

Nederlandse norm

NEN-EN 17818

(en)

Devices for in-situ generation of biocides - Active
chlorine generated from sodium chloride by
electrolysis

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EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

EN 17818

December 2023

ICS 13.060.20

English Version

Devices for *in-situ* generation of biocides - Active chlorine
generated from sodium chloride by electrolysis

Équipements pour la production *in situ* de biocides -
Chlore actif produit à partir de chlorure de sodium par
électrolyse

Anlagen zur *In-Situ*-Erzeugung von Bioziden - Aktives
Chlor hergestellt aus Natriumchlorid durch Elektrolyse

This European Standard was approved by CEN on 27 November 2023.

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European foreword

This document (EN 17818:2023) has been prepared by Technical Committee CEN/TC 164 “Water supply”, the secretariat of which is held by AFNOR.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by June 2024, and conflicting national standards shall be withdrawn at the latest by June 2024.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN shall not be held responsible for identifying any or all such patent rights.

Devices according to this document may be used in different fields of application, e.g. drinking water, swimming pool water, wastewater, air treatment, surface disinfection, etc. Additional requirements to this document shall be observed, where appropriate for the specific application.

Any feedback and questions on this document should be directed to the users’ national standards body. A complete listing of these bodies can be found on the CEN website.

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Introduction

In respect of potential adverse effects on human and animal health and the environment, caused by the product covered by this document:

- a) this document provides no information as to whether the product may be used without restriction in any of the Member States of the EU or EFTA;
- b) note that, while awaiting the adoption of verifiable European criteria, existing national regulations concerning the use and/or the characteristics of this product remain in force.

1 Scope

This document defines the minimum requirements for treatment systems, which generate the active substance - “Active chlorine” - from sodium chloride by electrolysis for on-site (*in situ*) operation.

The *in situ* generated active substance (IGAS), in this case active chlorine, may be put into a solution (“off-line”) or directly generated in the pipes (“in-line”).

This document specifies the device construction, and test methods for the equipment used for *in situ* generation of active chlorine. It specifies requirements for instructions for installation, operation, maintenance, safety and for documentation to be provided with the product.

The *in situ* generation of active substances and the placing of their precursors on the EU market are subject to the specifications of the Biocidal Products Regulation (EU) 528/2012 [“Biocidal products”]. Active substances, generated by devices, which are claiming compliance with this document, shall comply with the BPR for both the registered active chlorine, quality standards and the precursor in accordance with appropriate application and “Product Type” as listed in the BPR.

This standard does not identify applications for *in situ* devices for generation of active chlorine. The range of applications for *in situ* generation of chlorine is diverse. It is the responsibility of the economic operator/product supplier, claiming compliance with this standard, to identify the appropriate system type and operating conditions for the specific application and to:

- specify the quality of the biocide appropriate to the application. This may be defined in national or international standards;
- specify the appropriate product type and operating conditions (concentration, dosage rate and quality of the active chlorine);
- specify any other regulatory requirements relevant to the specific application;
- specify the appropriate precursor sodium chloride, for the application;
- and to label the product accordingly.

2 Normative references

The following documents are referenced in the text in such a way that some parts of these or their entire contents constitute requirements of this document. With dated references, only the referenced issue is applicable. With undated references, the last issue of the referenced document is applicable (including all changes).

EN 1717, *Protection against pollution of potable water in water installations and general requirements of devices to prevent pollution by backflow*

EN IEC 60751, *Industrial platinum resistance thermometers and platinum temperature sensors (IEC 60751)*

EN ISO 7393-1, *Water quality — Determination of free chlorine and total chlorine — Part 1: Titrimetric method using N,N-diethyl-1,4-phenylenediamine (ISO 7393-1)*

EN ISO 7393-2, *Water quality — Determination of free chlorine and total chlorine — Part 2: Colorimetric method using N,N-dialkyl-1,4-phenylenediamine, for routine control purposes (ISO 7393-2)*

EN ISO 10304-1, *Water quality — Determination of dissolved anions by liquid chromatography of ions — Part 1: Determination of bromide, chloride, fluoride, nitrate, nitrite, phosphate and sulfate (ISO 10304-1)*

EN ISO 10304-4, *Water quality — Determination of dissolved anions by liquid chromatography of ions — Part 4: Determination of chlorate, chloride and chlorite in water with low contamination (ISO 10304-4)*

EN ISO 15061, *Water quality — Determination of dissolved bromate — Method by liquid chromatography of ions (ISO 15061)*

ISO 3696, *Water for analytical laboratory use — Specification and test methods*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <https://www.electropedia.org/>
- ISO Online browsing platform: available at <https://www.iso.org/obp>

In addition, the terminology contained in Article 3 of the BPR is to be included in the application for this document.

3.1

biocidal active substances

substance or microorganism that has an action on or against harmful organisms

[SOURCE: (Definition of active substance in BPR Article 3 (1) (c).)]

3.1.1

technical active substance (TAS)

active substance produced including minor constituents and any contaminants produced during the process

3.1.2

IGAS – in situ generated active substance

biocidal active substances, when they are generated from one or more precursors at the place of use

3.2

anolyte

medium output from the anode compartment

3.3

buffer tank

one or several tanks separate from the electrolysis cell or the reactor for temporary provision of the generated chlorine solution that is intended for the application

3.4

diaphragm

porous barrier in a divided electrolysis cell without ion selectivity between the anode and cathode compartment of the electrolysis cell

Note 1 to entry: In contrast to the membrane, the diaphragm permits the passage of a limited quantity of hydroxide ions from the cathode compartment to the anode compartment. This reduces the pH-value in the cathode compartment, while the pH-value in the anode compartment increases at the same time.

EN 17818:2023 (E)**3.5****electrochlorination system**

device that uses the principle of electrolysis to produce active chlorine excluding additional equipment

3.6**electrolysis cell**

system in which positively charged electrodes (anodes) and negatively charged electrodes (cathodes) are positioned face to face

3.6.1**divided electrolysis cell**

electrolysis cell in which the anode and cathode compartments are divided by a membrane or diaphragm

3.6.2**non-divided electrolysis cell**

electrolysis cell in which the anode and cathode compartments are not divided, therefore enabling unimpeded liquid, ion and gas transport in the space between the electrode pairs

3.7**expert**

person who, due to their technical scientific training, work experience and knowledge of applicable standards and regulations, is able to assess an electrolysis system with regard to functions and safety

Note 1 to entry: This person can be from the manufacturer or an independent third-party organization (such as a test institution) without limitations, an inspector according to EN ISO/IEC 17020 Type C [8], fulfils this criterion.

3.8**feed water**

water in accordance with the chemical requirements of the corresponding manufacturer's specifications for the production of sodium chloride solution and/or operation of the electrolysis system

3.9**gas separator**

system for the physical separation of gases (in this case: hydrogen/chlorine) from liquids

3.10**injector**

component that enables the flow of the sodium chloride solution, the active chlorine solution, the chlorine gas or their mixtures into a water flow, typically employing the venturi principle

3.11**in-line electrolysis**

process in which the water to be treated is the operating medium and fed directly into the electrolysis cell

3.12**in-situ generation**

reaction of at least one precursor to generate the technical active substance on site

3.13**membrane**

cation-selective barrier in a divided electrolysis cell between the anode and cathode compartment

Note 1 to entry: This prevents the reaction between the chlorine gas and hydroxide ions (OH⁻), by allowing monovalent cations and inhibiting anions (chloride and hydroxide) to permeate through the membrane.

3.14**nominal capacity**

maximum production rate of active chlorine as specified by the manufacturer

3.15**operating media**

artificial or natural sodium chloride solutions that are used for electrolysis

3.16**precursor**

substance that is fed to the in-situ device for production of the biocide active substance, independent of its disinfection or biocide-law related properties substance or mixture (formulation containing the precursor(s)), from which an active substance (including free radicals) is generated in situ

3.17**product range**

systems that operate according to the same functional principle but with different capacities

3.18**reactor**

system for converting chlorine gas and sodium hydroxide into a sodium hypochlorite solution

3.19**sodium chloride solution****3.19.1****artificial sodium chloride solution**

solution produced using manufactured sodium chloride

Note 1 to entry: E.g. in accordance with EN 14805, EN 973, EN 16370 or EN 16401.

3.19.2**natural sodium chloride solution**

naturally occurring sodium chloride containing solution, such as sea water and brackish water

3.20**stability curve**

representation of the chlorine content and by-products at the specified temperature over time

Note 1 to entry: In systems with buffer tanks, this forms a basis in order to ensure that the active substance content and the amount of by-products such as chlorate in the generated chlorine solution in the buffer tank do not change unacceptably during the time between generation and metering the chlorine solution.

3.21**system type**

system in a product range with a representative capacity

Note 1 to entry: Production capacity in kg/h chlorine.

4 Requirements

4.1 General

The manufacturer/supplier, claiming compliance with this standard, shall fulfil the following requirements:

4.2 Design

4.2.1 Temperature

The equipment shall be designed to operate to the requirements of this standard with water temperatures between 5 °C and 25 °C and with ambient temperatures between 5 °C and 35 °C minimum. For higher temperatures, the device shall be designed accordingly.

4.2.2 Backflow prevention

If connected to a drinking water supply, the device shall be fitted with a backflow prevention device appropriate to the application in accordance with EN 1717.

4.2.3 Safety

System design shall include appropriate measures for management of release potentially hazardous hydrogen gas, excess chlorine and surplus production (see Clause 7). It shall include protection against stray electrical discharge and compliance with relevant standards to the application.

4.3 Performance

The device shall be tested at the highest active chlorine concentration and maximum production rate as specified by the manufacturer and appropriate to the requirements of the end user application.

This test may be conducted on the manufacturer's premises or on the installed system.

4.4 Instructions

The manufacturer/supplier of the device shall provide detailed instructions for installation (see Clause 8), operation and maintenance for the complete system, including appropriate safety procedures (see Clause 7).

5 Electrolysis system and components

5.1 General

Electrochlorination systems shall include, as a minimum, an electrolysis cell and control unit. Optional items may also be included (see 6.3).

5.2 Electrolysis cell

The electrolysis cell comprises a vessel into which positive (anode) and negative (cathode) electrodes are appropriately located.

The electrodes, which can vary in number, shape, material and dimensions, produce the disinfectant and oxidizing agent under the action of the electric current.

NOTE Depending on its chemical composition the feed water supply might increase mineral deposits precipitating on the cathodes. The higher the total hardness of the water, the greater the scaling, thereby significantly reducing the production of disinfectant and possibly also the flow through the electrolysis cell in the case of inline electrolysis. To reduce these effects, the electrolysis cells can function with polarity reversal,

automatic/semi-automatic acid washing systems or alternatively, the water supply can be (softened) treated appropriately.

Sufficiently resistant materials shall be used for all parts of the systems and devices that come into contact with the chemicals and their solutions that are utilized and generated.

The electrochlorination system should be assembled and installed in accordance with the manufacturer's instructions and in compliance with the requirements of applicable standards – e.g. electrical.

5.3 Control unit

The control unit can be built into or independent of the electrochlorination device.

The control unit integrates the components that control the cell power supply and therefore the production of disinfectant. The control unit shall deliver a Safety Extra-Low Voltage (SELV) supply.

Where the control unit is not included in the device, it shall bear a manufacturer's plate indicating the data, in particular:

- the identification of the distributor (commercial name or logo, etc.);
- the power supply voltage in Volt;
- the frequency in Hertz;
- the power input in Watt;
- the current in Ampere;
- the protection index (IP);
- and the insulation class if necessary.

The control unit shall be installed in accordance with:

- the information indicated on this plate;
- the manufacturer's requirements and recommendations;
- applicable standards.

