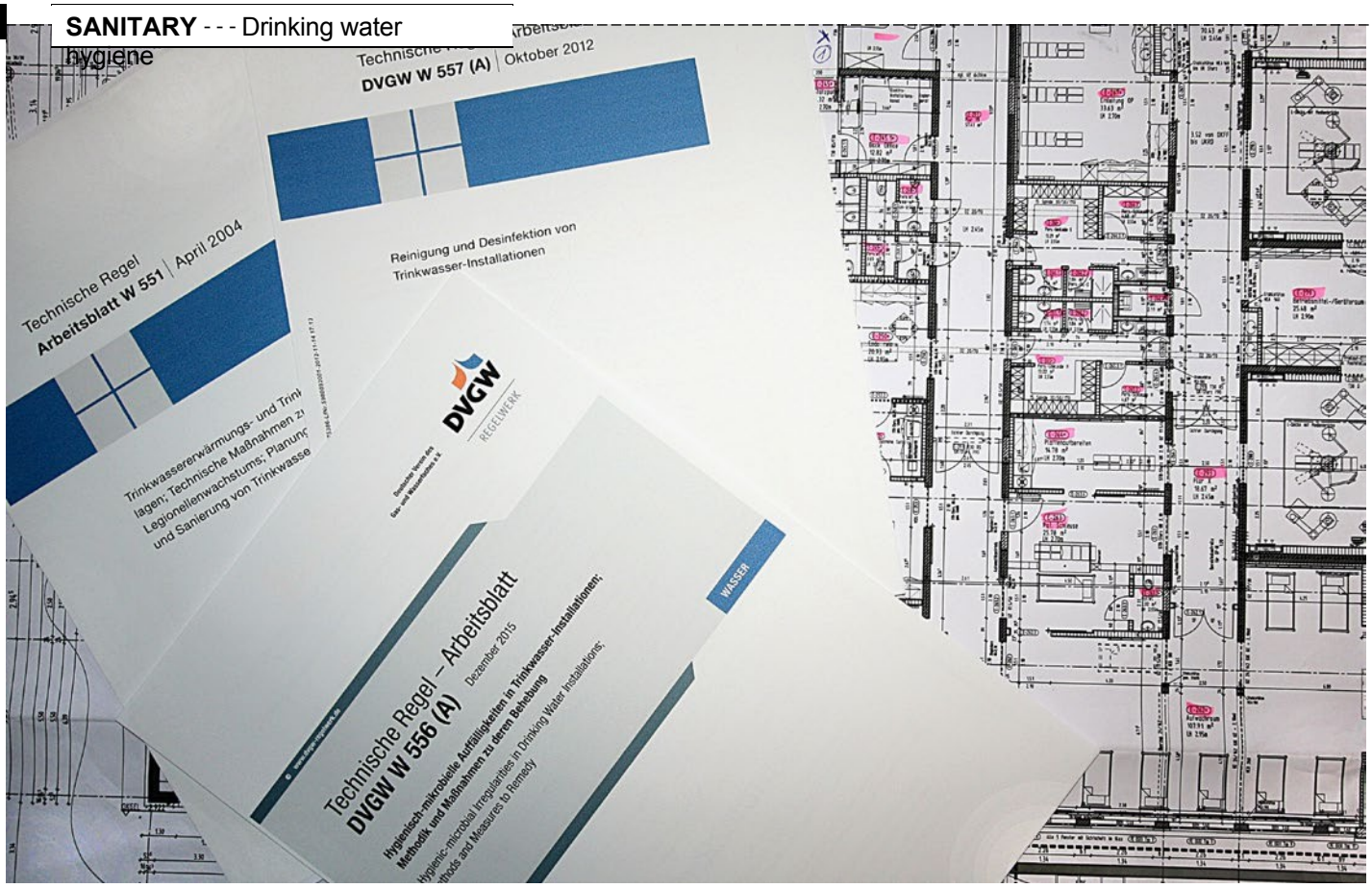
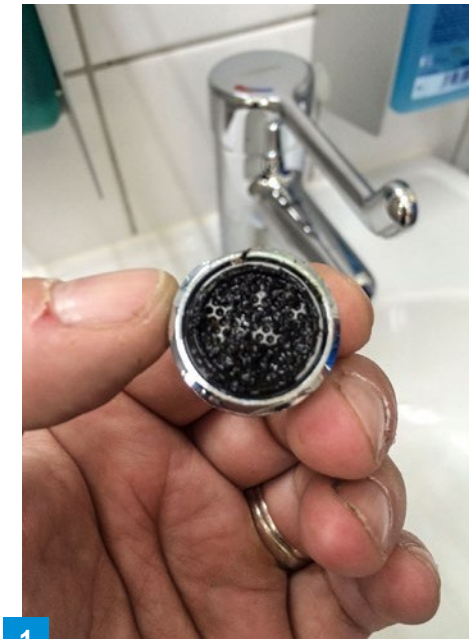


