Disinfection – Past and Present

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Member of the following committees:
CEN / DIN SCW AA water treatment
DIN SCW AA swimming pool water CEN / DIN SC Sport AA swimming pool equipment

CEN / DIN SC Sport AA privately used swimming pools

Technical committee of the German society for Bathing and Wellness in the WG water

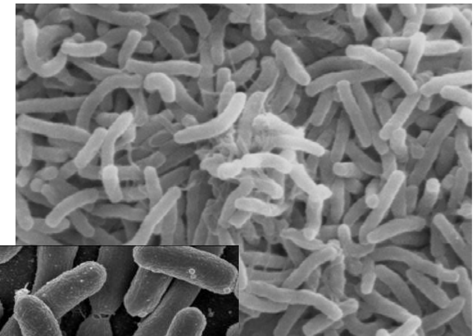
Technical Advisory Board of the Federal Association Swimming Pool and Wellness
FIGAWA WG chlorine and chlorine compounds

Spokesman of the working groups for the creation of new regulations such as floating or processing and operation of fountains

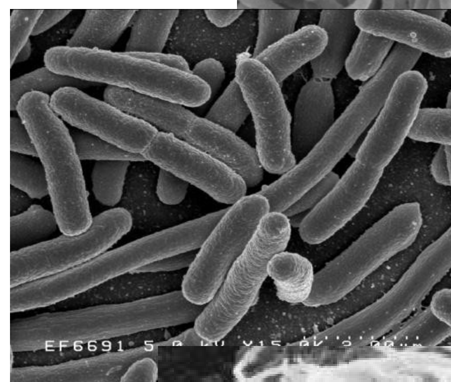
Need for Water Disinfection

The disinfection of drinking water by chlorine has substantially led to the control of epidemics and epidemics, e.g. be triggered by cholera, E. coli or typhoide bacteria.

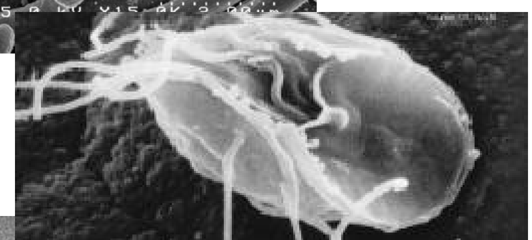
Cholera

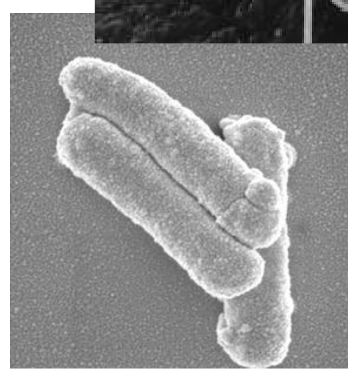


E.Coli



Giardia Lamblia





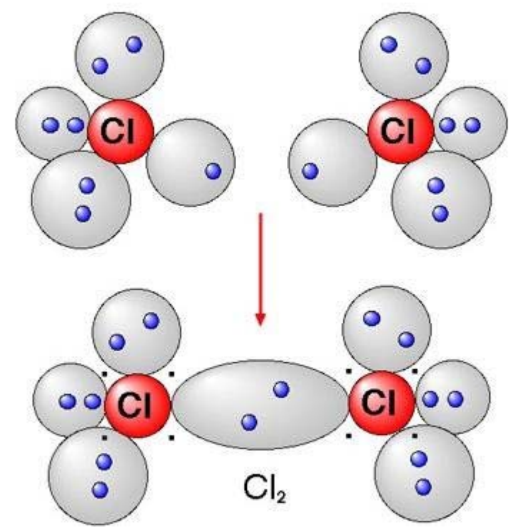
Typhoid

History of Water Disinfection

- Around 3000 BC there were pipes for water supply in the Euphrates Valley
- Around 2500 BC. Egypt already used wells and sewage systems
- Around 300 BC the Romans built pipelines for water supply in the form of aqueducts
- Around 1350 AD in Europe, the first wooden tubes were used, around 1450 cast iron water pipes
- The first central water supply in Germany was built 1848 in Hamburg and the first clarifier in Frankfurt in 1895

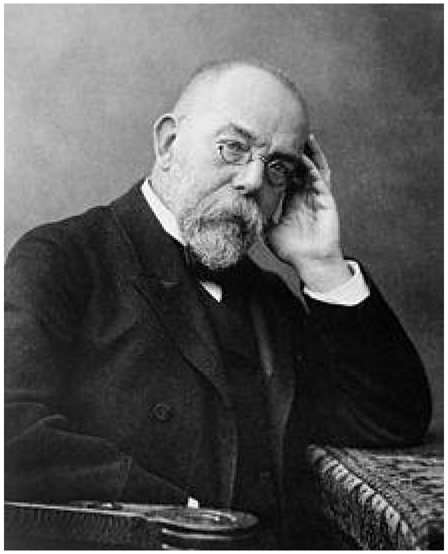
The Element Chlorine

- Discovered in 1774 by Carl Wilhelm Scheele usually gaseous state of matter
- Does not exist in nature in elemental form but predominantly as chloride anion
- Recovery of chlorine usually by electrolysis of a sodium chloride solution
- $2NaCl + 2H_2O \rightarrow 2NaOH + Cl_2 + H_2$



