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Expert evaluation

White paper on expert evaluation of two different installation methods of a drinking water installation from a hygienic point of view

Contracting Authority:

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Contracting Authority	UPONOR GmbH

Content

1 Definition of the task

This document is an expert assessment of two different drinking water system designs from a hygienic and technical perspective.

Design documents provided by the client for two drinking water installations for identical residential buildings are compared. One design foresees a T-joint installation and the other a loop installation with an automatic flushing device. Any potential adverse changes to drinking water quality are given special consideration within the report.

In particular, the possibilities of Legionella contamination and the later operational use of both installation variants are evaluated with regard to their specified standard operation according to § 17 para. 1 TrinkwV (national German Drinking Water Ordinance) [1].

2 Foundations of the assessment

2.1 Description of the building and equipment

The drinking water installation was designed for a residential building with seven apartments (water supply system according to TrinkwV [1] § 3 Para. 1, serial no. 2 Letter e and serial no. 10) over four full storeys. All residential units are equipped with individual devices to monitor consumption (water meters for hot and cold drinking water).

Designs for 1) loop installation and 2) T-joint installation were prepared.

The water appliances and fixtures in the apartments are identical in both designs for comparability:

1st floor: 2 flats, each with standard facilities, consisting of kitchen, toilet, washbasin, shower and washing machine

2nd and 3rd floors: two flats each with standard facilities, consisting of kitchen, toilet, washbasin, bathtub and washing machine.

4th floor: an apartment with luxury facilities, consisting of kitchen, guest toilet and washbasin, washing machine and a separate bathroom with washbasin, bathtub and toilet.

According to the design and calculation documents submitted, the contents of the PWH and PWC pipes, within the distribution and individual connection pipes, amount to < 3 litres each for both design variants.

2.2 Description of the installation method: Variant 1) loop installation

In design variant 1 (loop installation), a decentralised heat interface unit was provided in each apartment after the water meter. Compared to variant 2), the house installation has no centralised drinking water heating and circulation.

According to the design submitted, the total capacity of the PWH pipes subsequent to the drinking water heating unit within the 3rd floor apartment amounts to > 3 litres. However, the volume of the pipe in the most unfavourable flow path between the outlet of the drinking water heater and the tap is < 3 l. This means that variant 1) cannot be defined as a large system in accordance with § 3 Para. 1 No. 12 TrinkwV [1]. Therefore, there is no legal obligation to carry out periodic analyses in accordance with German law (§ 14b TrinkwV [1]).

An automatic, programmable flushing station for PWC and PWH was provided as an additional component in each housing unit. Due to the spatial distribution and the sanitary equipment, the apartment on the 3rd floor was divided into two loops in the PWC and equipped with two flushing stations.

Due to the closed loop of the floor installation system, the route of the pipes is slightly longer.

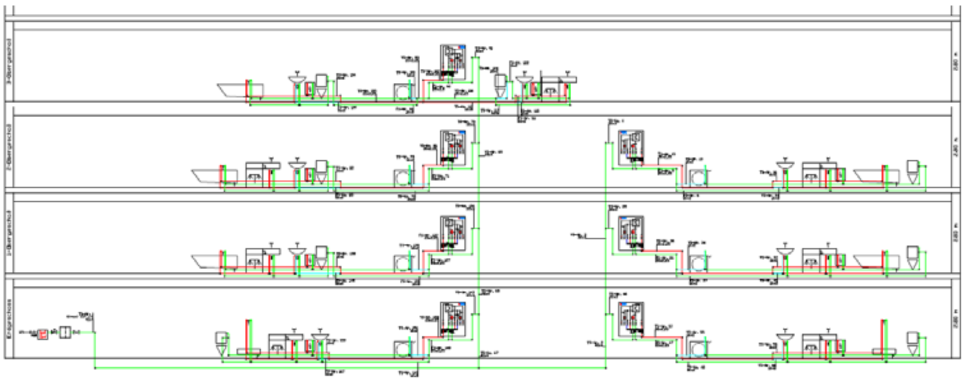

Image 1: Excerpt schematic diagram of the drinking water installation Variant 1)

2.3 Description of the installation method: Variant 2) T-joint installation

The design of variant 2) (T-joint installation) requires a central water heater with a storage vessel implemented for the entire system within the house.