5.4 Optional items

5.4.1 Flow detector

This component informs the electrochlorination system of an adequate flow, required for the electrolysis process. This flow can be used to control or shut down the chlorine production.

5.4.2 System for dissipating stray electrical currents

This system enables the safe dissipation of stray currents of all origins present.

5.4.3 Chlorine production adjustment feature

This feature allows the level of production of disinfectant and oxidizing agent chlorine by the electrochlorination system to be adjusted according to one or more predetermined parameters set by the manufacturer (operating time, production power, etc.) independently of the actual needs of the application or depending on external signals, such as redox measurement, chlorine level measurement by amperometric sensors or colorimetric methods, etc.

EN 17818:2023 (E)**5.4.4 Temperature probe**

This probe measures the water temperature and displays it on the control unit. Examples of use: Production temperature monitoring, protection of the cell, estimation of the salt level, display the water temperature, etc.

5.4.5 Conductivity / TDS probe

This component serves to determine the concentration of the sodium chloride solution fed into the electrolysis cell.

5.4.6 Buffer tank

Systems with a buffer tank can be sized with lower nominal capacity in order to serve the maximum chlorine demand than systems without a buffer tank.

The buffer capacity shall be designed so that the chlorate concentration can be minimized according to the corresponding application. The possible influences on the installation location shall also be considered (sunlight, temperature, contamination, etc.).

Storage over a period of longer than 24 h should be avoided. The operator should be able to adjust the level in the buffer tank, but should not be able to exceed the maximum level specified by the manufacturer. The manufacturer shall provide suitable instructions.

For systems without a buffer tank, the nominal capacity of the electrolysis system shall cover the intended maximum chlorine demand.

6 Process variants**6.1 Overview of process variants**

There are various processes available to generate the active substance “Active chlorine, generated from sodium chloride by electrolysis” on site (*in situ*) and put it into a solution. One feature that all processes have in common is the use of artificial sodium chloride solution (produced using marketable sodium chloride, e.g. in accordance with EN 14805, EN 973, EN 16370 or EN 16401) or sea water/brackish water as the precursor.

This section specifies the two main product variants – non-divided electrolysis variants and divided electrolysis cell (membrane or diaphragm) – see Figure 1. Non-divided cell variants produce alkaline hypochlorite solution at 2 alternative levels of production capacity and dosing duration. Divided cell variants operate on the higher production capacity/duration but can be adapted to produce either alkaline, acidic, or neutral chlorine solution.

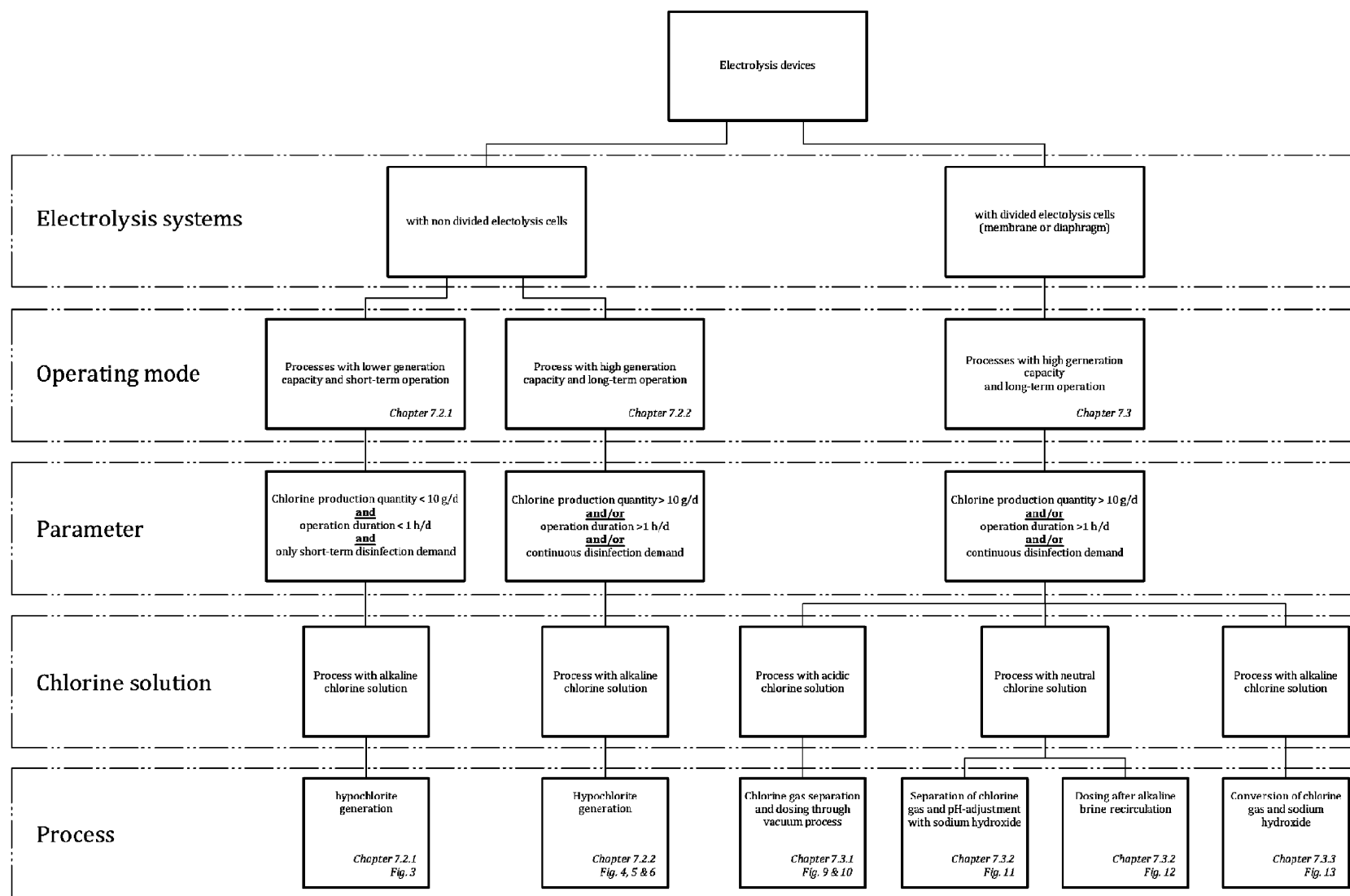
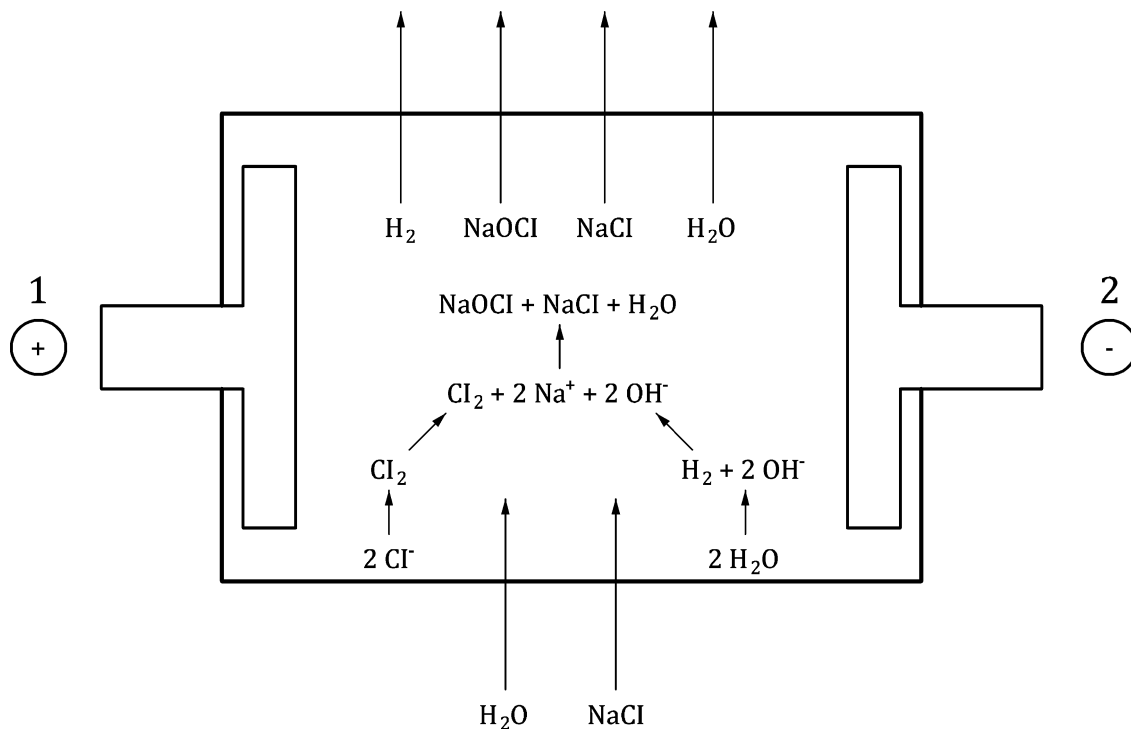


Figure 1 — Overview of process variants

6.2 Electrolysis systems with non-divided electrolysis cell

6.2.1 General

In the case of electrolysis systems with non-divided electrolysis cells, the cell is fed with an aqueous sodium chloride solution. The electrolysis process results in chlorine gas at the anode, while hydrogen, hydroxide ions and consequently also sodium hydroxide are produced at the cathode. Due to the unimpeded transport of liquid and gas, the chlorine and alkali react in the cell to produce sodium hypochlorite (see Figure 2). Part of the chloride used is not converted in the cell and remains in the hypochlorite solution generated.



Key

- 1 anode
- 2 cathode

Figure 2 — Non-divided electrolysis cell

6.2.2 Processes with lower generation capacity and short-term operation

Processes with lower generation capacity and short-term operation are those that comply with all of the following criteria:

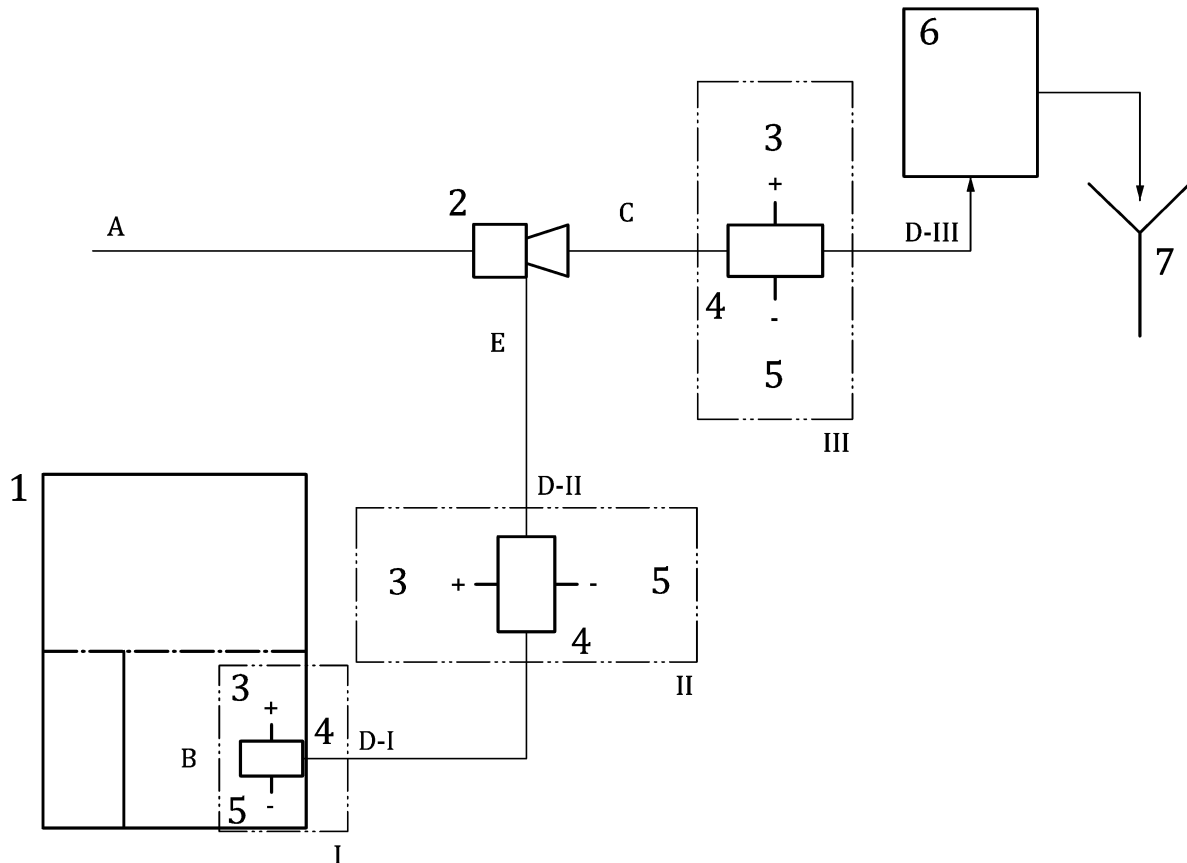
- the maximum production quantity is less than 10 g of chlorine per day and
- the intended, cumulated operating duration is less than one hour per day and
- the application or the disinfection requirement only requires a certain (minimum) chlorine value in the water to be maintained for a short time.