Professional renovation

Combating legionella contamination ▪ If there is contamination in a drinking water installation, a risk analysis should uncover and evaluate all defects, identify options for sensible remediation and serve as the basis for a maintenance plan. In practice, however, when it comes to the remediation of drinking water installations, often only uncoordinated individual measures are taken, which have nothing to do with a proper and professional remediation plan and which may even increase the damage and risks for users. → **Arnd Bürschgens**

A defect in a drinking water installation can be detected in various ways. For example, through a positive test result or a system-oriented inspection of the installation. However, user complaints or, in the worst case, cases of illness that could be related to the use of drinking water can also bring deficiencies to light. Irrespective of legal obligations to carry out a risk analysis, there is always the option of carrying out a preventive ("system-oriented") risk analysis, to identify existing weak points in a drinking water installation at an early stage. A system-oriented risk analysis can be particularly useful when taking over or evaluating properties. A hazard analysis not only helps to prevent health hazards and unnecessary liability risks, but also to The maintenance plan is not only a means of avoiding defects, but also contributes to calculable budgets for the operation and maintenance of a system so that defects can be rectified at an early stage or do not arise in the first place. With this in mind, every system should have a complete maintenance plan in accordance with VDI/DVGW 6023.

A defect can be non-compliance with the requirements of the Drinking Water Ordinance, but can also be an aesthetic change in the drinking water (e.g. black biofilms, changes in odor and taste, rust, microorganisms, etc. (**Fig. 1**). In existing drinking water installations with galvanized steel pipes in the



Black, slimy deposits on extraction sites are often caused by

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Corrosion in pipes made of hot-dip galvanized steel pipes often leads to considerable browning of the drinking water after thermal disinfection.

In the hot water sector, for example, corrosion can lead to discoloration of the drinking water even after short stagnation times (**Fig. 2**).

Regulations as a guideline for action

DVGW Code of Practice W 556 describes how microbiological contamination caused by Legionella or Pseudomonas aeruginosa, for example, can be eliminated. Important information on the remediation of a system in the event of contamination with legionella can also be found in DVGW Code of Practice W 551. The draft of the new DVGW worksheet W 558 is currently available for the repair of drinking water installations that have been damaged by corrosion or the formation of stones, and general specifications for the cleaning and disinfection of drinking water installations in the event of microbiological or chemical contamination can be found in DVGW worksheet W 557. These regulations show in a practical way which measures are suitable in each case to eliminate the defects, which requirements must be met for this and which measures are correspondingly unsuitable. DVGW W 556 (A), for example, clearly defines that ozone disinfection in drinking water installations is not suitable.

However, these regulations are not always entirely free of contradictions: DVGW W 551
(A), for example, thermal disinfection is still listed among the immediate measures for a Legionella contamination of > 10,000 CFU/100 ml. However, W 556 and W 557 make different statements: According to W 556 (A), disinfection measures - whether chemical or thermal - are not among the possible immediate measures.

measures, as disinfection always requires certain information, such as detailed knowledge of the materials used, the presence of stagnant areas and previous damage. As a rule, disinfection can only be carried out with a certain amount of technical and organizational effort, which requires a certain amount of advance planning and rules out immediate protection of consumers. Such a disinfection measure can therefore only be an "operational maintenance" measure, if at all, as part of a refurbishment. Measures that ensure the immediate protection of users are, after all Restrictions on use (shower ban) and the protection of tapping points with terminal sterile filters.

No individual measures

DVGW Code of Practice W 556 states the following: "On the basis of the hazard analysis, the operator must initiate measures for the hygienic-technical rehabilitation of the drinking water installation. In doing so, technical aspects of the drinking water installation as well as health aspects of the users and possible transmission paths must be taken into account." However, according to W 557, the term sanitation is clearly defined as the entirety of "operational and constructional measures to restore the intended operation of a drinking water installation within the meaning of the Drinking Water Ordinance, which go beyond cleaning and/or disinfection, whereby cleaning and disinfection can be components of a sanitation".

This definition already makes it clear that a "hot rinse", the installation of a disinfection system, a thermo- or a chemical drinking water disinfection does not constitute a remediation of a contaminated drinking water installation.

Restore proper operation

The aim of a renovation plan, based on a well-founded determination of the causes, must always be to permanently restore suitability for use, i.e. to repair a drinking water installation in such a way that it can then be operated as intended in accordance with the requirements of the Drinking Water Ordinance.