The volume of the storage water heater was calculated by the client at 300 l, the PWH pipe capacity between the outlet of the storage vessel and the tapping point in the most unfavourable flow path is > 3 litres (without circulation). According to § 3 Paragraph 1 No. 12 TrinkwV [1], German law would define this as a large-scale system for heated drinking water. Therefore, the system is subject to periodic water analysis according to § 14b TrinkwV [1].

According to the general layout presented, the installation for hot drinking water was designed as a circulating system in two vertical risers. Each riser for cold and hot drinking water, and circulation supplies the respective superimposed residential units.

The circulation line (PWH-C) that maintains the temperature in the PWH ends before the water meter.

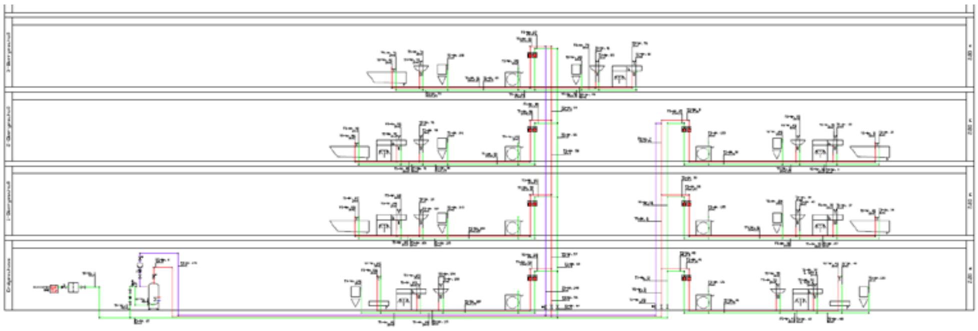

Image 2: Excerpt schematic diagram of the drinking water installation Variant 2)

2.4 Documents used

The following documents and data, provided in digital form, were used in the subsequent evaluation:

- Example plumbing project design calculation/T-joint of 22.12.2018 from „Ingenieurbüro für Haustechnik Ramezani“
- Example plumbing project design schematic/T-join) from „Ingenieurbüro für Haustechnik Ramezani“
- Example plumbing project design calculation/loop installation of 22.12.2018 from „Ingenieurbüro für Haustechnik Ramezani“
- Example plumbing project design schematic/loop installation from „Ingenieurbüro für Haustechnik Ramezani“

2.5 Abbreviations

PWC	Domestic cold water green
PWH	Domestic hot water red
PWH-C	Domestic hot water circulation purple
TrinkwV	German Drinking Water Ordinance
DIN	German Institute for Standardisation
VDI	Association of German Engineers
DVGW	German Association for Gas and Water
CEN	European Committee for Standardisation
TR	Technical Report

3 Evaluation

3.1 Preliminary remarks

According to § 17 para. 1 TrinkwV [1], a water supply system must at minimum be designed, constructed and operated in accordance with common codes of practice (technical standards).

The rules summarised under the term "common codes of practice" – with reference to drinking water hygiene in domestic installations according to the German Drinking Water Ordinance – were defined by the German Federal Environmental Agency within "Recommendation of the Federal Environmental Agency after hearing the opinion of the Drinking Water Commission for the performance of a hazard analysis in accordance with the Drinking Water Ordinance" of 14.12.2012 [2], point 4:

"A risk analysis shall be based on the requirements of the TrinkwV, as well as on the common codes of practice (technical standards), in particular:

1. Guideline VDI/DVGW 6023 [4]
2. Worksheet DVGW W 551 (A) [15]

Further basic principles can also be found in the following regulations:

1. Series of standards DIN EN 806 ff [5-7]
2. Series of standards DIN 1988 ff [10-14]"

For drinking water hygiene, particular attention should be paid to complying with the requirements of DVGW W 551 (A) [15] for the installation of hot drinking water and VDI/DVGW 6023 [4] for cold drinking water.

Basic hygienic evaluation criteria are as follows:

- Temperature maintenance PWH/PWH-C ≥60/55 °C acc. to DVGW W 551 (A) [15]
- Temperature stability PWC <25 °C (recommended <20 °C) acc. to VDI/DVGW 6023 [4]
- Complete water exchange in the entire system within max. 72 hrs. (incl. reservoir and volume of the conduits PWC, PWH, PWH-C) acc. to VDI/DVGW 6023 [4]

According to DVGW W 551 (A) [15] Section 5.6, no circulation lines can be installed after domestic water meters. The volume of water in one floor and individual supply lines must be limited to 3 litres. If this is not possible, the domestic water meters must be arranged accordingly (e.g. at the tapping points) or self-regulating heat-tracing systems must be used (so-called "3-litre rule").