In electrolysis systems with low generation capacity and short-term operation, the electrolysis cell has a continuous flow of water containing chloride. Generation of active chlorine by electrolysis is performed periodically. The solution generated *in situ* is of an alkaline nature (Hypochlorite solution).

After disinfection, the residual disinfectant shall be flushed out of the system and discarded to drain.

Structurally, the electrolysis cell is to be installed between the supply of the water containing chloride (e.g. from a salt solution container) and the system to be disinfected (for a schematic illustration see Figure 3). The electrolysis cell is operated in the salt solution container (installation example I) and in the sodium chloride solution suction line (installation example II) with saturated sodium chloride solution or after the injector (installation example III) with diluted sodium chloride solution.

The system shall be self-venting during operation, so that any potential accumulation of hydrogen gas is prevented. Due to the mode of operation of the electrolysis cell, no safety-relevant quantities of hydrogen gas are produced per disinfection process.

**Key**

A	feed water supply
B	artificial (saturated) sodium chloride solution
C	diluted sodium chloride solution
D-I	active chlorine solution in installation example I
D-II	active chlorine solution in installation example II
D-III	active chlorine solution in installation example III
E	suction line for sodium chloride solution
1	salt solution container with artificial sodium chloride solution
2	injector
3	anode
4	non-divided electrolysis cell
5	cathode
6	water to be disinfected
7	drain or further use
I	installation example: salt solution container
II	installation example: sodium chloride solution suction line
III	installation example: diluted sodium chloride solution

Figure 3 — Use of non-divided electrolysis cells with installation examples

6.2.3 Processes with high generation capacity and/or long-term operation

Processes with high generation capacity and/or long-term operation are those that meet at least one of the following criteria:

- the maximum production quantity is more than 10 g of chlorine per day and/or
- the sum of the designated operating time is more than one hour per day and/or
- the disinfection requires a continuous (minimum) chlorine concentration in the water to be maintained.

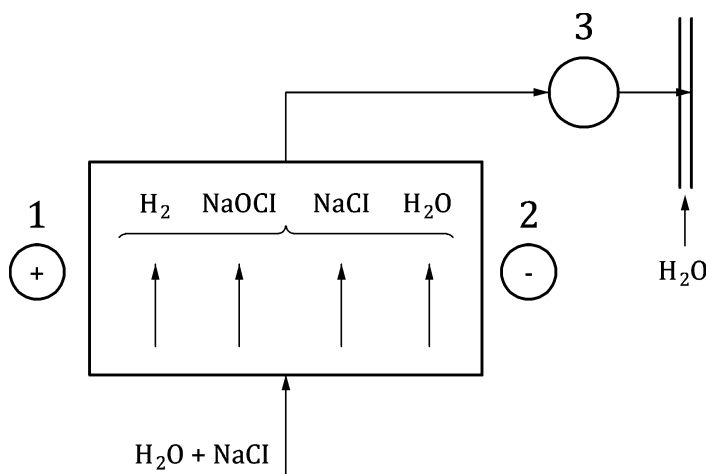
The hypochlorite solution is fed into a buffer tank (see Figure 4) or used directly (see Figure 5).

The hydrogen gas that incidentally occurs shall be safely discharged with consideration to its explosiveness.

In the non-divided cell for direct use, a hypochlorite solution is generated with a concentration of > 2 g/l active chlorine.

A special case of non-divided electrolysis cells is such, where the electrolysis cell is part of the water flow to be treated ("in-line", see Figure 6). In this case the reaction between the generated chlorine gas and the water takes place more rapidly than the reaction between chlorine gas and sodium hydroxide. Thus, a chlorine solution of hypochlorous acid and sodium hypochlorite is formed instead of a sodium hypochlorite solution in a higher concentration. The resulting solution is therefore nearly neutral/slightly alkaline, depending on the pH of the feed water, the ability to buffer the pH (alkalinity) and the ratio between the generated solution and the feed water (flow of the feed water). The water shall have a sufficient chloride concentration. The hydrogen that incidentally occurs shall be safely discharged with consideration to its explosiveness.

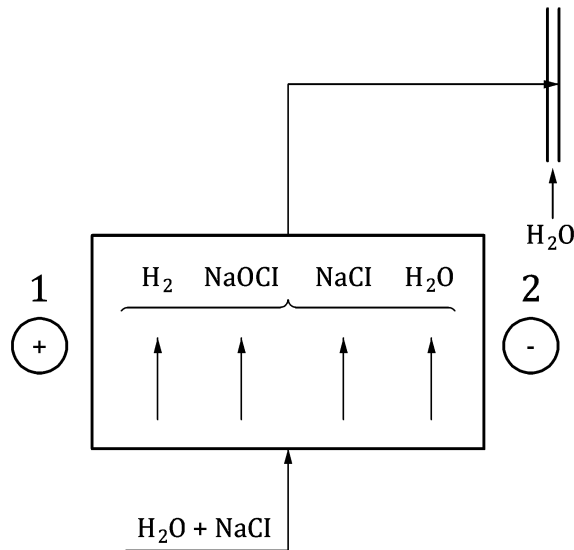
NOTE This might take place, for example, via the surface of the water into rooms of sufficient size and/or with good ventilation.



Key

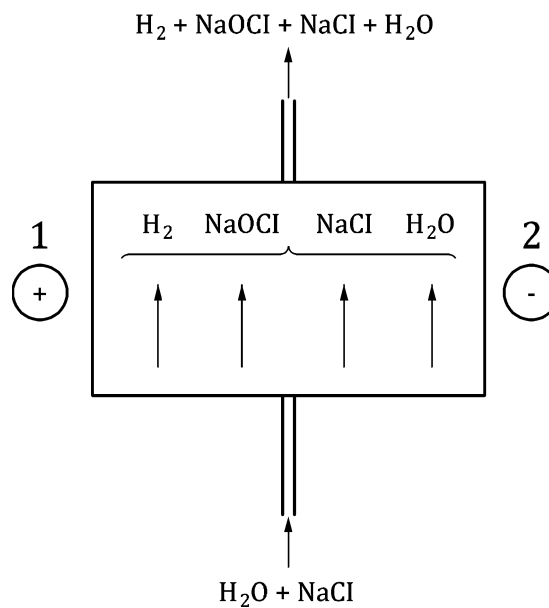
- | | |
|---|-------------|
| 1 | anode |
| 2 | cathode |
| 3 | buffer tank |

Figure 4 — Process with alkaline hypochlorite solution with buffer tank

**Key**

- 1 anode
2 cathode

Figure 5 — Process with alkaline hypochlorite solution for direct use

**Key**

- 1 anode
2 cathode

NOTE In electrolysis system with non-divided electrolysis cells ("inline" according to Figure 6), the pH value can also be mainly determined by the feed water for operational reasons.

Figure 6 — Process with alkaline hypochlorite solution, where the electrolysis cell is part of the flow of the water to be treated ("in-line")

6.3 Electrolysis system with divided electrolysis cell (membrane or diaphragm)

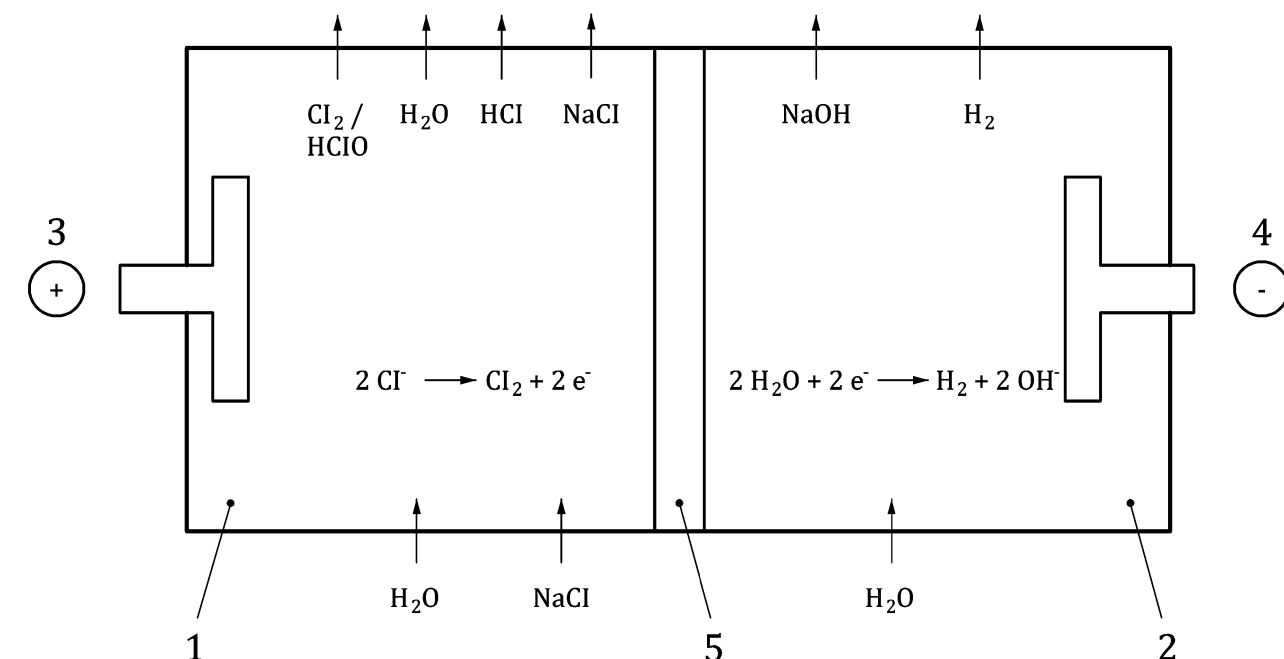
6.3.1 General

Electrolysis systems with divided electrolysis cells are those with high generation capacity and/or long-term operation that meet at least one of the following criteria:

- the maximum production quantity is more than 10 g of chlorine per day and/or
- the intended, cumulated operating duration is more than one hour per day and/or
- the disinfection requires a continuous (minimum) chlorine concentration in the water to be maintained.

The anode compartment is supplied with artificial sodium chloride solution, produced from feed water and sodium chloride (e.g. in accordance with EN 16370 or EN 16401) as the operating media, whereby the chloride (Cl^-) is oxidized to chlorine (Cl_2) at the anode. The sodium cation (Na^+) passes through the semipermeable membrane to the cathode compartment (see Figure 7).

