



SLOVENSKI STANDARD

SIST DIN 19643-4:2003

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Treatment of water of swimming pools and baths - Part 4: Combination of process:
Flocculation, ozonisation, multilayer filtration, chlorination

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Ta slovenski standard je istoveten z:

ICS:

13.060.25 Voda za industrijsko uporabo Water for industrial use

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**Treatment and disinfection of water used in
bathing facilities**
Part 4: Combined coagulation, ozonization, multi-layer filtration
and chlorination method

DIN
19643-4

ICS 13.060.25

Supersedes parts of
DIN 19643, April 1984
edition.

Descriptors: Water treatment, bathing facilities, requirements.

Aufbereitung von Schwimm- und Badebeckenwasser –
Teil 4: Verfahrenskombination: Flockung – Ozonung –
Mehrschichtfiltration – Chlorung

In keeping with current practice in standards published by the International Organization for Standardization (ISO), a comma has been used throughout as the decimal marker.

Foreword

This standard has been prepared by Technical Committee IV 13 of the *Normenausschuß Wasserwesen* (Water Practice Standards Committee).

This revision of DIN 19643 is response to article 11 of the *Bundessteuergesetz* (German Federal Communicable Diseases Act) which deals with water for swimming pools and public baths. The *Legionella pneumophila* and trihalomethane (haloform) values specified in the regulation which implements this article (the *Schwimm- und Badebeckenwasserverordnung* (German Regulation on water used in bathing facilities)) *) have been incorporated into the present standard.

At the same time, the standard was divided into several parts: Part 1 specifies general requirements, while subsequent parts deal with different combinations of water treatment methods. Additional parts can now be added to the series as the state of the art develops.

To ensure proper application of this standard, water treatment systems should be designed, built and monitored only by experienced specialists. Attention is drawn to *DVGW-Arbeitsblätter* (DVGW Codes of practice) W 200 and W 201, which specify procedures for certifying water treatment experts.

Amendments

This standard differs from DIN 19643, April 1984 edition, as follows:

- a) The standard now consists of four parts.
- b) The standard has been brought in line with the state of the art.

Previous edition

DIN 19643: 1984-04.

1 Scope

This standard specifies a method for the treatment of water in bathing facilities, combining coagulation, ozonization, multi-layer filtration and chlorination.

It is to be used together with DIN 19643-1.

2 Normative references

This standard incorporates, by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text, and the titles of the publications are listed below. For dated references, subsequent amendments to or revisions of any of these publications apply to this standard only when incorporated in it by amendment or revision. For undated references, the latest edition of the publication referred to applies.

*) Currently at draft stage.

Continued on pages 2 to 11.

Translation by DIN-Sprachendienst.

In case of doubt, the German-language original should be consulted as the authoritative text.

| | |
|-------------|--|
| DIN 19603 | Activated carbon for water treatment – Technical delivery conditions |
| DIN 19605 | Fixed-bed filters for water treatment – Design and components |
| DIN 19627 | Ozone generators for water treatment |
| DIN 19643-1 | Treatment and disinfection of water used in bathing facilities – General requirements |
| DIN 38409-7 | German standard methods for the examination of water, waste water and sludge – Parameters characterizing effects and substances (group H) – Determination of acidity and alkalinity (H7) |
| DIN 66131 | Principles of determining the effective surface area of solid particles by the Brunauer, Emmett and Teller (BET) gas adsorption method |
| DIN EN 878 | Chemicals used for treatment of water intended for human consumption – Aluminium sulfate |
| DIN EN 881 | Chemicals used for treatment of water intended for human consumption – Aluminium chloride, aluminium chloride hydroxide and aluminium chloride hydroxide sulfate (monomeric) |
| DIN EN 882 | Chemicals used for treatment of water intended for human consumption – Sodium aluminate |
| DIN EN 888 | Chemicals used for treatment of water intended for human consumption – Iron(III) chloride |
| DIN EN 890 | Chemicals used for treatment of water intended for human consumption – Iron(III) sulfate |
| DIN EN 891 | Chemicals used for treatment of water intended for human consumption – Iron(III) chloride sulfate |
| DIN EN 896 | Chemicals used for treatment of water intended for human consumption – Sodium hydroxide |
| DIN EN 897 | Chemicals used for treatment of water intended for human consumption – Sodium carbonate |
| DIN EN 898 | Chemicals used for treatment of water intended for human consumption – Sodium hydrogen carbonate |
| DIN EN 899 | Chemicals used for treatment of water intended for human consumption – Sulfuric acid |
| DIN EN 936 | Chemicals used for treatment of water intended for human consumption – Carbon dioxide |
| DIN EN 939 | Chemicals used for treatment of water intended for human consumption – Hydrochloric acid *) |