According to VDI/DVGW 6023 [4] Section 6.3.1, individual supply lines should be as short as possible with regard to output times. A water volume of 3 litres must not be exceeded.

Note: There is the possibility of saving energy by lowering the operating temperature of hot drinking water with decentralised heat interface unit heater with a line capacity < 3 l in accordance with DIN 1988-200 [11] Sec. 9.7.2.4 or DVGW W 551 (A) [15] Sec. 5.2.1 compared with an installation with a central PWH cylinder:

"Decentralised instantaneous water heaters can be operated without further requirements if the downstream pipe volume of 3 l within the flow path is not exceeded."

This, however, is not initially considered as an aspect in the further evaluation, but it is taken into account in the concluding summary under point 4.

With the current communication of the Federal Environment Agency after hearing the Drinking Water Commission of 18 December 2018 [3] it was made clear that Legionella -contamination can occur if decentralised heat interface unit with temperatures PWH < 60 °C are operated without -sufficient water exchange:

"Decentralised PWH heaters are PWH heaters (flow-through devices or devices with low storage capacity) which supply one or more closely spaced tapping points. To date, decentralised heat interface unit have been regarded as safe with regard to Legionella contamination. Recent findings show, however, that Legionella can also multiply in decentralised heat interface unit and in the pipelines subsequent to them."

From a hygienic point of view, an operation mode with lowered temperature in the hot drinking water is therefore not recommended, even with decentralised heat interface unit, as there is concern of Legionella contamination in the case of insufficient water exchange in accordance with VDI/DVGW 6023 [4].

3.2 Variant 1) loop installation with flushing station

In variant 1), PWH is not centrally stored. Compared to variant 2), this means that the PWH cylinder is no longer required as a component, nor are the fittings, pipes with shaped and connecting joints, pipe insulation and fixing material required for a PWH cylinder installation.

Instead, a decentralised heat interface unit was provided in each apartment. The production of hot water takes place within the apartments as required.

Maintenance measures must be carried out in accordance with the manufacturer's instructions.

In comparison to variant 2), no separate installation room is required for a PWH cylinder, but space must be provided for a heating buffer cylinder and, within the apartments, an installation location for the heat interface unit.

This installation variant 1) also eliminates the need to install two conduits for PWH and PWH-C, including all piping, insulation and fittings, as well as the circulation pump, respectively. Operating costs for the continuous electrical operation (24/7) of the circulation pump are also eliminated. Compared to variant 2), there is also no need for hydraulic balancing in each line via control valves.

By dispensing with the storage of water and a separate pipe system PWH/PWH-C, the overall drinking water volume of the installation, which would have to be replaced by manual or automated withdrawal according to VDI/DVGW 6023 [4], is significantly reduced (see Chapter 3.1).

By dispensing with a PWH/PWH-C circulating piping system, the following is also reduced

- The space requirement and expenditure within the building for shafts, breakthroughs, fire protection measures for wall ducts, etc.
- At the same time the risk of any unpermitted warming of the cold drinking water inside the shafts

A possible heat input into adjacent PWC risers due to heat radiation from the warming PWH/PWH-C pipes is eliminated in this variant. In the planning variants, the riser pipes PWC are not of the same dimensions (variant 1 DN 40, variant 2 DN32), since in variant 1) the entire demand for drinking water (hot) and (cold) must be transported via this pipe.

In general, however, a heat load within the shafts without thermal decoupling of the cold drinking water pipes through the still existing heating pipes cannot be ruled out in principle. A thermal decoupling of the cold water pipe from warm pipes (heating flow and return) within the shafts may also be required in this variant according to VDI/DVGW 6023 [4].

Due to the higher water volume inside the bigger pipe in variant 1) a potential warming of PWC is deferred.

By dispensing with a hot water storage cylinder and the decentralised arrangement of the instantaneous water heaters, a pipe volume of < 3 l in the flow path between the drinking water heater and the extraction point can be realised in variant 1). This means that there is no obligation to take samples to test for Legionella contamination in accordance with German law (§ 14b TrinkwV). This eliminates the costs for regular sampling and analysis every three years at minimum, as well as the costs associated with installing sampling valves.

Operational and standby losses due to heat radiation from the central storage water volume and the circulating PWH and PWH-C lines – including electrical energy for permanent operation of a sufficiently dimensioned circulation pump – are also avoided, which significantly reduces the overall energy required to heat the drinking water. Energy loss due to heat radiation from the heat exchangers within the heat interface units is comparatively low.