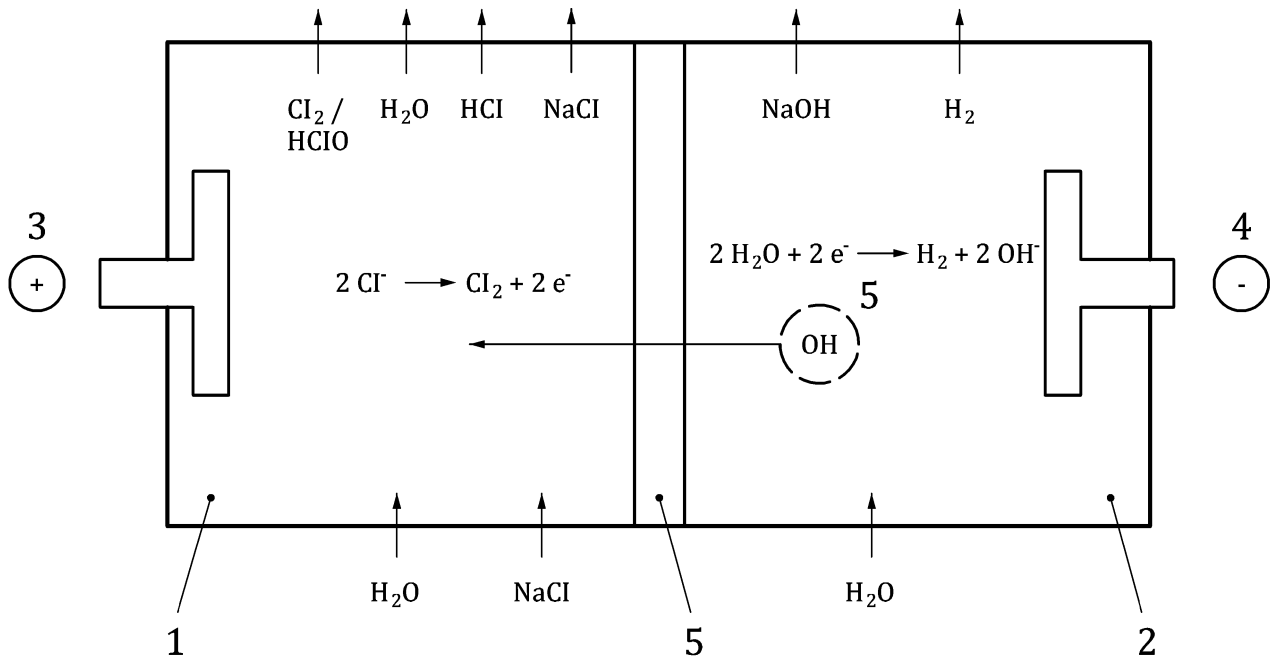
With the diaphragm-electrolysis process, a diaphragm is used instead of a membrane. In contrast to the membrane, the diaphragm permits the passage of hydroxide ions from the cathode compartment to the anode compartment. This reduces the pH-value of the cathodically formed sodium hydroxide in the cathode compartment, while the pH-value of the anolytes in the anode compartment increases at the same time (see Figure 8).



Key

- 1 anode compartment
- 2 cathode compartment
- 3 anode
- 4 cathode
- 5 membrane

Figure 7 — Membrane cell

**Key**

- 1 anode compartment
- 2 cathode compartment
- 3 anode
- 4 cathode
- 5 diaphragm permeable for monovalent ions

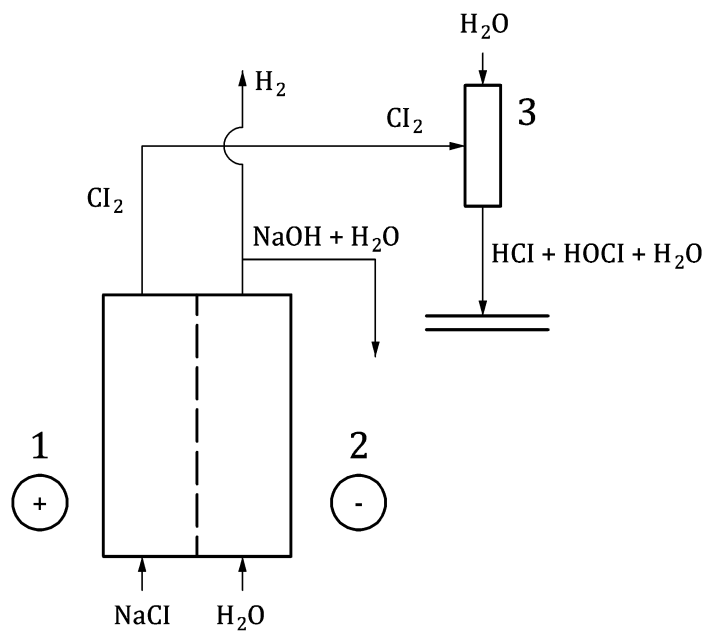
Figure 8 — Diaphragm cell

The quantity of chloride used, which is dissolved in water, is not fully converted in the electrolysis cell. The solution from the anode chamber can be used, discarded or fed directly into the anode compartment through recirculation. Alternatively, this can also be fed back into the salt solution tank. In this case, additional equipment or functions shall be used to avoid a release of the chlorine gas, e.g. by increasing the pH or dechlorination, e.g. by means of active carbon treatment.

Feed water is fed to the cathode compartment and is reduced to hydrogen (H_2) at the cathode. The remaining hydroxide ions (OH^-) together with the sodium- (Na^+)-cations form sodium hydroxide ($NaOH$). The hydrogen is separated from the alkaline solution in a gas separator. The hydrogen gas that incidentally occurs shall be safely discharged with consideration of its explosiveness.

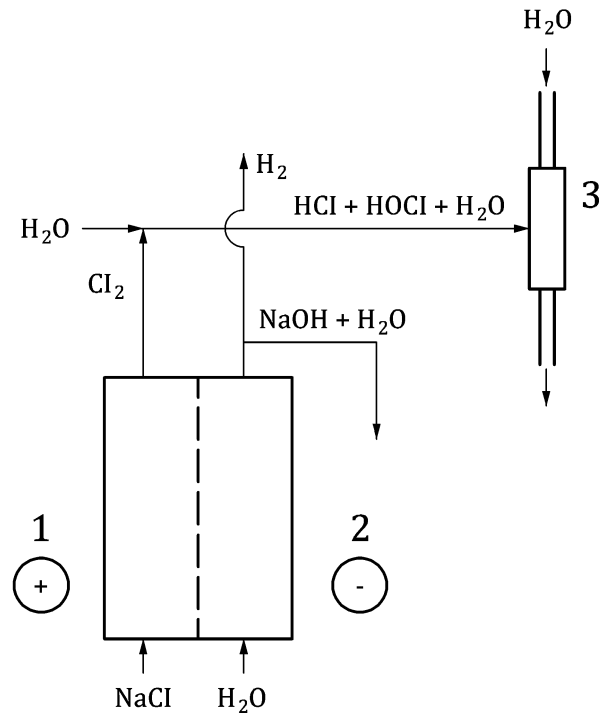
6.3.2 Process with acidic chlorine solution

The chlorine gas that is generated in the electrolysis cell is separated from the anolyte and fed directly in a vacuum process to the water to be treated, extracted either as chlorine gas or as a chlorine solution (see Figure 9 and Figure 10).

**Key**

- 1 anode
- 2 cathode
- 3 injector

Figure 9 — Process with acidic chlorine solution (extracted as chlorine gas)

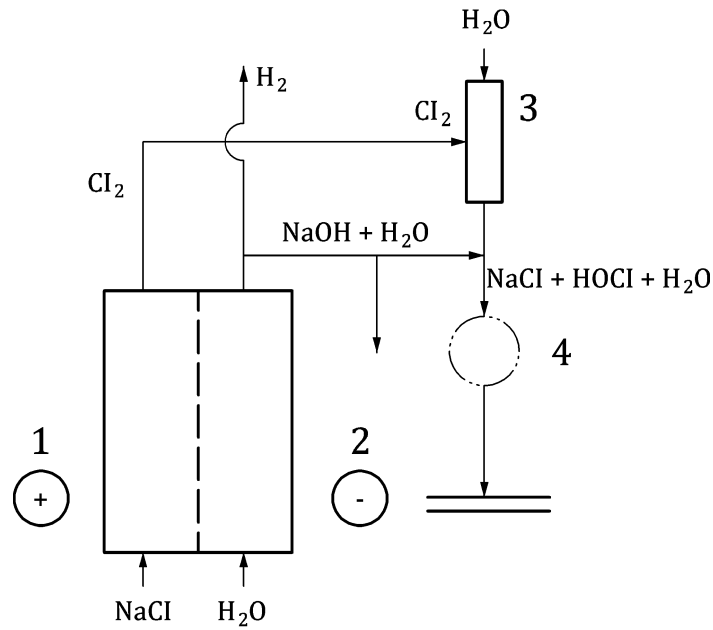
**Key**

- 1 anode
- 2 cathode
- 3 injector

Figure 10 — Process with acidic chlorine solution (extracted as chlorine solution)

6.3.3 Process with neutral chlorine solution

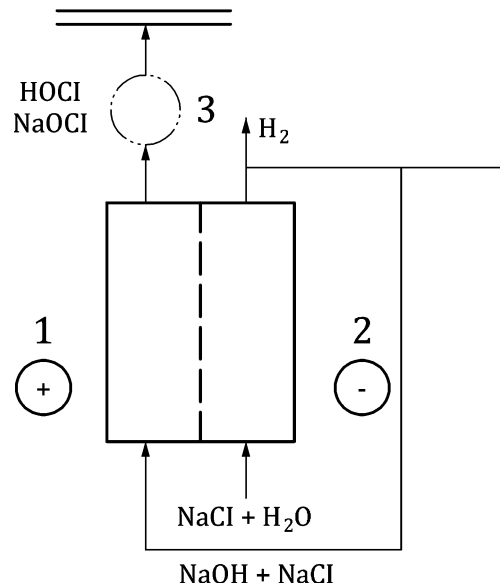
The chlorine gas separated from the anode side is dissolved in water, after which the pH value is adjusted to between 6,5 and 7,5 using the separately collected alkali (see Figure 11).

**Key**

- 1 anode
- 2 cathode
- 3 injector
- 4 buffer tank

Figure 11 — Process with neutral chlorine solution

In an alternative process, the sodium chloride solution is alkalisied in the cathode compartment. With the possible discarding of a pre-set quantity of the alkaline sodium chloride solution, this is transferred to the anode compartment, where the elementary chlorine generated on the anode is converted into neutral chlorine solution in the alkaline sodium chloride solution (see Figure 12).

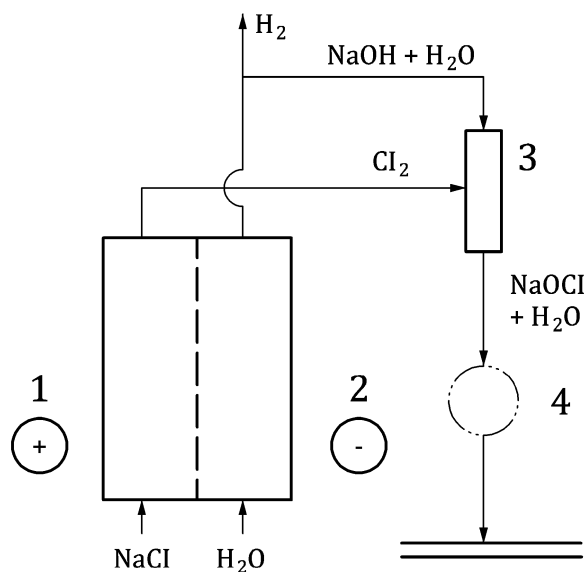
**Key**

- 1 anode
- 2 cathode
- 3 buffer tank

Figure 12 — Process with neutral chlorine solution (alkaline sodium chloride solution recirculation)

6.3.4 Process with alkaline chlorine solution

The chlorine gas that is generated in the electrolysis cell is separated from the anolyte and converted into a hypochlorite solution in a separate reactor with the sodium hydroxide produced in the cathode compartment (see Figure 13).