DVGW-Arbeitsblätter (DVGW Codes of practice)**)

DVGW-Arbeitsblatt W 200 *Zertifizierung von Unternehmen für Wasseraufbereitungsanlagen – Anforderungen und Prüfung* (Certification of water treatment plant manufacturers – Requirements and testing)

DVGW-Arbeitsblatt W 201 *Zertifizierung von DVGW-Sachverständigen für Wasseraufbereitung – Anforderungen und Prüfung* (Certification of DVGW experts for water treatment – Requirements and testing)

DVGW-Arbeitsblatt W 240 *Beurteilung von Aktivkohlen für die Wasseraufbereitung* (Assessment of activated carbon for water treatment)

[SIST DIN 19643-4:2003](#)

[1] Moll, H.-G. *Die Bettausdehnung bei der Filterspülung* (Filter bed expansion during backwashing). Archiv des Badewesens, 1992: **45**, p. 530. [7c688ae15b22/sist-din-19643-4-2003](#)

3 Principle

3.1 General

Dissolved and dispersed colloidal impurities and orthophosphates are first destabilized by coagulation using iron(III) or aluminum salts and ozone, and then removed by filtration. Chlorine by-products are adsorbed and any residual ozone and chlorine removed. In the case of variant D, coagulation is only performed if the natural iron content of the filling water is not high enough to eliminate phosphates. A high redox potential due to the effects of the ozone leads to a quick elimination of microorganisms and the inactivation of viruses.

The filtrate is then chlorinated and fed to the bath or pool water.

The maximum load capacity factor, k , obtained is $0,6 \cdot \text{m}^{-3}$, equivalent to a treated water volume of $1,67 \text{ m}^3$ per person.

3.2 Variants A and B

(See figures 1 and 2.)

Dispersed colloidal impurities are first destabilized by coagulation using iron(III) or aluminium salts, and orthophosphates are precipitated. During this process, the pH value of the raw water is kept within a range consistent with the type of coagulant used.

Following coagulation, ozone is added in order to oxidize chemical constituents of the water, eliminate microorganisms and inactivate viruses. The metal salts present serve as catalysts and accelerate the decomposition of nitrogenous impurities. To ensure a complete reaction, the chamber in which the water to be treated comes in contact with the ozone (e.g. ozone reactor) should have a volume large enough to ensure a water residence time of at least ten minutes.

*) Currently at draft stage.

**) Obtainable from *Wirtschafts- und Verlagsgesellschaft Gas und Wasser mbH*, Postfach 14 01 51, D-53056 Bonn.

Next, the treated water is passed through either an open (variant A) or a closed (variant B) multi-layer filter, removing any residual ozone, separating off the substances precipitated by ozone treatment and coagulation, and largely adsorbing haloforms.

Finally, the filtrate is chlorinated and fed to the bath or pool water.

3.3 Variant C

(See figure 3.)

Dispersed colloidal impurities are first destabilized by coagulation using iron(III) or aluminium salts, and orthophosphates are precipitated. During this process, the pH value of the raw water is kept within a range consistent with the type of coagulant used.

Following coagulation, ozone is added in order to oxidize chemical constituents of the water, eliminate microorganisms and inactivate viruses. The metal salts present serve as catalysts and accelerate the decomposition of nitrogenous impurities.