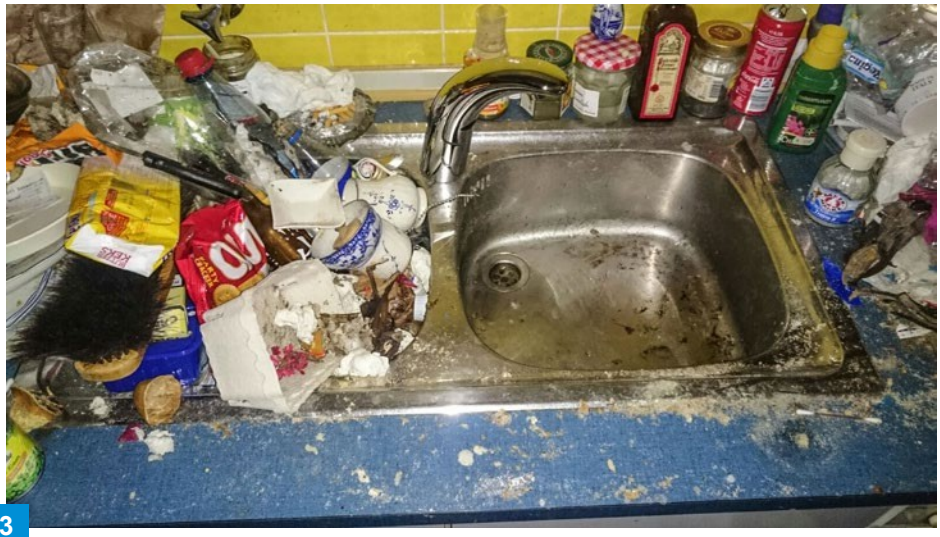
Regular, professional maintenance is the prerequisite for hygienically safe operation of a drinking water installation in accordance with its intended use. According to W 557 (A), proper operation exists if

- the drinking water installation is operated as planned,
- stagnation in the entire drinking water installation is avoided (e.g. regular water withdrawal),
- the temperatures for cold and heated drinking water are maintained
- the measures for the protection of drinking water in accordance with DIN EN 806-5, DIN EN 1717 and DIN 1988-100
- and the maintenance intervals, in particular the service intervals, are adhered to.

Regardless of the size of the drinking water installation, it should be checked before starting a refurbishment whether a comprehensive refurbishment or perhaps a new installation makes sense. In any case, however, the reporting obligations according to TrinkwV 2001 must be observed! However, in the case of local contamination due to stagnation, perhaps because a tenant does not use all of the tapping points in the apartment, no extensive renovation or new installation is necessary (**Fig. 3**).

The impact on the overall system should always be considered in advance for any intended measure. If, for example, an operational measure is to replace the existing
If the "energy-saving" temperature of the drinking water heater is raised from the previous 48 °C to the necessary 60 °C, this could lead to unintentional heating of the cold water in the shafts of the risers, for example due to insufficient insulation or a lack of water exchange. On the other hand, increasing the temperature in the storage tank could also lead to reduced water changes, as the residents always shower at the same temperature. Higher temperatures in the storage tank then lead to the temperature being reduced.

Picture: Otto Kamp GmbH



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It also sometimes helps with local contamination as the cause of a deficiency, if the user is relieved of responsibility by automatic fittings.

This means that less hot water is being used when the boiler is set to a low temperature and the storage tank is suddenly oversized.

Microbiological contamination

According to W 556, the use of bacteria-proof filters ("hygiene filters", ultrafilters, "sterile filters", etc.) can only allow for continued operation at selected terminal tapping points during the sanitation period on a temporary basis. With the exception of high-risk areas in hospitals, bacteria-proof filters should only be installed temporarily until microbially safe conditions are restored (**Fig. 4**). For reasons of immediate health protection, for example if a facility must continue to be operated, a partial shower ban is not possible and extraction points cannot b e protected with sterile filters, it may be necessary to install bacteria-proof filters.

It may be necessary to carry out a temporary continuous disinfection of the drinking water before and/or during a technical renovation. However, it cannot be ruled out that drinking water disinfection can lead to potential damage to the downstream pipes and components. Under no circumstances, however, does disinfection replace the renovation of a drinking water installation. The use of permanent drinking water disinfection to save energy (lowering the temperature in the hot water due to the supposed safety of disinfectants) is also not permitted according to the generally recognized rules of technology and is therefore a clear violation of the TrinkwV 2001.

Refurbishment process

The refurbishment process is structured as follows:

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Bacteria-dense filters must not be used (except in high-risk areas of hospitals) should never be used preventively or permanently, but only temporarily for the duration of the renovation.