Within the residential units, the slightly longer pipes of the loop installation increases the pipe length (pipe material, shaped and connecting joints, insulation material), as well as the pipe content within the apartments, as compared to variant 2). The installation variant 1) with closed pipe ring ensures, however, that all pipe sections are flowed through at each tapping point, since the water (depending on the tapping point and pipe length) flows from both directions to the tapping point, thereby ensuring water exchange in all sections of the pipe. This therefore avoids any stagnation of water in sections of the pipe where the tapping points are used infrequently.

Since the temperature of the hot drinking water is not maintained inside the apartments (after the water meter), the PWH lines can cool down quickly after use. This reduces the risk of heating up adjacent PWC lines, but that possibility cannot be completely excluded (e.g. heat input with pre-wall installation). In principle, this aspect is identical to variant 2), but due to the loop design for all tapping points and the closed line ring, a slightly longer line length is present in the design as compared to variant 2), which also increases the heat radiating surface of the lines.

The flushing units used in variant 1) (here: Smatrix Aqua PLUS) ensure complete automatic water exchange even when the users are absent, so the system is not solely dependent on the behaviour of residents. The flushing system used triggers regular flushes (depending on the setting and variant) both after a pre-set time interval without use or when a temperature limit is exceeded. If a maximum temperature is reached in the PWC, flushing can prevent a further temperature increase in the PWC that would exceed a hygienically critical limit. The contents of the lines are rinsed out as required, unless a water exchange has already occurred due to use.

However, an automated, central flushing device can only replace the water within the looped installation. Since the valves are not opened, a small amount of water remains inside the valves and the connecting pipes if one or more tapping points are not used sufficiently.

3.3 Variant 2) T-joint installation without flushing station

Design variant 2) foresees a central supply of PWH via PWH cylinder. As opposed to variant 1), this design requires the purchase and professional installation of the PWH cylinder as a system component, as well as the fittings necessary for a PWH cylinder installation, pipes with shaped and connecting joints, pipe insulation and fixing material. Compared to variant 1), heat interface units are no longer required within the apartments.

In comparison to variant 1), a separate installation room is required for the PWH cylinder, which in variant 1 is occupied by a heating buffer cylinder. However, a separate installation location for the heat interface unit is not required.

The drinking water installation designed here is a large-scale system for heating drinking water according to German law (§ 3 Para. 1 No. 12 TrinkwV [1]).

According to DVGW W 551 (A) [15] item 5, drinking water heating systems must be as small as possible and only as large as necessary in accordance with common codes of practice. The production of hot drinking water does not take place as required in a system with a central storage drinking water heating system, but the entire stored water volume must be maintained at ≥ 60 °C at all times, regardless of whether it is used or not. At no point in the circulating system may the temperature fall below 55° C. According to DVGW W 551 (A) [15], the temperature differential in the system (PWH heating system output/ circulation inlet) must not exceed a maximum of 5 K. The temperatures of the hot and circulating water must be measured and documented in the individual sections (system-specific).

According to DIN EN 806 Part 5 [7] Table A.1 Line 42 in conjunction with Annex B.20, PWH cylinders must be inspected every two months (e.g. visual inspection for leaks, temperature control) and serviced at annual intervals. In order to maintain proper operation of the system, it shall be ensured that deposits (anode sludge, stone formation) are removed from the storage tanks within the scope of annual maintenance.

In accordance with the German Drinking Water Ordinance [1] § 14b para. 3, the operator and any other owner of the water supply system has to ensure that suitable sampling points are available in the water supply system, which is subject to monitoring in accordance with technological standards. The position of the sampling points in the drinking water heating system is specified in DVGW W 551 (A) [15]. Sampling points at peripheral consumption points shall be determined by hygienically/technically competent persons (e.g. VDI certificate according to VDI/DVGW 6023 [4] Cat. A).

Due to the central PWH heating, the additional installation of two conduits for PWH and PWH-C respectively, including all pipes, insulation and installation materials, as well as the circulation pump, is necessary for the transport of hot water within the house installation in comparison to variant 1). Compared to variant 1), this results in additional operating costs for the continuous, electrical operation (24/7) of the circulation pump and the necessity of hydraulic balancing via regulation valves in each line.

The storage water volume and the separate pipe system PWH/PWH-C increase the total drinking water volume of the installation, which has to be replaced regularly by the users and residents by manual withdrawal according to VDI/DVGW 6023 [4] in comparison to variant 1) (see Chapter 3.1).