Key

- | | |
|---|-------------|
| 1 | anode |
| 2 | cathode |
| 3 | injector |
| 4 | buffer tank |

Figure 13 — Process with alkaline chlorine solution and divided cell (conversion of chlorine gas and sodium hydroxide)

7 Safety requirements

7.1 General requirements

Electrolysis systems shall be operated properly with consideration of the requirements applicable to the corresponding system type, e.g. regarding handling chemicals and electrical systems. Note that precursors that are harmless from a hazardous substance perspective can produce aqueous solutions and gases that can have specific hazardous properties. The safety requirements shall be configured so that hazard prevention is ensured.

7.2 Hydrogen

With all electrolysis systems, hydrogen is produced as a by-product of the process. The electrolysis system shall be designed for safe dilution and discharge of the hydrogen, this shall be specified in the system documentation described in 10.2.1.

In all electrolysis systems with divided electrolysis cells, as well as electrolysis systems with non-divided electrolysis cells operated with buffer tank (see Figure 4), the following applies for diluting and discharging the hydrogen:

- the hydrogen produced is to be diluted with air to a safe hydrogen concentration at the site of generation with a fan (see safety concept, 10.2.1). The discharge and flow rate of the dilution air shall be monitored by a flow monitor;
- the electrolysis system shall be designed to switch off automatically in case the quantity of dilution air is insufficient;

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- the diluted hydrogen is to be fed into the open air via a dedicated, gas-tight line with a constant 2 % inclination with a discharge height difference of ≥ 2 m above the electrolysis unit;
- the outlet of the hydrogen discharge shall be installed in an area that is not generally accessible;
- in systems with chlorine production of less than 250 g/h (equates to 7,04 g/h hydrogen), hydrogen disposal can take place without a fan and without a flow monitor if corresponding dimensioning of the hydrogen outlet (e.g. DN 50 at 250 g/h) ensures that the flow is subject to sufficient dilution of the generated hydrogen on the electrolysis system and to ensure independent degassing;
- if the produced hydrogen is used, the safety concept shall be supplemented accordingly.

With systems with non-divided cells in in-line operation, or for direct use (see Figure 5) use the following applies to hydrogen disposal:

- the degassing takes place via the water surface;
- through the sufficient supply of outside air, it shall be ensured that a flammable mixture cannot form in rooms with open contact to the water and that the generated hydrogen can be safely discharged outside. The hydrogen that is produced shall not accumulate in tanks or pipework;
- in order to prevent uncontrolled hydrogen enrichment, the electrolysis shall be equipped with devices that shut off the electrolysis system by, for example, monitoring the water flow rate with a flow monitor or by temperature measurement;
- in electrolysis systems with low generation capacity and short-term operation, the aforementioned safety measures are not required due to the low level of hydrogen formation; details shall be specified in the safety concept.

7.3 Chlorine gas

In electrolysis systems in accordance with Figure 9 and Figure 10, the chlorine gas that is produced is preferably dosed to the untreated water via a motive water line in a vacuum process. The chlorine gas, solution and motive water lines shall be kept as short as possible. The negative pressure shall be monitored by suitable equipment (e.g. pressure sensor) and the electrolysis system shall switch off automatically with insufficient low pressure.

As a general rule for all system types, suitable technical measures during the process (e.g. setting of the pH-value depending on the concentration or flow control) shall be applied to ensure that no hazardous concentrations of chlorine gas are released into the ambient air.

The manufacturer's safety concept shall demonstrate that no danger exists due to the release of chlorine gas during the process.

7.4 Excess products and solutions

All procedure-specific reaction products and solutions that are not utilized (e.g. sodium hydroxide) shall be disposed of. Details shall be specified in the safety concept.

7.5 Buffer tank

The buffer tank for chlorine solutions and sodium hydroxide shall satisfy the following requirements and have the following equipment features:

- static stability;
- chemical resistance to the constituents;

- suitability for emissions-free operation, i.e.
 - with alkaline chlorine solutions: odour trap;
 - with acidic chlorine solutions: additional extraction and dechlorination unit for gases containing chlorine;
- device to equalize the pressure with the atmosphere;
- labels with the following information (with small tanks, whereby the sign cannot be installed for sufficient visibility, this information can also be provided in the operating manual):
 - date of commissioning or manufacture;
 - volume;
 - material;
 - medium inside;
- warning signs, if applicable on the safety bund (see 7.7);
- mechanical or electronic level control and overflow protection;
- can be drained, e.g. with drainage nozzles or transfer pumps.

Details shall be specified in the system documentation.

7.6 Safety bunds

With ≥ 200 l substances hazardous to water, separate safety bunds shall be provided to store the solutions produced during electrolysis and by-products if required.

The safety bunds shall be designed as follows:

- the volumetric capacity shall correspond with the volume of the buffer tank as a minimum;
- the chemical resistance of the material to the storage chemicals (e.g. sodium hypochlorite (see Annex A) solution) shall be ensured;
- the tanks shall be manufactured to appropriate mechanical design;
- safety bunds shall be equipped with leak sensors that switch off the electrolysis system if triggered.

Buffer tanks and systems with a nominal capacity of < 200 l should also be installed in safety bunds. In the case of storage quantities < 200 l, leak sensors are not mandatory equipment.

7.7 Prevention against backflow

If connected to a drinking water installation, backflow prevention equipment in accordance with EN 1717 shall be installed.

8 Equipment of the room or area for installation of the electrolysis system

The manufacturer of the electrolysis system shall provide detailed instructions on the installation conditions in their documentation.

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Electrolysis systems should preferably be installed in a dedicated room, although they may also be installed in areas (as close to the site of use as possible) like treatment areas, production areas, etc.

The installation place shall be cool, frost-free and dry insofar as possible. The ambient temperature should not exceed 35 °C or the manufacturer's instructions. Sufficiently dimensioned access and traffic routes in and around the building are essential for installation, operation and maintenance of the electrolysis systems. Access to the installation rooms shall be established such that it is as level as possible. The room lighting shall be tailored to the requirements of the system and the system conditions.

Sufficient ventilation shall be provided. Mechanical ventilation, in particular with systems with a production capacity > 250 g/h, is recommended. It is necessary here to document the system-specific pressure conditions and the operational reliability of the hydrogen disposal.

The floor should be easy to clean, chemical resistant and liquid-tight. Tanks and if applicable safety bunds shall be permanently and clearly labelled to indicate their contents and fitted with warning signs and / or hazard symbols if applicable.

Supply lines and discharge lines from electrolysis systems shall be labelled to indicate their flow direction and medium. Additionally, in rooms in which a chlorine electrolysis system is in operation, the use of a chlorine gas warning device may be appropriate depending on the process, system size and system type.

9 Operation and maintenance

Device manufacturers shall provide suitable application information that shall contain precise specifications for the installer and the user regarding installation, operation and maintenance. Installers and operating staff should observe these instructions regarding operation, and maintenance. The scope and frequency of the function tests on site shall be detailed and the system should be commissioned by the operator on the basis of the manufacturer's recommendations.

Applicable normative specifications regarding operation and maintenance of electrolysis systems should be observed. If there are no specifications for operation and maintenance, electrolysis systems shall be subjected to maintenance by a qualified person at least once per year. This shall be documented in a log, which contains a record of the scope of work and a list of the parts replaced. It shall also verify the faultless operating status of the system. During maintenance, a functional inspection of the safety equipment present and a visual inspection of the system for leak-tightness and completeness shall be performed.

During operation, electrolysis systems shall always comply with the applicable requirements of the application, e.g. with regard to operational stability and durability, such as the effects of the quality of the biocide on the application for in-line systems. The individual requirements of the application in this regard are not described in this document.

10 Test requirements

10.1 General

Electrolysis systems shall be subjected to an individual test or a sample test by an expert according to 3.7 in the factory or, if applicable, on-site. Technically identical systems that originate from series production may be subject to testing of a representative type.

If the manufacturer does not ensure the test by using their own staff, others with sufficient capabilities shall be assigned to perform the test.

The test result shall be documented.

10.2 Scope of testing

10.2.1 General

When testing, it shall be ensured that the requirements applicable for the corresponding electrolysis system are adhered to. The test shall be configured in two steps. In the first step, the applicable requirements shall be determined by the manufacturer using the electrolysis system documentation and its mode of operation. In a second step the chemical characterization of the produced chlorine solution is carried out. The requirements applicable to the chlorine solution generated are derived from their intended or correct application.

10.2.2 System documentation

The system documentation shall contain specifications on the following points:

- installation conditions (see also Clause 8);
- safety concept (in particular, but not only, with regard to the generation of hydrogen);
- operation and usage conditions (e.g. ambient temperature and operating temperature, requirements applicable to the operating personnel, etc.);
- specification of the precursors (e.g. salt);
- hydraulic, pneumatic and electrical interfaces;
- quality of the feed water, and if applicable the cooling water;
- chemical characterization according to 10.2.3;
- performance, the manufacturer shall declare the minimum and maximum output of the biocide at the specified operating mode.

If the electrolysis system or parts thereof are subjected to a conformity assessment procedure or comparable, legally-prescribed tests due to applicable legal requirements, the technical documents compiled in this context are basically also sufficient for the purposes of this document.

Corresponding supplementary system documentation shall be compiled for retrospective system changes (e.g. using the hydrogen generated).

10.2.3 Chemical characterization

10.2.3.1 General

The subject of the test is the chlorine solution generated (before buffering, if applicable).

The result of the chemical characterization shall be documented and provided to the user.

The chlorine solution generated shall be tested in a sufficiently qualified laboratory. The subject of the test here is a representative mixed sample that considers the reasonably expected worst-case conditions based on the specific design of the electrolysis system. At least the ratio of chlorate and bromate to active chlorine, the pH-value, the chloride and the temperature shall be determined.

NOTE The extent of a "sufficient qualification of the laboratory" depends on the purpose for which the analytical data are used. If they are to be used for authorization or certification purposes, for example, an accreditation can be required.

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Further tests regarding characterizing the electrolysis system, also remain possible. If there are corresponding specifications in the technical documents, instructions or operating manuals, the manufacturer shall specify the designation of the test performed.

10.2.3.2 Sampling**10.2.3.2.1 Sampling points**

Sampling shall be enabled via a defined sampling point (e.g. a sampling valve). This shall allow for representative sampling of the chlorine solution and guarantee sufficient safety when sampling. The sampling point shall be as close as possible to the system outlet (e.g. on the outlet from the in-line electrolysis cell or in the injector outlet), where complete mixing of the chlorine solution shall be ensured. The electrolysis system manufacturer shall provide suitable instructions for sampling.

For electrolysis systems that are not accessible for sampling, the chlorine solution shall be generated separately in test equipment and fed for testing.

10.2.3.2.2 Sampling diagram

Sampling shall be performed in accordance with a sampling diagram. The manufacturer of the electrolysis device shall design a sampling diagram specific to the technical requirements of the particular device and considering the demands of this clause. An example is shown below (Figure 14).

If the user is not able to adjust the current or the cell voltage, the electrolysis cell shall be operated at the current or cell voltage that was pre-set by the manufacturer.