1. Identification of contamination sources and causes, e.g.as part of further investigation and hazard analysis
2. Necessary structural measures (removal of dead and stagnant sections, replacement or repair of components or equipment)
3. Cleaning of the system and removal of all mobilizable deposits (sediment, biofilm) and, if necessary, one-off disinfection of the system/the affected areas
4. Sustainable elimination of the causes of contamination (systemic/local) by implementing a remediation concept based on the risk analysis
5. Ensuring consistent operation in the long term
6. Periodic review of the effectiveness of the measures taken (follow-up inspections in accordance with DVGW W 551 (A)) (**Fig. 5**).

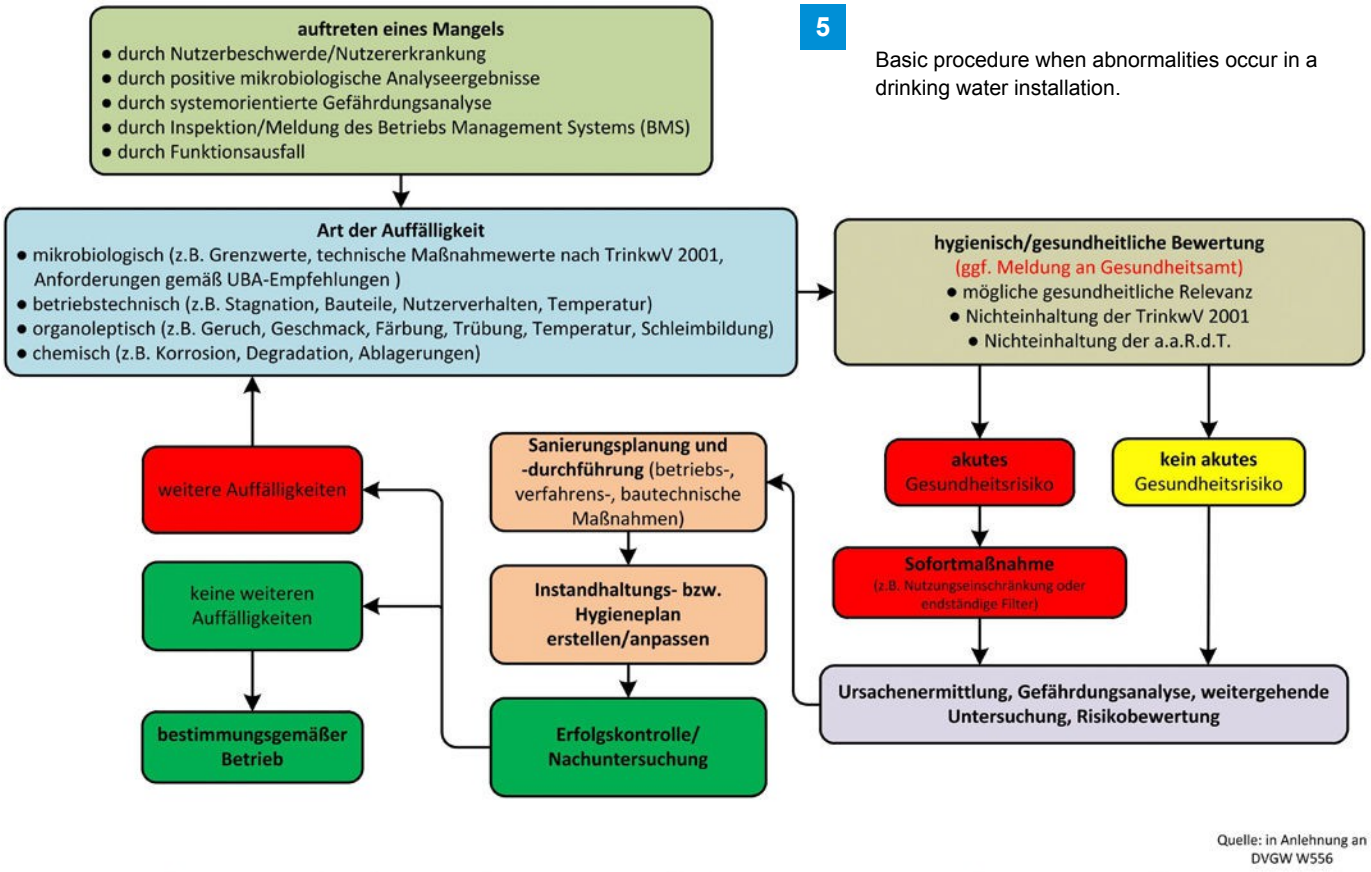
Carrying out cleaning at the beginning of a sanitation project can also improve the sampling results in the short term in the case of higher contamination levels, which can save time for the actual sanitation. However, cleaning and/or disinfection are only effective in the long term if the measures can reach every area and section of a drinking water installation. Before cleaning and disinfection measures can be tackled, all stagnation and dead pipes must therefore be removed.