After a reaction time of more than three minutes, the treated water is passed through a multi-layer filter comprising a top layer of pumice, an intermediate layer of powdered activated carbon, and a bottom layer of sand. This removes any residual ozone, separates off the substances precipitated by ozone treatment and coagulation, and largely adsorbs haloforms.

Finally, the filtrate is chlorinated and fed to the bath or pool water.

3.4 Variant D

(See figure 4.)

In a pressurized reactor, ozone is added to the water to be treated in order to oxidize chemical constituents of the water, eliminate microorganisms and inactivate viruses. If the iron content of the filling water is not high enough to eliminate phosphate, then orthophosphates are precipitated by adding iron(III) or aluminium salts.

Next, the ozonated water is passed through a closed, multi-layer filter with a mixture of pumice and powdered activated carbon as the top layer, and sand as the bottom layer. This removes any residual ozone, separates off the substances precipitated by ozone treatment and coagulation, and largely adsorbs haloforms.

Finally, the filtrate is chlorinated and fed to the bath or pool water.

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4 Procedure

4.1 Acidity adjustment

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4.1.1 General

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To achieve satisfactory coagulation, the acidity, $K_{S4,3}$ (cf. DIN 38409-7), of the raw water shall be adjusted to a given minimum value, unless the acidity of the filling water is high enough to preclude that of the raw water from dropping below the minimum value. Acidity adjustment shall be made by adding an aqueous solution of sodium carbonate or sodium hydrogencarbonate to the raw water via a feeder.

4.1.2 Reagents

Sodium carbonate (as in DIN EN 897) or sodium hydrogencarbonate (as in DIN EN 898) shall be used for acidity adjustment.

4.1.3 Minimum acidity

When the method as described in this standard is used for bathing facilities other than hot whirlpool baths (with in-house treatment system), $K_{S4,3}$ shall be not less than 0,7 mol/m³, and, when this method is used for hot whirlpool baths (with in-house treatment system), $K_{S4,3}$ shall be not less than 0,3 mol/m³.

4.1.4 Check

After the reagents added have been thoroughly dispersed, the acidity shall be determined to check for compliance with the values specified in subclause 4.1.3.

4.2 pH value adjustment

4.2.1 General

For satisfactory coagulation and adequate disinfection with the lowest possible consumption of disinfectant, the pH value of the water shall be adjusted to a preset value using a feeder which automatically controls this value. The reagents added shall be thoroughly mixed with the water before they reach the pH sensor and the sampling point.

4.2.2 Reagents

The following reagents shall be used for pH value adjustment:

- sodium carbonate (as in DIN EN 897) or sodium hydroxide (as in DIN EN 896) if the pH value of the raw water is too low;
- carbon dioxide (as in DIN EN 936), hydrochloric acid (as in DIN EN 939), sulfuric acid (as in DIN EN 899), or sodium hydrogensulfate if the pH value of the raw water is too high.

4.2.3 pH value range

The pH shall range between 6,5 and 7,2 if aluminium salts are used for coagulation and between 6,5 and 7,5 (or 7,8 in the case of sea water) if iron salts are used for coagulation.

4.2.4 Check

After the reagents have been added, check whether the preset pH value is maintained to within $\pm 0,1$, using a pH meter.

4.3 Coagulation (variants A, B and C only)

4.3.1 General

After the acidity and pH value of the water have been adjusted, coagulant shall be added continually so that it is evenly distributed across the water surface, using a feeder.

The coagulant shall be rapidly and completely mixed with the water directly at the feed point. This can be achieved, for example, by means of a sudden change in pipe diameter (e.g. by reducing the pipe diameter by 30 %) immediately downstream of the feed point. The reaction time prior to the water entering the liquid head of the filter shall be at least ten seconds, with the flow velocity of the water not exceeding 1,5 m/s. After flocs have formed in the reaction section, care shall be taken to ensure that they are not destroyed by internal pipe fittings.