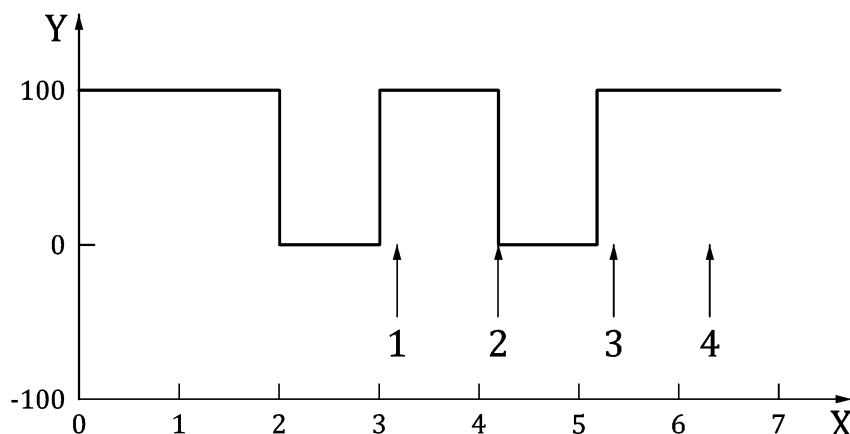
If the owner or user is intended to be able to adjust the current or the cell voltage, the electrolysis cell shall be operated at the maximum current or cell voltage that was approved by the manufacturer.

The manufacturer shall specify the maximum salt concentration and the minimum flow rate at which the electrolysis cell will be operated.

The electrolysis system shall be operated under full load for at least 2 h. Afterwards, a total of 4 samples are extracted at regular intervals. In systems that operate in periodical cycles (e.g. if the process in the electrolysis cell runs discontinuously and batchwise), only one sample may be taken per cycle.

In order to illustrate the worst-case conditions, chlorine production shall be interrupted for at least 1 h prior to sampling with 2 of the 4 samples. This results in a sampling diagram like the one shown in Figure 14 for example. The sampling diagram shall be specified and documented for each system type by the manufacturer with consideration to the system-specific on-off effects, as well as with cyclically operating systems with consideration to the production cycles for each system type. The samples taken at the relevant times are merged to form a mixed sample.

In contrast, in electrolysis systems in accordance with the processes with lower generation capacity and short-term operation as specified in 6.2.2, it is sufficient to take a uniform sample after the electrolysis cell starts up at nominal capacity under consideration of the system-specific on-off effects.

**Key**

X	time [h]
Y	chlorine production in %
1-4	sampling points

Figure 14 — Example of a sampling diagram

In electrolysis systems with buffer tanks, the storage period for the chlorine solution in the buffer tank is highly significant. During sampling, this shall be considered as part of a worst-case scenario using one of the following preparations:

- Generally, the chlorine solution shall be taken as a representative mixed sample in the manufacturer's factory and filled into a container that shall be suitable for the material (e.g. canister), is to be stored in accordance with the manufacturer's specifications for the intended operation at the maximum permissible temperature and the sample shall be taken after the maximum permissible storage period.

NOTE 1 This preparation is to be considered especially in electrolysis systems from standard product manufacturing.

- If a test in the factory is not possible, on-site sampling is also possible but the buffer tank may only be filled up to the maximum intended fill-volume in accordance with the requirements specified in this document. The electrolysis system shall be operated intermittently with breaks in chlorine production of at least one hour in order to enable a representative mixed sample. If a time sequence as illustrated in Figure 14 is not sufficient for filling the buffer tank completely, it shall be repeated at corresponding intervals. Sampling shall be performed in accordance with the maximum intended storage period for the chlorine solution in the storage tank.

NOTE 2 This preparation is to be considered especially in individually produced single systems.

In electrolysis systems in which the generated chlorine solution is held in a buffer tank for immediate use, the stability curve of a representative mixed sample can be recorded at the specified temperature. The duration and temperature are defined by the manufacturer based on the electrolysis system's intended use and illustrated in a measurement schedule.

10.2.3.2.3 Sampling

When sampling, at least 125 ml within two minutes shall be extracted, if possible, in accordance with the sampling diagram. If a sampling time of two minutes is insufficient for system reasons, the sampling time shall be extended in accordance with the aforementioned requirements.

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Put 1 ml of sodium hydroxide solution (10.2.4.3) in a 100 ml measuring flask made of brown glass, in order to adjust the subsequent sample to a pH-value of > 13 . Then fill the measuring flask with a sample up to the line measure. The sample shall be thoroughly mixed and cooled and stored in a dark place prior to analysis. If a pH-value of > 13 is not reached with the specified quantity of sodium hydroxide, the concentration of the sodium hydroxide added may be increased. The remaining sample shall be stored separately in a dark place for pH-value determination.

In order to record stability curves, instead of the sodium hydroxide, 1 ml of distilled water is placed into the 100 ml measuring flask. Then fill the measuring flask with a sample up to the line measure. The sample shall be thoroughly mixed and cooled ($< 5\text{ }^{\circ}\text{C}$) and stored in a dark place, until the entire sampling procedure is complete. All partial samples are then combined into a mixed sample and incubated in accordance with the conditions (temperature, time, etc.) specified in 10.2.3.2. If the required measurement points described in the measurement schedule in accordance with 10.2.3.2.2 require a larger measurement volume, the sampling volume of 100 ml as described above shall be increased accordingly.

An overview of the samples described and their use is shown in Figure 15.

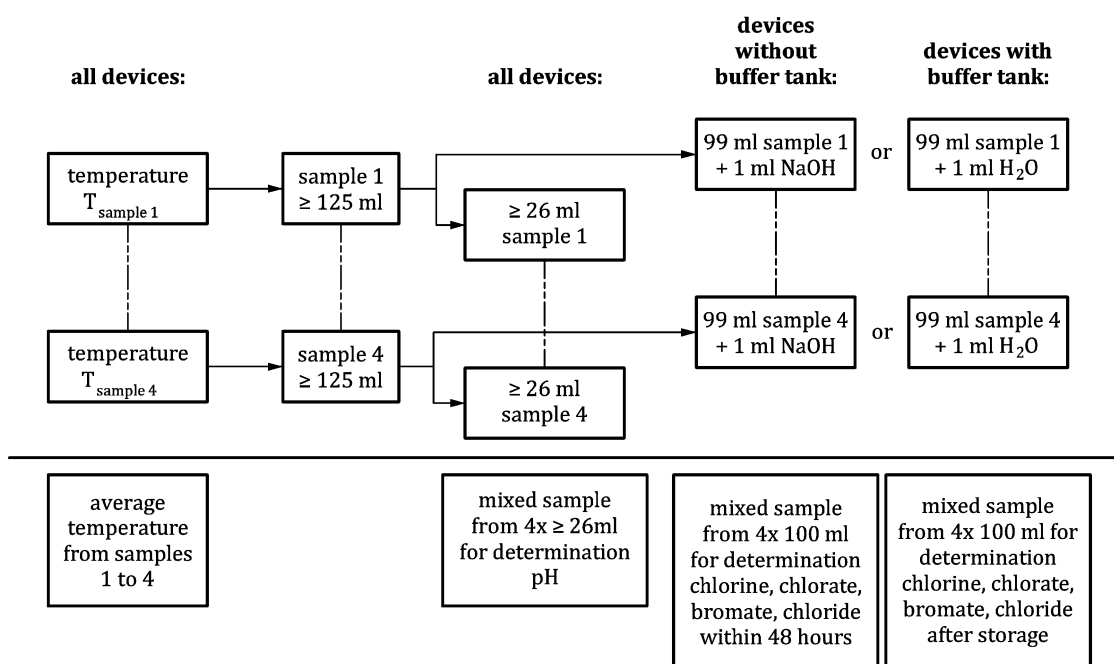


Figure 15 — Sampling overview

10.2.3.3 Testing the chlorine solution

The temperature shall be measured directly after sampling in each of the four samples of at least 125 ml in accordance with EN IEC 60751. The resulting temperature is expressed as the mathematical average of the four individual measurements.

The four samples that were stored separately to determine the pH value shall be combined to a mixed sample and analysed directly after its production at the site of sampling.

Determination of the pH-value shall take place with an electrometric pH-probe after a 2-point calibration with buffer solutions that span the expected pH value of the sample solution.

The remainder of the sample shall be cooled to $< 5\text{ }^{\circ}\text{C}$, stored in a dark place, and analysed within 48 h or in accordance with the measurement schedule.

10.2.4 Determination of the active chlorine content (main constituent)

10.2.4.1 General

This process applies to chlorine solutions with an active chlorine content $\geq 0,2$ g/l.

After dilution to a maximum of 1:40, chlorine solutions of $< 0,2$ g/l are analysed in accordance with EN ISO 7393-1 or EN ISO 7393-2 (titrimetric or colorimetric determination of the free chlorine with DPD).

10.2.4.2 Brief description

Iodine is released through the reaction of chlorine with potassium iodide in the presence of acetic acid. The iodine is titrated with sodium thiosulfate standard reference solution in the presence of a starch indicator solution. The titration may also be carried out on a potentiometric basis with the help of titration machines, so that in this case the addition of a starch solution is not necessary.

10.2.4.3 Reagents

All reagents shall be present in recognized analysis quality, the water used shall correspond with quality 3 per ISO 3696 (standard lab deionised water).

10.2.4.3.1 Sodium hydroxide solution, (analytical grade) 20 % mass fraction".

10.2.4.3.2 Potassium iodide solution, 10 % mass fraction.

To create the solution the following steps shall be taken dissolve $(100 \pm 0,1)$ g iodate-free potassium iodide, in water and dilute to 1 l.

10.2.4.3.3 Concentrated acetic acid, minimum purity of 99 % mass fraction.

If titration to determine the active chlorine content is performed on-site at ambient temperatures of below 17°C , the acetic acid might crystallize. In this case, 80 or 60 % acetic acid is to be used and the volume specified in 10.2.4.5.2 shall be increased accordingly.

10.2.4.3.4 Sodium thiosulfate standard reference solution, $c(\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}) = 0,1$ mol/l.

Standard reference solutions are available to purchase and may also require dilution.

Alternatively, it is possible to produce a standard reference solution as follows: Dissolve 24,8 g $\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$ in 0,75 l water in a 1 000-ml measuring flask. Following temperature equalization, fill up with water to the mark and mix thoroughly.

To determine: Weigh 3 600 g of dry potassium iodate to 0,1 g (m). Dissolve with water in a 1 000-ml measuring flask, fill up with water to the mark and mix thoroughly (standard reference solution $c(1/6 \text{ KIO}_3) = 0,1$ mol/l). Add 200 ml water to a 500-ml Erlenmeyer flask with stopper, add $(2 \pm 0,5)$ g potassium iodide and stir to dissolve. Then use a pipette to add 10,0 ml to the sodium thiosulfate solution to be determined and mix with (15 ± 1) ml hydrochloric acid (diluted 1:1) and (5 ± 1) ml starch solution (10.2.4.3.5). Immediately titrate with the potassium iodate standard reference solution until the blue colouration endures for 30 s. Record the volume of iodate used (V_1).

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The concentration c of the sodium thiosulfate standard reference solution ($\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$, quoted in mol/l, is calculated using the Formula (1):

$$c = \frac{V_1 \times c_1}{V} \quad (1)$$

where

- c_1 is the concentration of the potassium iodate standard reference solution [$c(1/6 \text{ KIO}_3) = 0,1 \text{ mol/l}$], in mol/l;
- V is the volume of the sodium thiosulfate standard reference solution to be determined ($V = 10 \text{ ml}$), in ml;
- V_1 is the volume of the potassium iodate standard reference solution used during titration in ml.