DVGW W 551 (A) distinguishes between operational, constructional and procedural measures for rehabilitation, whereby today the organizational measures (sampling scheme, flushing, maintenance or hygiene plans) are also included.

Operational measures include all adjustment, control and regulation processes on system components and equipment with the aim of optimizing the system. This includes

including increasing the setpoint setting on DHW heating systems or optimizing pump runtimes in the circulation system). The operational measures are the easiest and quickest to implement, as they usually do not require any intervention in the system.

Structural measures refer to all technical interventions in the entire system or individual parts of the system in order to bring the drinking water installation into line with the current generally recognized rules of the trade.



5 Basic procedure when abnormalities occur in a drinking water installation.

Quelle: in Anlehnung an DVGW W556

technology. Structural measures can include reducing the volume of storage water, increasing the insulation thickness, retrofitting suitable control valves for hydraulic balancing in the circulation system, dismantling stagnant pipes (and recalculating the remaining distribution pipes accordingly), etc.

According to DVGW W 551, old systems in existing buildings must be operated in the same way as a new system in terms of operating conditions after optimization through constructional and operational measures (minimum temperature at the outlet of the drinking water heater 60 °C, maximum 5 K cooling until the circulation re-enters, i.e. minimum temperature of 55 °C at every point in the drinking water system, pump running times,...). In most cases, this can only be achieved if correct hydronic balancing is also ensured in existing buildings and, if necessary, retrofitted.

As a procedural measure, system disinfection is a one-off measure that covers a drinking water installation in its entirety up to the consumer's tapping point. An essential prerequisite for the effectiveness of a disinfectant is that it is applied in sufficient concentration to all contaminated areas without exception.

the drinking water installation. Before starting disinfection, it should therefore be checked whether or, if so, by which measures this can be ensured. Dosing certain disinfectants, such as sodium hypochlorite, for example, only makes sense if the temperature in the drinking water (hot) does not comply with the generally recognized rules of technology and cannot be increased in the short term (e.g. if the output of the drinking water heater is insufficient or if the insulation is inadequate). At a temperature of > 30 °C, a daily loss of effective chlorine of a sodium hypochlorite solution of up to 5.6 g/l free chlorine must be expected. However, procedural measures also include the cleaning of a system or thermal disinfection.

The fact is that no single measure can ever be effective on its own. Successful refurbishment always requires a sensible, individual combination of different refurbishment measures.

Cleaning the system

After stagnation areas have been removed, the first preparatory step in renovation work should be cleaning, in particular flushing the conspicuous areas of a drinking water installation, in accordance with W 556 and [E] W 558.

be a disinfection. Thermal or chemical system disinfection may be required as a final measure. This must be carried out in accordance with DVGW Code of Practice W 557. Cleaning is only a preparatory measure to increase or ensure the effectiveness of thermal or chemical disinfection. Without removing deposits or biofilm, thermal disinfection would leave an ideal breeding ground for bacteria flowing into the pipe, which can quickly lead to renewed germination. A chemical disinfectant or oxidizing agent would initially react on the surface of the biofilm; the disinfectant would be consumed, the concentration of reactants would increase and in terminal areas of the installation, an effective disinfectant may no longer be available.

According to [E] W 558, cleaning processes are also used to repair drinking water installations that are constricted by deposits and/or affected by internal corrosion. The corrosion products and deposits in the affected pipes are removed mechanically and/or chemically. However, each method has its specific advantages and disadvantages: In pre-damaged areas, cleaning can expose openings in the pipe wall.

Mechanische Reinigungs-verfahren	Anwendungsbereich	Bemerkungen	Anforderungen
Spülen mit Wasser	Vor Inbetriebnahme einer neuen Anlage sowie bei Ablagerungen	Ohne empfindliche Bauteile	Fließgeschwindigkeit min. 2m/s Wasservolumen ca. 20x austauschen
	Nach chemischer Reinigung sowie nach Anlagendesinfektion (Freispülen)	Mit eingebauten Armaturen	Fließgeschwindigkeit <2m/s ausreichender Wasserwechsel
Spülen mit Wasser-/Luft-Gemischen oder Impulsspülverfahren	Bei festen Ablagerungen und Inkrustationen sowie bei mikrobieller Kontamination	Raumdeckend turbulente Strömung reduzierter Wasserbedarf gegenüber Spülung mit Wasser Empfindliche Bauteile entfernen und manuell reinigen	Fließgeschwindigkeit min. 0,5 m/s Erhöhte Reinigungsleistung hohe verfahrens- und sicherheitstechnische Anforderungen
Spülen mit Wasser und mechanischen Hilfsmitteln	Bei festen Ablagerungen und Inkrustationen sowie bei mikrobieller Kontamination	Empfindliche Bauteile entfernen und manuell reinigen	Eis oder inerte Feststoffe erhöhte Reinigungsleistung