Throttle valves shall only be fitted upstream of the reaction section or downstream of the filter section.

Provided the requirements specified in table 2 in DIN 19643-1 are complied with, it will not be necessary to add coagulant between bathing sessions.

4.3.2 Coagulants

The following may be used as coagulants:

- aluminium sulfate, as in DIN EN 878;
- aluminium chloride hexahydrate, as in DIN EN 881;
- sodium aluminate, as in DIN EN 882;
- aluminium chloride hydroxide or aluminium chloride hydroxide sulfate, as in DIN EN 881;
- iron(III) chloride hexahydrate, as in DIN EN 888;
- iron(III) chloride sulfate solution, as in DIN EN 891;
- iron(III) sulfate, as in DIN EN 890.

4.3.3 Minimum quantity of coagulant to be added

The minimum quantity of coagulant added shall be 0,05 g/m³ for aluminium salts (calculated as Al) and 0,1 g/m³ for iron salts (calculated as Fe).

4.3.4 Check

The correct performance of the coagulation process shall be checked by verifying compliance with the requirements set out in table 3 (at filter outlet).

4.4 Ozonization

4.4.1 General

Ozone generators shall comply with DIN 19627, with the ozone being introduced into water either directly or indirectly.

4.4.2 Ozone concentration

The concentration of ozone in the gas mixture shall be greater than 20 g/m³ of O₃ under reference conditions¹⁾. Lower ozone concentrations should be avoided since they lead to poorer absorption.

A temperature-dependent decomposition occurs simultaneously with the desired reactions between ozone and water constituents. Since the ozone decomposition rate at any point in time is proportional to the ozone concentration, ozone shall be added at the following concentrations:

- not less than 0,8 g/m³ for water temperatures up to 28 °C;
- not less than 1 g/m³ for water temperatures above 28 °C up to 32 °C;

¹⁾ Temperature: 0 °C. Atmospheric pressure: 1 013,25 mbar.

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- c) not less than 1,2 g/m³ for water temperatures above 32 °C up to 35 °C;
- d) not less than 1,5 g/m³ for water temperatures above 35 °C.

Ozone shall be added at a constant rate while the treatment system is operating.

4.4.3 Reaction systems

1) Variants A and B

Mix the ozonated water with the water to be treated in a series of two or more connected mixing or reaction chambers, at a hydrostatic pressure of about 0,25 bar.

2) Variant C

Either mix the ozonated water with the water to be treated in a mixing chamber, or provide pipe internals which ensure a thorough mixing of the water, in either case at a pressure of at least 0,8 bar. After the ozone has been thoroughly mixed with the water, the reaction time of the ozone shall exceed three minutes; this time is given by the residence time of the water between the ozone feed point and the excess ozone removal point (top of activated carbon filter layer).

3) Variant D

Add the ozonated air to a pressurized reactor containing porous diffusers, and then to the raw water. The reactor shall be a vertical pressure vessel that is at least 2 m high, with a distributor pipe above the diffusers and a bottom tray with nozzles. The water level shall lie below the tray and shall be monitored and – when necessary – adjusted. The space required for the diffusers determines the hydraulic design of the vessel and its diameter. The total effective surface area of particles in the diffusers shall be at least 3 m² for every 1 m³/h of flow.

4.5 Filtration

4.5.1 General

Sorption filtration removes any residues of ozone, chlorine and its substitution products, destabilized colloids and oxidized substances from the water.

Any inactivation of activated carbon may be detected by comparing the difference in redox potentials measured at the inlet and outlet of the sorption filter. This shall be at least 250 mV (Pt-Ag/AgCl 3 m KCl).

EXAMPLE:

- potential at filter inlet = + 825 mV;
- potential at filter outlet = + 530 mV;
- difference = + 295 mV.

Since the redox potential (in a poorly buffered system) establishes only slowly, each measurement period shall last at least five hours.

The following filters shall be used:

1) Variant A

Open, multi-layered fixed-bed filters as in DIN 19605.