The use of a PWH/PWH-C circulating pipe system increases the space requirement and expenditure within the building for shafts, breakthroughs, fire protection measures for wall ducts, etc. in comparison with variant 1), and at the same time increases the risk of any non-permitted heating of the cold drinking water within the shafts.

A heat input into adjacent PWC risers by heat radiation from the warming PWH/PWH-C pipes and the adjacent risers of the heating system must be worried. It is also possible to assume a heat load within the shafts without thermal decoupling of the cold drinking water pipes. A thermal decoupling of the cold water pipe from warm pipes (PWH, PWH-C, heating flow and return) within the shafts is to be constructed in this variant according to VDI/DVGW 6023 [4].

Due to the pipe volumes of > 3 l in the flow path between the drinking water heater and the tapping point, it is considered a large system, which means water samples must be taken to test for Legionella contamination in accordance with German law (§ 14b TrinkwV). Compared to variant 1, this results in additional operating costs for regular sampling and analysis every three years at minimum, as well as the associated costs for the installation of sampling valves.

Operating and standby losses due to heat radiation from the central storage water volume and the circulating lines PWH and PWH-C incl. electrical energy for the continuous operation of a sufficiently dimensioned circulation pump are also incurred, which significantly increases the overall energy required to heat the drinking water.

Within the residential units, the simple routing of the T-joint installation reduces the pipe length (pipe material, shaped and connecting joints, insulation material) and the line content within the apartments as compared with variant 1).

However, the installation variant 2) with individual connection lines that are not looped does not guarantee that, during normal operation, the users and residents in all line sections can ensure complete water exchange in accordance with VDI/DVGW 6023 [4]. The stagnation of water in sections of the pipes with less frequently used tapping points must be avoided by manual flushing, which falls under the user's responsibility.

Due to the lack of temperature maintenance in the hot drinking water within the apartments (after the water meter), PWH lines can cool down quickly after use, which reduces the risk of heating adjacent PWC lines, but cannot completely exclude it (e.g. heat input with pre-wall installation). Basically, this aspect is identical to variant

1), however, due to the T-joint installation, only a simple pipe length is planned in the present design as compared to variant 1), which also reduces the heat radiating surface of the pipes.

Due to the lack of automatic flushing in comparison to variant 1), a complete water exchange is not guaranteed in principle and depends solely on the behaviour of residents (e.g. pipes to guest toilets or sporadically used tapping points).

Manual flushing during normal operation can replace the water in the entire installation, including the connecting pipes to and the volume within the tap fittings. However, the ongoing proper functioning of the system is completely dependent on the tenants and users of the drinking water installation, who must be instructed and understand the necessity of manual flushing. Therefore, it cannot be considered guaranteed.

Also, it is not possible to ensure the demanding flushing of PWC pipes when a maximum, hygienically critical temperature is reached.

4 Conclusion and summary

From a hygienic and technical point of view, variant 1) has clear advantages over variant 2).

Due to the decentralised, demand oriented PWH heating, no unnecessary amount of water has to be stored and continuously heated; by dispensing without a central PWH cylinder, the space requirement and installation costs are reduced.

A circulating pipe system for hot water and circulation is completely eliminated, which leads to lower heat loss/energy consumption and, despite the slightly longer pipe routing within the apartments, to reduced space, installation and material requirements for the pipe system.

The larger dimension selected for the PWC distribution line does not lead to disadvantages here. In addition, the risk of heating up in the pipes for drinking water (cold) is further minimised by the elimination of the warming PWH/PWH-C lines.

However, the additional expense of installing heat interface units in each apartment must be taken into account, which is largely compensated for by the elimination of the drinking water heater and the PWH/PWH-C risers.

Due to the loop installation within the apartments, water stagnation in pipe sections of less frequently used tapping points is avoided up to the fittings, and the automatic flushing station facilitates the complete, demand-oriented water exchange independent of user behaviour and unavoidable user absences.

Due to the constant guarantee of complete water exchange (avoidance of stagnation), there is a lower risk of contamination in the installation with variant 1), so that a lower operating temperature of PWH ≥ 50 °C according to DIN 1988-200 [11] point 9.7.2.4 would also be possible.

Variant 2) is a large-scale system for PWH heating in accordance with § 3 Para. 1 No. 12 of the German Drinking Water Ordinance [1]. In comparison to variant 1), this means that additional sampling points must be determined and installed, and there is a regular obligation for sampling by an accredited inspection body.