Nach DVGW W557 Tabelle 2 – Anwendungsbereiche der mechanischen Reinigungsverfahren

6

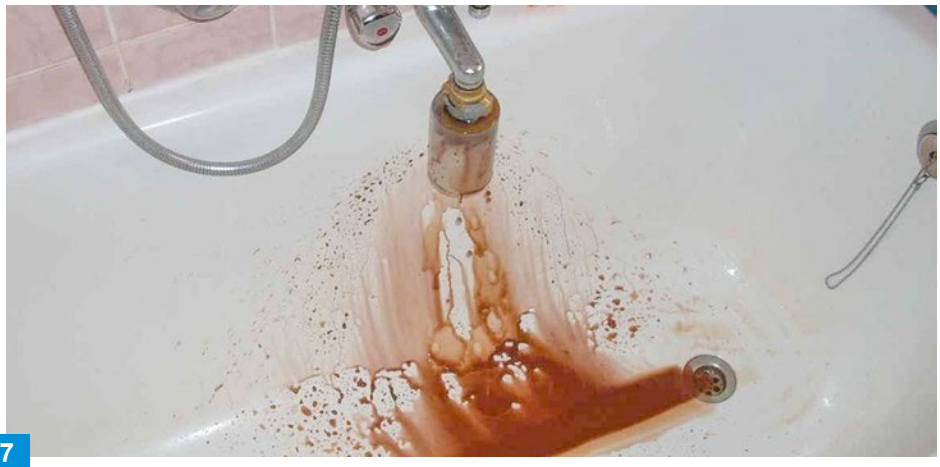
The illustration shows the possible mechanical cleaning methods according to DVGW W 557 (A), their area of application and the respective requirements.

Depending on the material, corrosion damage can occur after removal of the deposits without further corrosion protection measures, as protective cover layers are also removed depending on the process (**Fig. 6**).

When cleaning the pipes chemically, organic acids (e.g. citric, peracetic or acetic acid) should never be used for cleaning, as residues remaining in the drinking water installation can lead to germination.

In order to remove incrustations, deposits or biofilms in existing pipes, flushing with water and air is required to achieve an increased cleaning performance. The room-covering turbulent flow causes locally high, abrasive forces to mobilize deposits. Compared to simple rinsing with water, the water requirement is considerably reduced. The process is based on a controlled, pulse-like addition of compressed, technically clean air within a defined cleaning section in order to mobilize and remove even adhering contaminants and biofilm via shear and drag forces at high velocities of 10-20 m/s. In contrast to rinsing with water, this work has high procedural and safety requirements and must therefore be carried out by trained specialist companies (**Fig. 7**).

Picture: Hamann GmbH



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The requirements for preparation and special equipment mean that mechanical cleaning should only be carried out by trained specialist companies.

Process engineering measures

After the operational and constructional measures and after the installation has been prepared by suitable cleaning, a one-off system disinfection may be the final measure of a refurbishment. The aim of system disinfection is to restore the drinking water installation to a hygienically perfect condition after a technical refurbishment so that it can be used as intended.

In principle, however, a distinction must be made between system disinfection and drinking water disinfection: In contrast to drinking water disinfection, system disinfection is a discontinuous (one-off) measure that covers a drinking water installation as a whole or a contaminated area up to the consumer's tapping point. Drinking water disinfection, on the other hand, is a continuous (longer-lasting) measure that is primarily intended to reduce the microorganisms present in drinking water and has little or no effect on the installation itself. System disinfection is only sustainable if the causes of the contamination have been eliminated. System disinfection can be carried out both chemically and thermally, depending on the system in question, the type of contamination, the materials used, etc. UV disinfection is also an approved disinfection process, as it is used to reduce, kill and inactivate microorganisms.