10.2.4.3.5 Starch solution, 1 % mass fraction.

Produce a suspension of $(1 \pm 0,1) \text{ g}$ starch and $(5 \pm 1) \text{ ml}$ water. Add this suspension to $(90 \pm 5) \text{ ml}$ boiling water. Stir the suspension to dissolve it and then leave the solution to cool. In order to avoid dissolution of the starch and with this an undefined end point, store the solution in a cool place. Use the solution within one week.

Indicators for iodine titration are available to purchase, which can be used in place of the described starch solution assuming they have been checked in advance for their effectiveness.

10.2.4.4 Equipment

Standard laboratory and glass equipment.

10.2.4.5 Execution**10.2.4.5.1 Test solution**

Add a sample volume V_2 containing 20 mg to 70 mg of active chlorine (Cl_2) to a 250-ml Erlenmeyer flask and top up with to 100 ml with water.

10.2.4.5.2 Determination

Add 10 ml potassium iodide solution (10.2.4.3.2) and 5 ml of the concentrated acetic acid (10.2.4.3.3) to the test solution.

Titrate with the sodium thiosulfate standard reference solution (10.2.4.3.4) until the iodine staining has almost disappeared. Subsequently add 3 ml of the starch indicator solution (10.2.4.3.5) and perform titration until the black/blue colouration has disappeared. Record the volume V_1 of the sodium thiosulfate standard reference solution added.

10.2.4.6 Specification of the results

The concentration c_2 of active chlorine (Cl_2), in g/l, shall be calculated using the Formula (2):

$$c_2 = \frac{V_1 \times c \times 35,453}{V_2} \times \frac{101}{100} \quad (2)$$

where

V_1	is the volume of the sodium thiosulfate standard reference solution (10.2.4.3.5) used during titration, in ml;
c	is the concentration of the sodium thiosulfate standard reference solution (10.2.4.3.5), in mol/l;
35,453	is the molecular weight of chlorine in g/mol, (the 1 ml sodium thiosulfate solution with $c(\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}) = 1,00$ mol/l corresponding mass of the chlorine (Cl_2), in mg);
V_2	is the sample volume used for producing the test solution (10.2.4.5.1), in ml;
$\frac{101}{100}$	is the correction factor for consideration of the volume change through the pH-value setting with sampling.

10.2.5 Determination of the chlorate content (ClO_3^-)

10.2.5.1 Execution

The concentration c_3 of chlorate (ClO_3^-), in mg/l, shall be determined in accordance with EN ISO 10304-4.

10.2.5.2 Specification of the results

The chlorate content p_1 as a purity criterion of a chlorine solution, in % chlorate of the active chlorine, shall be calculated using the Formula (3):

$$p_1 = \frac{c_3 \times 100}{c_2 \times 1000} \quad (3)$$

where

c_3	is the concentration of chlorate (ClO_3^-), in mg/l;
c_2	is the concentration of chlorine solution (Cl_2), in g/l.

To improve the comparability with the specifications in EN 901 [7] for sodium hypochlorite for the treatment of water for human consumption, the chlorate content p_1' can also be specified as % sodium chlorate of the active chlorine. The calculation is carried out in accordance with Formula (4):

$$p_1' = p_1 \times \frac{106,46}{83,47} \quad (4)$$

where

p_1	is the chlorate content (ClO_3^-), in % chlorate of the active chlorine;
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106,46 is the molecular weight of sodium chlorate, in g/mol;

83,47 is the molecular weight of chlorate, in g/mol.

10.2.6 Determination of the bromate content (BrO_3^-)**10.2.6.1 Execution**

The concentration c_4 of bromate (BrO_3^-), in mg/l, shall be determined in accordance with EN ISO 15061.

10.2.6.2 Specification of the results

The bromate content p_2 as a purity criterion of a chlorine solution, in % bromate of the active chlorine, shall be calculated using the Formula (5):

$$p_2 = \frac{c_4 \times 100}{c_2 \times 1000} \quad (5)$$

where

c_4 is the concentration of bromate (BrO_3^-), in mg/l;

c_2 is the concentration of chlorine solution (Cl_2), in g/l.

To improve the comparability with the specifications in EN 901 [7] for sodium hypochlorite for the treatment of water for human consumption, the bromate content p_2' can also be specified as g sodium bromate/kg of the active chlorine. The calculation takes place in accordance with Formula (6):

$$p_2' = p_2 \times \frac{150,89}{127,90} \quad (6)$$

where

p_2 is the bromate content (BrO_3^-), in % bromate of the active chlorine;

150,89 is the molecular weight of sodium bromate, in g/mol;

127,90 is the molecular weight of bromate, in g/mol.

10.2.7 Determination of the chloride content (Cl^-)**10.2.7.1 Execution**

The concentration c_5 of chloride (Cl^-), in mg/l, shall be determined in accordance with EN ISO 10304-1.

10.2.7.2 Specification of the results

The chloride content p_3 as a purity criterion of a chlorine solution, in % chloride of the active chlorine, shall be calculated using the Formula (7):

$$p_3 = \frac{c_5 \times 100}{c_2 \times 1\,000} \quad (7)$$

where

p_3 is the chloride content (Cl^-), in % chloride of the active chlorine;

c_5 is the concentration of chloride (Cl^-), in mg/l;

c_2 is the concentration of chlorine solution (Cl_2), in g/l.

Annex A (informative)

Natural decay of stored hypochlorite solutions

A.1 General

The present document concerns devices intended for the in-situ generation of Chlorine and/or Sodium Hypochlorite solution basically for immediate use.

Therefore, the buffer tanks, which could be part of the device supplied by the manufacturers, has the only scope of smoothing peaks of chlorine demand for optimizing the biocide distribution under variable operation modes.

Nonetheless the user may wish to store the produced biocide for delayed application or even for marketing.

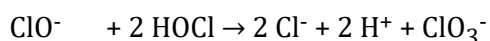
This practice is not recommended because the stored Sodium Hypochlorite decays depends on many natural factors listed below. (See Figures A.1 to A.4)

The effect of each factor will be illustrated, with non-exhaustive examples, just for letting the user to roughly evaluate not only the decay of Active Chlorine but the correspondent formation of Chlorate whose concentration is strictly regulated in the EU Directive for water intended for human consumption and other national provisions.

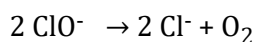
In addition, the user shall keep in mind that the actual decay is determined by the combined cumulated effect of each factor.

A.2 Decay reactions

Under slightly alkaline and neutral conditions, the hypochlorite ion is oxidized by the hypochlorous acid and degrades according to the following reaction:



The following reaction is possible but much slower and occurs under influence of light, in contact with particles and in contact with reactive surfaces.



In practice of handling solutions of active chlorine produced *in situ* by electrolysis chlorate is almost the only ambient degradation product of hypochlorite.

A.3 Factors influencing chlorine decay and chlorate formation

A.3.1 Influence of temperature and storage time

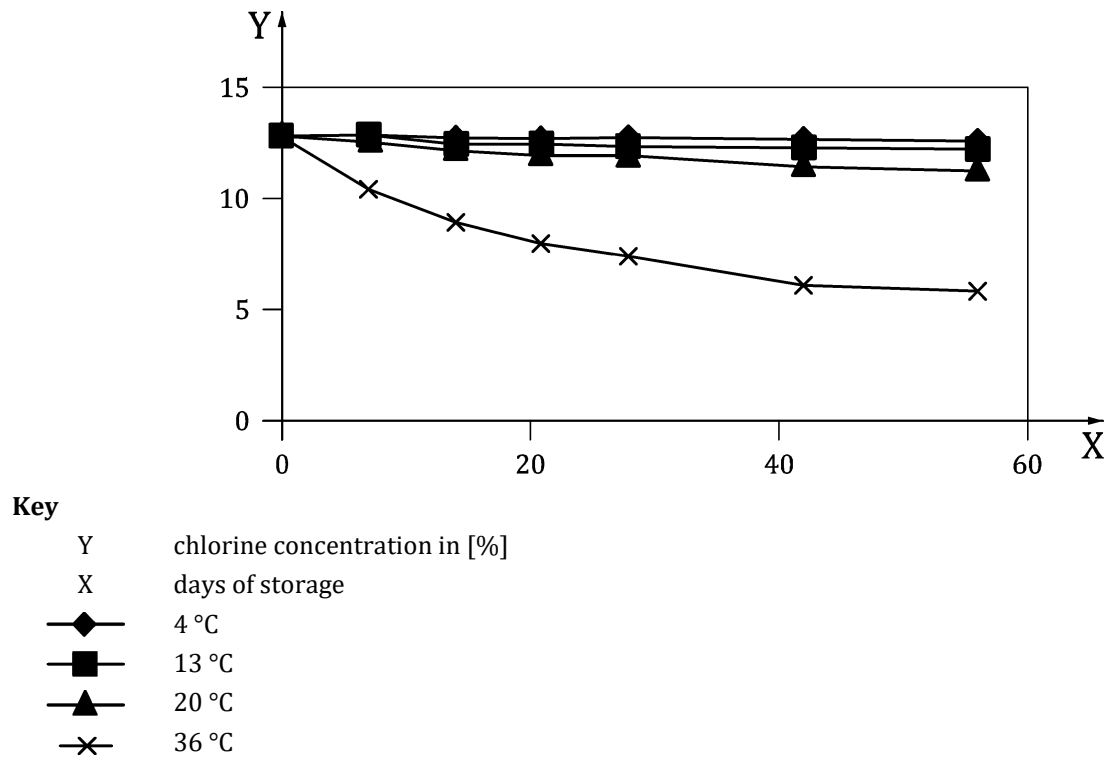


Figure A.1 — Chlorine decay vs. time & temperature (initial Cl₂ concentration 12,8 %)

A.3.2 Chlorate formation vs. time and temperature

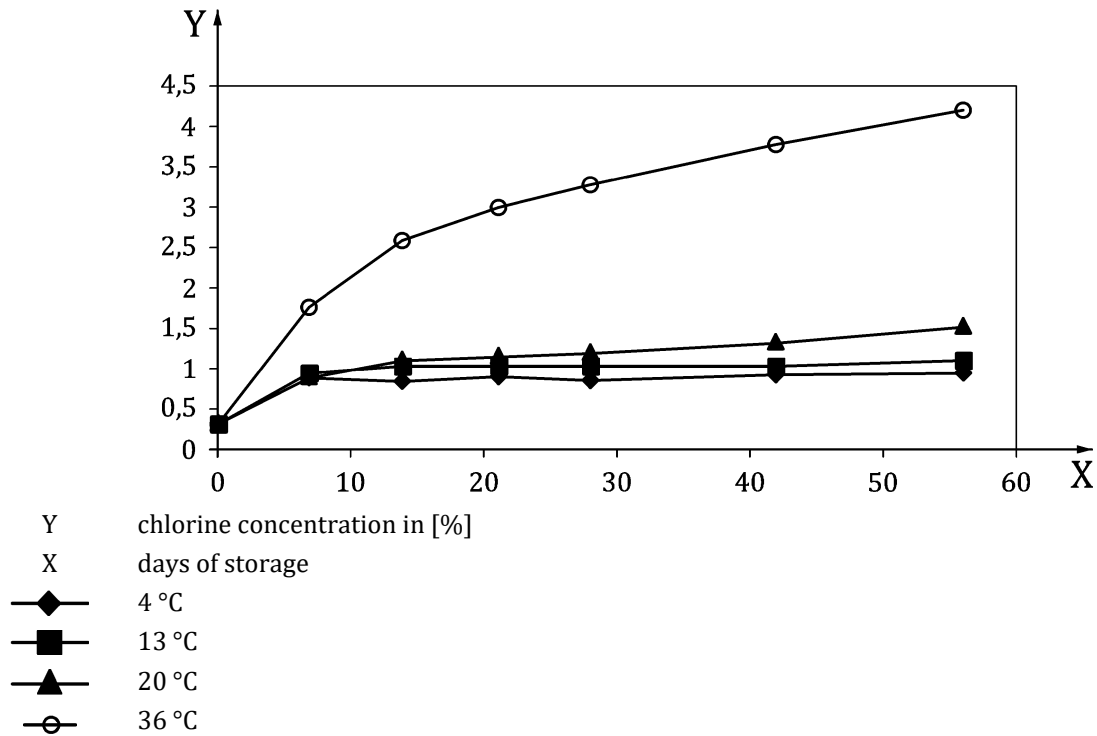


Figure A.2 — Chlorate increase vs time & temperature (initial Chlorate concentration 0,3 %, initial Cl_2 concentration 12,8 %)