2) Variants B and C

Closed, multi-layered fixed-bed filters as in DIN 19605.

3) Variant D

Closed, multi-layered fixed-bed filters as in DIN 19605, in a pressure vessel at least 2,3 m high.

4.5.2 Size fractions, bed heights and filtration rates

Filters shall satisfy the requirements specified in table 1.

4.5.3 Activated carbon losses

Since the activated carbon is constantly consumed by sorption processes and backwashing, the bed height shall be regularly monitored and the carbon replenished when the bed height has decreased by more than 10 %, but in any case at least once a year.

4.5.4 Backwashing filters

To backwash filters, the filter beds shall be fluidized and expanded by at least 10 % in order to remove substances retained in the filter, particularly any significant microorganisms found in the bath or pool water. The backwashing operation shall be automatic and shall not be interrupted. Before backwashing begins, ensure that the space above the filter bed is free of ozone.

The quantity of water required for backwashing shall be available before the backwashing operation is started. The water discharged as a result of lowering the water level can be retained and then used as backwashing water, for instance. In addition, care shall be taken to ensure that the waste water can flow off without hindrance; if necessary, a collecting tank shall be provided for waste water. When the backwashing process is complete, the filter bed shall be deaerated.

The backwashing programmes for all variants of this method are given in table 2.

4.5.5 Check

Check whether the values given in table 3 are complied with throughout the filtration process.

Table 1: Size fractions, bed heights and filtration rates for filters

| Parameter | Unit | Open fixed-bed filters | Closed fixed-bed filters | | |
|--|------|--|--------------------------|------------|-------------------|
| | | Variant A | Variant B | Variant C | Variant D |
| Size fraction a | mm | 0,4 to 0,8 | | | |
| b | | 0,71 to 1,25 | | | |
| c | | 0,8 to 1,5 | | | |
| d | | 0,6 to 2,4 | | | |
| e | | 1,4 to 2,5 | | | |
| Filter material combinations: Sand/powdered activated carbon ¹⁾ Sand/powdered activated carbon/ pumice | | b/d — | b/d — | — a/d/c | — b/d/e |
| Minimum bed height | m | 25 % of filter material bed height + 0,2 m | | | |
| Sand | | 1,0 | 0,5 | 0,4 | 0,4 |
| Powdered activated carbon | | 0,15 | 0,4 | 0,6 | 0,3 ³⁾ |
| Pumice | | — | — | 0,3 | 0,7 ³⁾ |
| Minimum freeboard | m | 25 % of filter material bed height + 0,2 m | | | |
| Maximum filtration rate ²⁾ for fresh water | m/h | 12 | 30 | 30 | 30 |
| for sea water and brackish water with a concentration above 2 000 mg/l | | 12 | 20 | 20 | 20 |
| ¹⁾ As compacted density and dechlorination capacity of activated carbon as in DIN 19603 (greater than 450 g/l and less than 10 cm, respectively). The total effective surface area of particles (determined by the BET method as in DIN 66131) shall be greater than 900 m ² /g. ²⁾ The bed height and filtration rate for mineral water should be determined by experiment. | | | | | |

4.6 Chlorination**4.6.1 General**

The filtrate is chlorinated to restore the disinfection capacity of the bath or pool water. See clause 11 of DIN 19643-1 for details of chlorination.

4.6.2 Chlorine concentration

To combat communicable diseases, chlorine shall be added while the water treatment system is operating, i.e. even when the bathing facility is closed. The free chlorine concentration in bath or pool water shall be 0,2 mg/l to 0,5 mg/l, except for hot whirlpool baths, where the concentration shall be 0,7 mg/l to 1,0 mg/l.

4.6.3 Check

Check whether – after thorough mixing of the chlorine with the bath or pool water and a flow time of at least 20 seconds (e.g. in a water tapping pipe) – the concentration of free chlorine in clean water does not exceed 2 mg/l in indoor baths or pools and 10 mg/l in outdoor baths or pools.