DVGW W557:2012 Tabelle 3

Bezeichnung	Spezifikation	Handelsform	Bemerkungen	Anwendungs-konzentration[c] und Einwirkzeit
Wasserstoff-peroxid H_2O_2	DIN EN 902	Wässrige Lösungen bis 50 %	Verwendung als Do-sierlösung zur Anla-gendesinfektion	150 mg H_2O_2/l 24 h
		Wässrige Lösungen 3 %	Direkte Anwendung zur Sprühdesinfektion	Maximal 3 % kurzzeitig
Natriumhypo-chlorit NaOCl	DIN EN 901	Wässrige Lösungen mit maximal 150 g/l „freiem Chlor“[a]	Verwendung als Do-sierlösung zur Anla-gendesinfektion	50 mg Cl_2/l[c] 12 h
Chlordioxid ClO_2	DIN EN 12671	Zwei Komponenten[b] A: Natriumchlorit B: Persulfate und/oder Säure	Verwendung als Do-sierlösung mit maximal 3 g ClO_2/l zur Anlagen-desinfektion	6 mg ClO_2/l 12 h

a Haltbarkeit beachten, siehe DVGW W 229 (A)
b Herstellung der Dosierlösung siehe DVGW W 224 (A)
Natriumchlorit nach DIN EN 938, Kaliumperoxomonosulfat nach DIN EN 12678, Natriumhydrogensulfat nach DIN EN 16037, Salzsäure nach DIN EN 939
c Die Konzentration von Chlor/Hypochlorit/hypochloriger Säure wird als „freies Chlor“ bestimmt.

8

Overview of application areas as well as application concentrations and exposure times of suitable disinfectants.

However, UV disinfection alone cannot be used as a sanitation measure, but is only suitable in combination with another disinfection process ("Aachen concept"). After thermal or chemical disinfection, e.g. permanent UV irradiation can be used to reduce legionella or to extend the necessary disinfection intervals.

Thermal disinfection

As soon as a temperature of ≥ 70 °C is reached at the re-entry of the circulation at the DHW heater after the heating phase, hot water must flow out of each individual tapping point at a temperature of at least 70 °C for longer than three minutes. If necessary, the tapping points must be opened one after the other and individually thermally disinfected to maintain the temperature. The water temperatures must be monitored during withdrawal. The temperature and duration must be strictly adhered to. If the temperature falls below 70 °C at a tapping point, the measure must be aborted at this point. Once the entire system has been reheated and the required temperature has been reached again, the measure must be repeated for the section in question.

Unfortunately, it is often the case that the "thermal disinfection" carried out does not even meet the requirements of the relevant regulations. They tend to have the character of a "hot rinse", as often only the set temperature of the drinking water heater is increased and the taps are flushed.

If these increased temperatures are then maintained over a longer period of time, this can lead to considerable corrosion damage in installations made of galvanized ferrous materials, for example, and thus to total economic loss of the entire drinking water system. According to DVGW W 551 and W 557 (A), a periodic, temporary temperature increase in the drinking water heater with or without a circulation system (e.g. "legionella circuit" or "legionella sluice") is not a thermal disinfection, as not all parts of the system are covered (e.g.tapping valves). If not all parts of the system are exposed to 70 °C for at least three minutes, recontamination from the non-disinfected areas can occur very quickly after the measure has been completed. Such a measure is therefore not expedient.

Requirements for successful disinfection

During disinfection of the system, no drinking water from the drinking water installation is available to the consumer, as the water flowing through is either mixed with disinfectant chemicals or has an extremely high temperature with the risk of scalding. Suitable precautions (organizational or technical) must be taken to ensure that no water can be taken from the treated system as drinking water. Given drinking water must be provided elsewhere.

For chemical system disinfection, a suitable safety device in accordance with DIN EN 1717 and DIN 1988-100 must also be installed in relation to the public drinking water supply. Sufficient personnel must also be scheduled to carry out system disinfection, who must be instructed accordingly and for whom suitable work safety equipment must be provided if necessary.

Each system disinfection puts a strain on the materials and components of the drinking water installation, which can lead to premature aging of the materials or direct damage to the drinking water installation. Regular, preventive repetition of system disinfection to prevent contamination is therefore not recommended under any circumstances.