The whole circulating system PWH/PWH-C of the drinking water installation of variant 2) has to be operated permanently at ≥ 60 °C at the outlet from the hot water storage vessel respectively ≥ 55 °C at the re-entrance of the circulation line into the water storage vessel.

5 Final remarks

“The expert is liable for claims – regardless of the legal basis – if he or his assistant have caused claims through a defective expert opinion intentionally or through gross negligence. This shall also apply to damage caused by the expert during the preparation of his expert opinion as well as to damage arising after subsequent performance. Liability for slight negligence shall be limited to reasonably foreseeable damage typical of the contract in the event of a breach of essential contractual obligations. This limitation of liability shall not apply in the case of damage to life, limb or health; it shall also not apply if the Expert fraudulently concealed the defect”

(Reference: Praxishandbuch Sachverständigenrecht, Verlag C. H: Beck, 4th ed. 2008, § 37, marginal 39)

The assessment was carried out independently and neutrally; all findings and recommendations are based to the best of our knowledge on common codes of practice and technical standards, which must be observed as a minimum requirement in accordance with TrinkwV [1] §§ 4 (1), 17 (1).

All assessments are based on actual findings as evidenced by the design documents provided as well as on the information provided to the expert witness and/or the information provided by the parties involved.

Therefore, it is expressly pointed out that the recommendations made in the expert opinion do not necessarily lead to the desired success but are regarded as suitable according to generally accepted standards of technology.

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Höpfingen, 31.07.2019

6 References

[1] **TrinkwV** - German Drinking Water Ordinance in the version promulgated on 10 March 2016 (BGBl. I p. 459), last amended by Article 1 of the Ordinance of 3 January 2018 (BGBl. I p. 99)

[2] **Recommendation of the Federal Environmental Agency** after hearing the Drinking Water Commission for the performance of a hazard analysis in accordance with the Drinking Water Ordinance, measures in the event of exceeding the technical measure value for Legionella of 14 December 2012

[3] **Communication of the Federal Environmental** after hearing the Drinking Water Commission of 18.12.2018 on the occurrence of Legionella in decentralised drinking water heaters

[4] **VDI/DVGW 6023** Hygiene in drinking water installations Requirements for planning, execution, operation and maintenance, edition April 2013

[5] **DIN EN 806** - Technical rules for drinking water installations - **Part 2**: Planning; German version EN 8062:2005, June 2005

[6] **DIN EN 806 -** Technical rules for drinking water installations - **Part 4**: Installation; German version EN 806-4 Installation 06_10

[7] **DIN EN 806** - Technical rules for drinking water installations - **Part 5**: Operation and maintenance; German version EN 806-5:2012

[8] **DIN EN 1717** - Protection of drinking water against pollution in drinking water installations and general requirements for safety devices for the prevention of drinking water pollution by backflow; German version EN 1717:2000; DVGW Technical Regulation, August 2011

[9] **CEN/TR 16355** - Recommendations for the prevention of Legionella growth in drinking water installations, June 2012

[10] **DIN 1988** - Technical rules for drinking water installations - **Part 100**: Protection of drinking water, preservation of drinking water quality; DVGW technical rule, August 2011

[11] **DIN 1988** - Technical rules for drinking water installations - **Part 200**: Installation type A (closed system) - Design, components, appliances, materials; DVGW technical rule

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[13] **DIN 1988** - DIN 1988 - Technical rules for drinking water installations - **Part 500**: Pressure booster systems with variable speed pumps; DVGW technical rule, February 2011

[14] **DIN 1988 -** Technical rules for drinking water installations **- Part 600**: Drinking water installations in connection with fire extinguishing and fire protection systems; DVGW Technical Rules, December 2010

[15] **DVGW W 551 (A)** - Drinking water heating and drinking water piping systems; technical measures to reduce the growth of legionella; planning, construction, operation and rehabilitation of drinking water installations, April 2004

[16] **DVGW W 553 (A) -** Design of circulation systems in central drinking water heating systems, December 1998

[17] **DVGW Technical Information** on Water No. 90: Information and Explanations on the Requirements of DVGW Code of Practice W 551, 03/2017

[18] **[E] VDI 3810 -** Operation and maintenance of technical building installations - Sheet 2: Drinking water installations, draft 12/2018

[19] **VDI 6003** “Drinking water heating systems - Comfort criteria and performance levels for planning, evaluation and use”, 10/2012