It shall be possible to maintain the maximum possible concentration of free chlorine in the pool water of 1,2 mg/l during operation.

5 Load capacity factor

When using the combined method described here, a load capacity factor of not more than 0,6 m⁻³ shall be used to calculate the flow (as described in clause 8 of DIN 19643-1).

Table 2: Backwashing programmes

| Stage | Procedure | Flow velocity, in m/h | Flow time, in minutes | | | |
|-------|---|------------------------|-----------------------|-----------|-----------|-----------|
| | | | Variant A | Variant B | Variant C | Variant D |
| 1 | Switch off ozone feed until liquid head compartment is free of ozone | — | +1) | + 1) | + 1) | + 1) |
| 2 | Lower water level to top of filter gutter or filter material | — | + 1) | — | — | + 1) |
| 3 | Pre-wash with water | ≥ 40 | 3 | — | — | — |
| 4 | Fill with water | — | — | — | — | + 1) |
| 5 | Lower water level to top of filter material | — | + 1) | + 1) | — | + 1) |
| 6 | Flush with air | ≥ 60 | 3 | 3 | — | — |
| 7 | Deaerate filter bed | — | + 1) | — | — | — |
| 8 | Backwash with water at 25 °C ²⁾ – for material combination a/d/c – for material combinations b/d and b/d/e | 40 to 55 ³⁾ | — | — | 6 | — |
| | | 60 to 65 ³⁾ | 3 | 6 | — | 6 |
| 9 | Discharge the first filtrate (quantity to be equal to at least one full filter bed volume) as waste | — | + 1) | + 1) | + 1) | + 1) |
| 10 | Re-establish water treatment operations | — | + 1) | + 1) | + 1) | + 1) |

1) Flow times shall be determined on a case-by-case basis.
2) To determine flow velocities and flow times for other temperatures and size fractions, see [1].
3) For loosely packed materials, the flow velocity may be reduced by 10 %, as long as the required filter bed expansion and fluidization specified in subclause 4.5.4 is achieved.

Table 3: Filtration requirements

| Subclause as in table 2 of DIN 19643-1 | Parameter | Unit | Requirement (maximum) |
|--|--|-------------------|--|
| 5.3.1.1 | <i>Pseudomonas aeruginosa</i> at (36 ± 1) °C | 1/(100 ml) | n.d. ¹⁾ |
| 5.3.1.3 | <i>Legionella pneumophila</i> at (36 ± 1) °C | 1/(100 ml) | n.d. ¹⁾ |
| 5.3.1.5 | Colony forming units (CFU) at (36 ± 1) °C | 1/ml | < 20 if free chlorine concentration is 0,1 (mg/l) or greater < 100 if free chlorine concentration is less than 0,1 (mg/l) |
| 5.3.2.2 | Turbidity | FNU ²⁾ | < 0,1 |
| 5.3.2.6 | Oxidizability of Mn VII → II above that of filling water, expressed as O ₂ content ³⁾ | mg/l | 0 |
| | Consumption of KMnO ₄ above that of filling water, expressed as KMnO ₄ content ³⁾ | mg/l | 0 |
| 5.3.2.10 | Combined chlorine ^{4),5),6)} | mg/l | < 0,1 |
| — | Ozone | mg/l | < 0,05 |
| 5.3.2.11 | Haloforms, expressed as chloroform content ^{4),5)} | mg/l | < 0,02 |

1) n.d. – not detectable.

2) FNU: formazine nephelometric unit.

3) If the oxidizability of the filtrate is lower than that of the filling water for an unoccupied pool, this lower value shall be used as the reference value; if, however, the oxidizability of the filling water is lower than 1 mg/l O₂ or lower than 4 mg/l KMnO₄, these values shall be used as reference values.

4) Existing systems that do not meet these requirements should be retrofitted within four years following publication of this standard.

5) Does not apply to cold-water plunge pools with a volume of 2 m³ or less and which have a continuous filling water flow.

6) In the case of water containing bromides and iodides, free and combined bromine or iodine shall be expressed as chlorine.