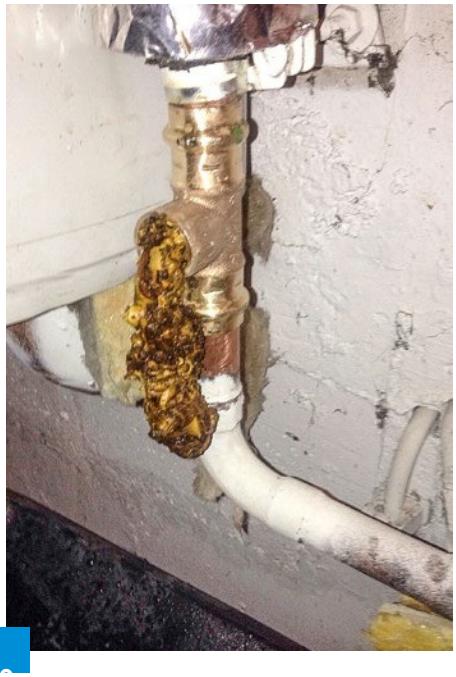
The respective cleaning or disinfection measure must be fully documented with all relevant accompanying circumstances. Corresponding forms are available in the appendix to DVGW W 557 (A) and should be completed in full and signed by the specialist company and handed over to the client after completion of the work. After system disinfection, the microbiological quality of the water must be checked by an inspection body in accordance with the Drinking Water Ordinance. These test results to document the success of the measure must also be handed over to the client for filing in the operating log.

Chemical disinfection

The disinfectants and disinfection procedures permitted for disinfecting drinking water are listed in the list of treatment substances and disinfection procedures in accordance with Section 11 TrinkwV 2001. The conditions specified in this list (including permissible minimum and maximum concentrations of disinfectants, scope of testing, frequency of testing, by-product concentrations) must be complied with at every tapping point of the drinking water installation in accordance with the Drinking Water Ordinance. The measurements for this must be taken at least daily; the results must be recorded. A violation of the requirements of § 11 and the associated list of the Federal Environment Agency is one of the few direct offenses under the Drinking Water Ordinance (**Fig. 8**). At the end of the exposure time, the disinfectant chemical used must still be detectable.

Impermissible measures

Some technical measures are decidedly not part of the refurbishment measures, as the use of various components and procedures, which are sometimes aggressively advertised on the market, is not even permissible according to the generally recognized rules of technology. One such method, which is sometimes controversially discussed, is the



Discharge of a detached epoxy resin layer from a drinking water installation: there is no alternative to completely reinstalling the pipe system.

Internal pipe coating in drinking water installations. Experts agree that the internal coating of drinking water pipes with epoxy resin or ceramic materials based on epoxy resin is neither a compliant solution for renovation nor for damage prevention. Nevertheless, the manufacturers of these methods continue to drum up a lot of publicity. For example, the manufacturers of these coating processes not only argue that rehabilitation costs are "well over 50 % lower". They also claim that the "old pipe is protected as if by metal armor". The coating material is "completely harmless to health, most preservative cans are coated with this material". Last but not least, the renovated pipes are allegedly "as durable as today's plastic pipes" (**Fig. 9**).

However, several recent court rulings have come to the conclusion that the internal coating with epoxy resin in the drinking water sector does not comply with the recognized rules of technology. For example, the reasoning of the Mannheim Regional Court (judgment of 23.10.2014 Ref.: 3 O 17/14) states: "In recent years, there has been an intensive discussion about the suitability of the resin from a hygienic point of view. As part of the discussion, it was claimed that epoxy resin components, such as the substances bisphenol A (BPA) and epichlorohydrin, are harmful to health and can be released when drinking water pipes are used". It is not only the material used in this method that must be viewed critically. The process itself is also questionable, as there are no valid guidelines for implementation, testing and qualification.

At the end

Both after cleaning and disinfection measures, tests must be carried out at representative sampling points to prove the success of the measure and to document a microbiologically flawless drinking water quality. If a chemical system disinfection has been carried out, measurements must be taken before microbiological sampling to prove that the disinfectant solution has been completely rinsed out of the drinking water installation and that sampling is carried out under "real conditions". After thermal disinfection, the operating temperature must be verified and documented by measuring representative sampling points (also in drinking water (cold)!).

If the three necessary follow-up examinations after 1 week, after 3 mo

LITERATURE

- Ordinance on the Quality of Water for Human Consumption (Drinking Water Ordinance - TrinkwV 2001) in the new version of the Drinking Water Ordinance of March 10, 2016
- Arnd Bürschgens: Legionella in drinking water installations, risk analysis and remediation, Beuth Verlag, January 2016
- DVGW Code of Practice W 551 Drinking water heating and drinking water piping systems; technical measures to reduce legionella growth; planning, construction, operation and renovation of drinking water installations
- DVGW Code of Practice W 556 Hygienic-microbial abnormalities in drinking water installations; methods and measures for their elimination
- DVGW Code of Practice W 557 Cleaning and disinfection of drinking water installations
- DVGW Code of Practice W 558 (draft) Repair of drinking water installations

If the limit values, requirements and the technical measure value of the Drinking Water Ordinance are complied with after 6 months, the renovated drinking water installation can be put back into operation as intended. The success of the remediation can therefore only be determined after submission of the flawless follow-up test results.

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