where they can proliferate best at temperatures between 25°C and 50°C. While *legionella* can occur in cold water, they are unable to proliferate at temperatures under 20°C (low risk). It is also known from practical experience that evidence of *legionella* is very rarely found with potable water temperatures under 20°C (they may also be present in a VBNC (viable but not culturable)-state). Circulation systems for potable hot water are to be operated in such a way that temperatures of at least 55°C are maintained in all individual sections, but local national regulations have to be observed.

Water exchange is defined as a complete exchange of the water volume contained in the respective pipe section by consumption or draining. Water in the installation should be drawn through every tap at least once every seven days.

Potable water installation should have the smallest possible water volume and should enable an effective, hygienically appropriate, water transfer – without stagnating pipe sections. The pipe network should be designed as simply and clearly structured as possible. To avoid dimensioning which might jeopardize hygienic operation, the design of the potable water system should be specifically tailored to requirements in consultation with the client.



Interdependency triangle for maintaining potable water quality. [According to Kistemann et al. 2012]

From the beginning of the design the hygienic aspects have to be taken into account. It is referred to the intended use of the building (or segments). A detailed sanitary room book can be coordinated with the owner of the building including a description of the intended use, and a comprehensive concept of the potable water installation.

It would also be recommended to approach projects with an "integrated design" concept (BIM = Building Information Modelling), that would also include in the initial building/space/room planning the structural architect, designers, contractor and the responsible operator (the project team). The position and types of lights, windows, glazing and any covering materials are likely to have an impact on water temperatures in piping systems (thermal radiation and heat transmission).

Minimum requirements to be met by the room sanitary room book as part of the room data sheet. In particular the following must be documented:

- use of the room, in particular temperatures to be expected
- number and type of taps
- frequency of use (expected simultaneous use)
- location and number
- backflow prevention (if required)
- maintenance requirements

The planner has to provide at least the following:

- arrangement of the pipes giving particular consideration to the temperatures (cold potable water: as cold as possible with a maximum of 25°C, hot potable water at least 55°C)
- materials in contact with the potable water
- required sampling points/taps (see below)
- connection(s) to extinguishing and fire protection systems as per national regulations
- protection of the potable water according to EN 1717
- accessibility for maintenance
- space requirements

Examples for Technical deficiencies and their potential effect on the hygiene quality of the potable water installation. *[according to DVGW-worksheet W 556]*

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, retroactive effects
Connection of eye and body showers	EN 1717		2	3		5			Insufficient water exchange, retroactive effects
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

Pipe sizes shall be calculated as specified in EN 806-3 and/or national standards or regulations. Recent research has shown that DIN 1988-300 provides a better fit for real water consumption than does EN 806-3. Simultaneous water demand is determined as a function of the data given in the sanitary room book (type of use).

The maintenance measures required for ensuring hygienically proper operation must be taken into account in maintenance planning to cover all valves, apparatus and water pipes planned and installed in the building. The intended operation of a potable water installation, as per the sanitary room book, must be ensured. Periodic, competent maintenance of a potable water installation is required for the intended operation to be hygienically acceptable. The operator shall rule out any risks that may ensue from the operation of the potable water installation, giving particular consideration to the organisational responsibility and the duties to maintain safety.

As required by national requirements, building administrators, owners and managers should regularly undertake and refresh the risk evaluation as circumstances demand. This should be revised in case of refurbishment, change of building use/destination or detection of an infection. Depending on the output of the risk evaluation, a control and maintenance plan shall be drafted. The control plan includes sampling operations, which means that from the outset of the project plan, those sampling points should be anticipated and located at appropriate points.

In order to keep a water system as safe as possible, all relevant risk factors should be considered at the start of the project, during the design stage. A project team should be established, including all relevant parties, ranging from the investor to the architect through to the planner and contractors. Correct sizing, positioning, installation and commissioning and use that conforms to the intentions of the initial project: these are all important steps to ensure good water quality. Disinfection may take place when needed, in case of bacteria growth that has been detected after scheduled water sampling, or after particular consideration, possibly by continuous disinfection however a general statement cannot be provided as it will be site specific. If water is contaminated due to stagnation, disinfectants are unlikely to reach sections where water flow is poor (as would also apply for thermal shock). It is clear that, in this case, filtration at the point of use should be considered. Also, piping material reaction with chemical disinfectants must be considered, as oxidation and corrosion leads to the creation of nutrients for bacteria.

Maintenance measures for potable water installations in buildings include preventive maintenance, inspection, corrective maintenance and improvement. They shall be carried out when a defect has occurred (corrective maintenance), at a defined interval (inspection and preventive maintenance) or for specific reasons (improvement).

The type and scope of all the required maintenance measures shall be specified, taking into account the potential hazards and the instructions given by the manufacturers of the systems, valves or apparatus, in the maintenance plan or in a sub-plan's preventive-maintenance plan, inspection plan or hygiene plan.

Technical deficiencies may indicate a potential microbial contamination. To determine whether there is such contamination, microbiological investigations are required. For example, the table show examples for various technical deficiencies which, as experience has shown, may affect the microbiological situation in the potable water installation. The effects on microbiology are similarly shown by way of example. The effect of these deficiencies on human health must likewise be evaluated. The evaluation of health risk requires hygiene-medical expert knowledge.

The information in this chapter also provides pipe system operators with information which allows them to take immediate measures at an early stage or to initiate detailed examinations for identifying the causes.

Conclusion

Because of the significant relevance of water quality to healthy living and working conditions, effective communication and agreement are essential between all parties responsible for design and construction, operation and maintenance. Health risks cannot be ruled out if the necessary technical and hygiene requirements are disregarded, if the water installation is not operated as specified, or if water installation maintenance activities are neglected.

We should, by no means, assume that drinkable water is available as a matter of course: On the contrary, it is something to which we should pay significant attention. We need to keep in mind that it requires a great deal of scientific, technological, regulatory and operational effort and care to ensure that people have access to high-quality water. ■