A.3.3 Influence of initial concentration vs. days of storage

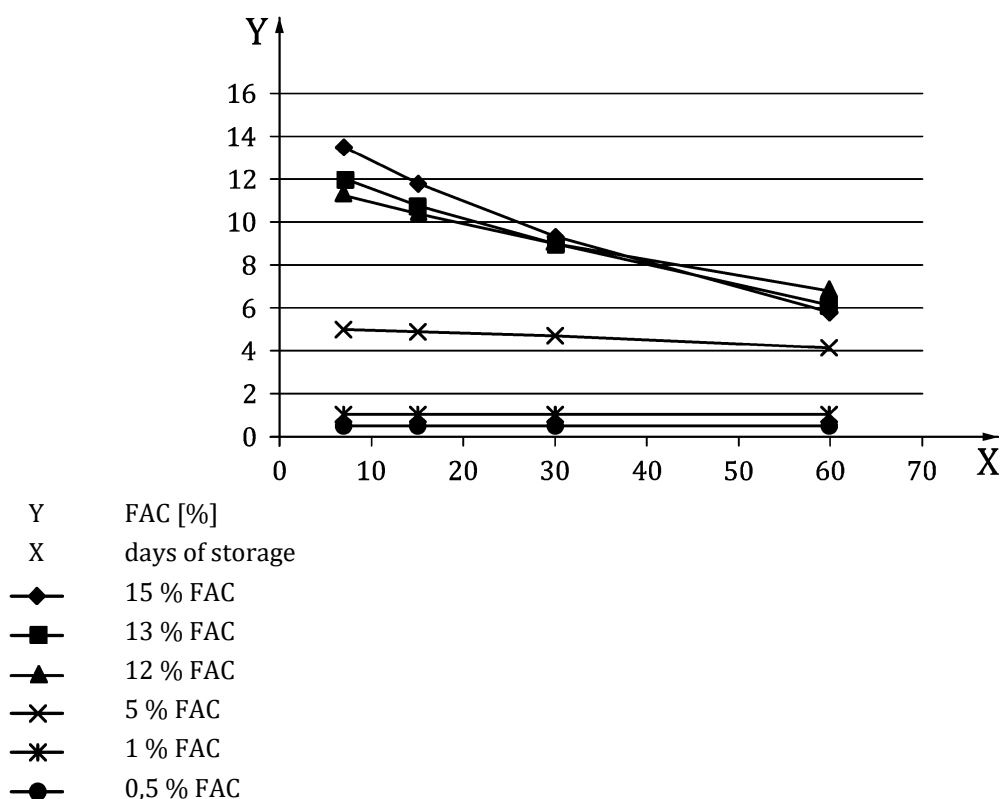


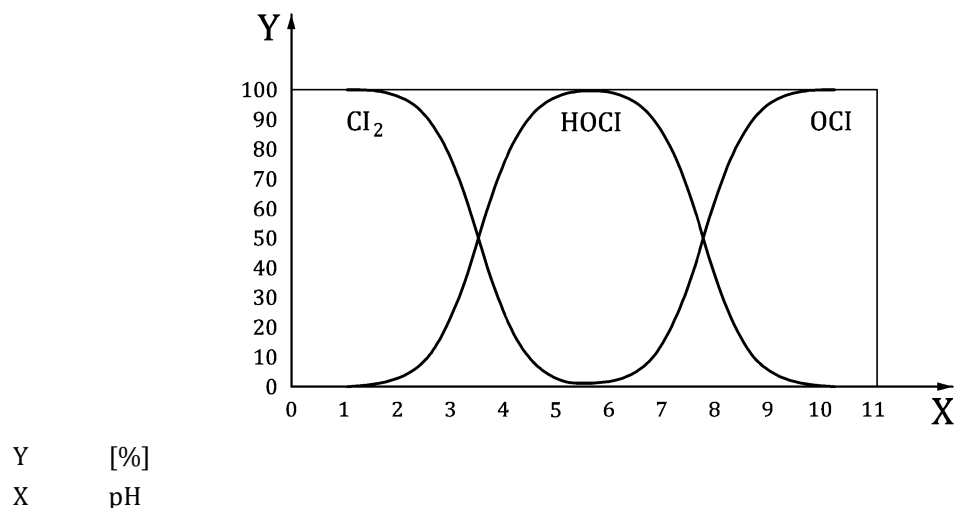
Figure A.3 — Chlorine concentration vs. storage time at 25 °C

A.4 Influence of pH

The pH has a significant effect on the stability of sodium hypochlorite solutions. Below pH 11 the decomposition of sodium hypochlorite is significant due to the shift in the equilibrium in favour of the more reactive hypochlorous acid. A pH between 12 and 13 gives the most stable solution. This equates to 0,4 to 4,0 g per litre (g/l) excess NaOH. Greater concentrations will not improve the stability. Excessively high alkalinity will damage textiles and retard the bleaching and disinfecting actions of the hypochlorite.

It shall be considered that the solutions of active chlorine produced by electrolysis devices according to this standard have pH lower than 11.

The ratio of $\text{Cl}_2/\text{HClO}/\text{ClO}^-$ is pH and temperature dependent. The pH-dependence is displayed in the following figure, where the percentage of the different species at the equilibrium is shown as a function of pH. Hypochlorous acid is predominant in the pH range from 4 to 5,5, whereas the hypochlorite anion predominates at pH > 10. Chlorine is relevant at pH < 4, only.

Figure A.4 — Cl_2 - HOCl - OCl^- vs. pH

A.5 Influence of decay catalysers (pollutants) and prevention

The quality and stability of sodium hypochlorite solutions can be affected by the concentration of certain impurities. Trace metals such as nickel, cobalt and copper form insoluble metal oxides, which cause the active chlorine to decompose catalytically. These trace metals, as well as oxides and carbonates of iron, calcium and magnesium, form sediment and may affect the hypochlorite solution. All equipment in contact with active chlorine solutions such as pipework, buffer tanks etc. should be free of those metals.

Bibliography

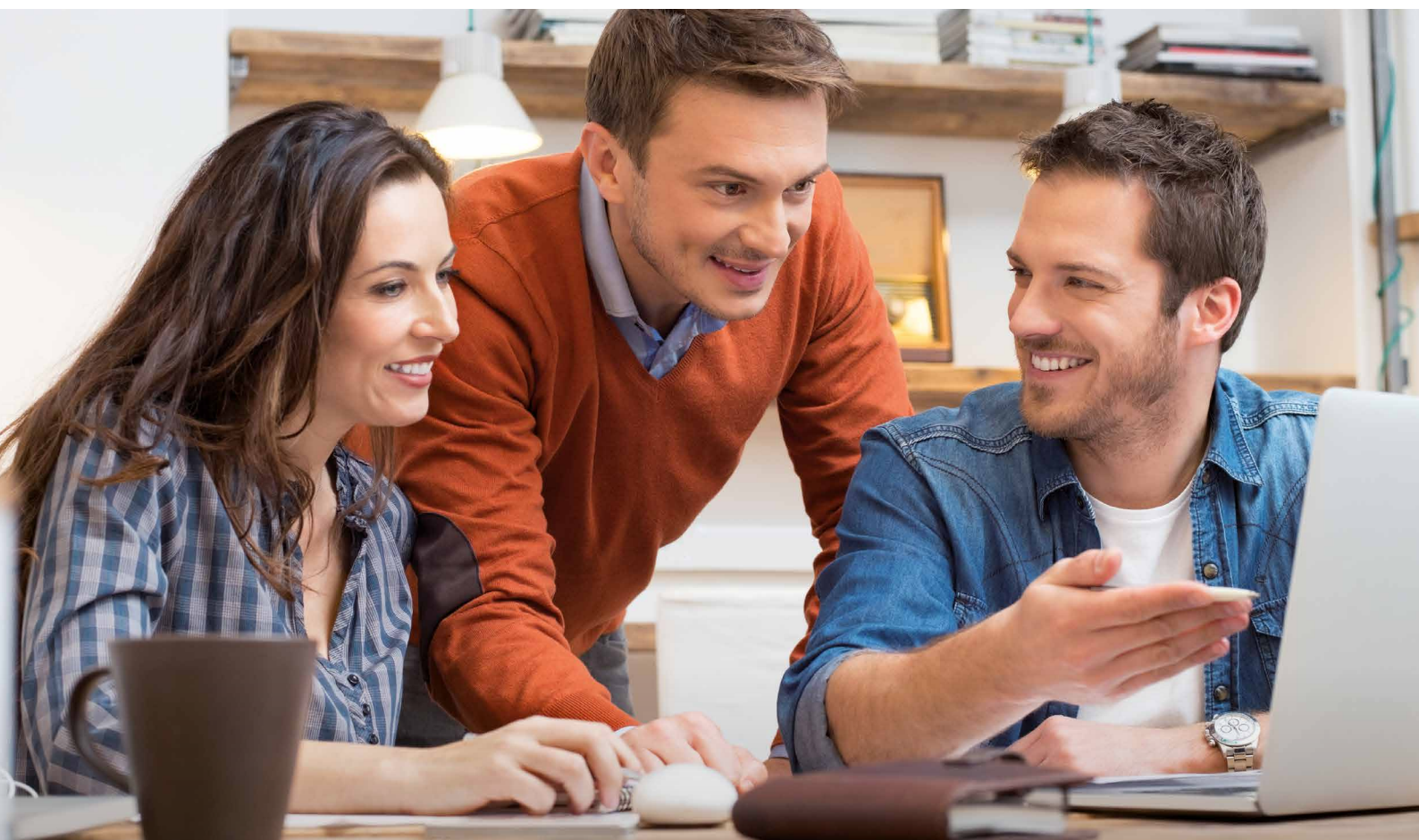
- [1] ECHA website <https://echa.europa.eu/regulations/biocidal-products-regulation/in-situ-generated-active-substances> & European Commission, 'CA-March15-Doc.5.1-Final, 59th meeting of representatives of Members States Competent Authorities for the implementation of Regulation 528/2012 concerning the making available on the market and use of biocidal products - Management of in situ generated active substances in the context of the BPR
- [2] EN 14805, *Chemicals used for treatment of water intended for human consumption — Sodium chloride for on site electrochlorination using non-membrane technology*
- [3] EN 973, *Chemicals used for treatment of water intended for human consumption — Sodium chloride for regeneration of ion exchangers*
- [4] EN 16370, *Chemicals used for treatment of water intended for human consumption — Sodium chloride for on site electrochlorination using membrane cells*
- [5] EN 16401, *Chemicals used for treatment of swimming pool water — Sodium chloride used for electrochlorinator systems*
- [6] EU Directive concerned with the quality of water intended for human consumption in force (e.g. Directive (EU) 2020/2184 on the quality of water intended for human consumption) set the legal framework to protect human health from the adverse effects of any contamination of water intended for human consumption by ensuring that it is wholesome and clean
- [7] EN 901, *Chemicals used for treatment of water intended for human consumption — Sodium hypochlorite*
- [8] EN ISO/IEC 17020, *Conformity assessment — Requirements for the operation of various types of bodies performing inspection (ISO/IEC 17020)*

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