Founding of bacteriology

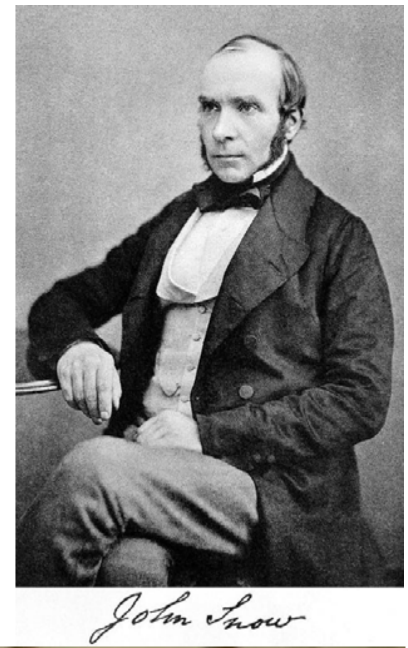
- In 1876 Robert Koch introduced the bacteriology
  There followed numerous studies on infectious diseases
- 1885 new chair for hygiene in Berlin
- 1892 cholera epidemic in Hamburg, Koch initiated the first disease control measure
- 30.06.1900 the Reichsseuchengesetz came into force
- 1905 Nobel Prize to Koch
- In 1913 there were about 3,500 disinfectors in Germany

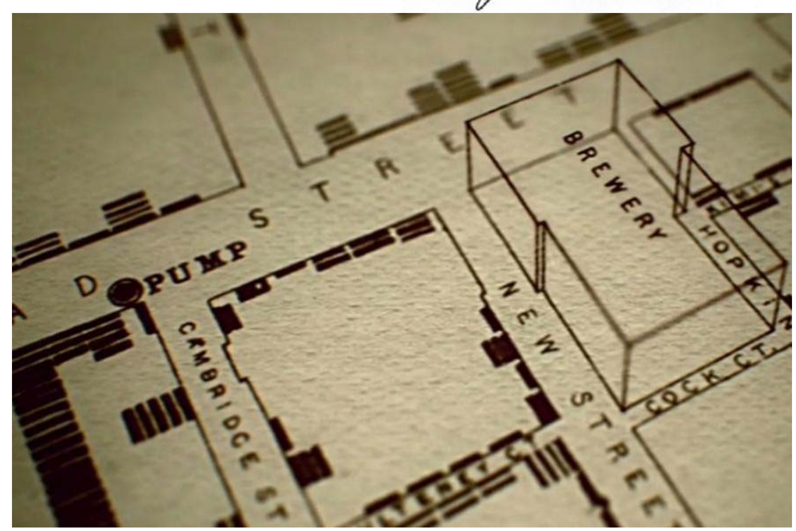


1892, disinfection workers deliver chloralkines to kill cholera pathogens

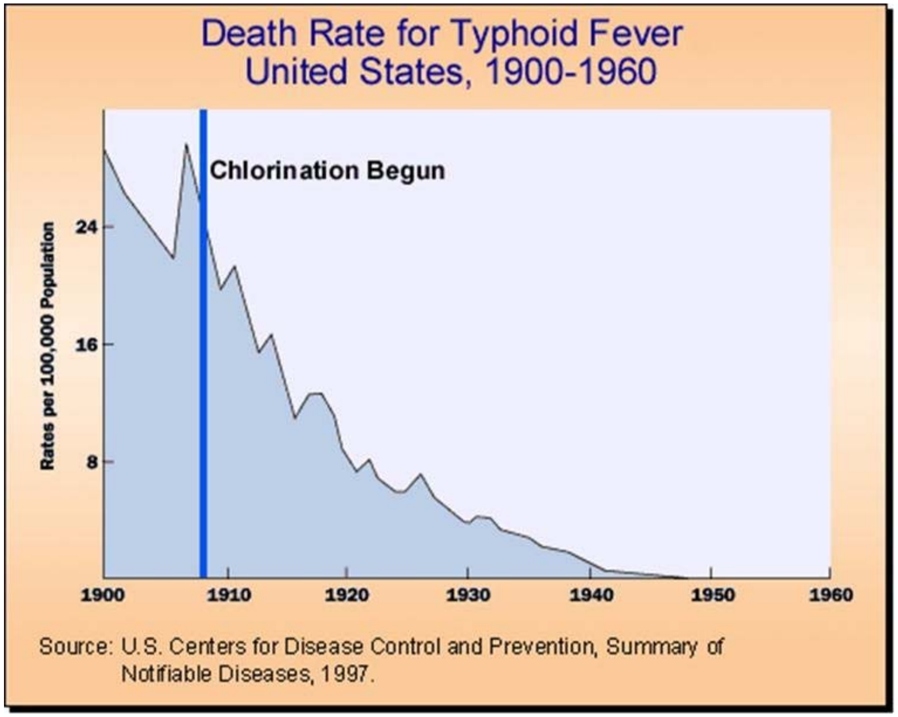
Transmission of diseases

- In 1854 in London, John Snow realized that cholera is transmitted via drinking water. He examined where the rate of the disease was highest. Near the water well, the morbidity rate was highest and lowest near the brewery.



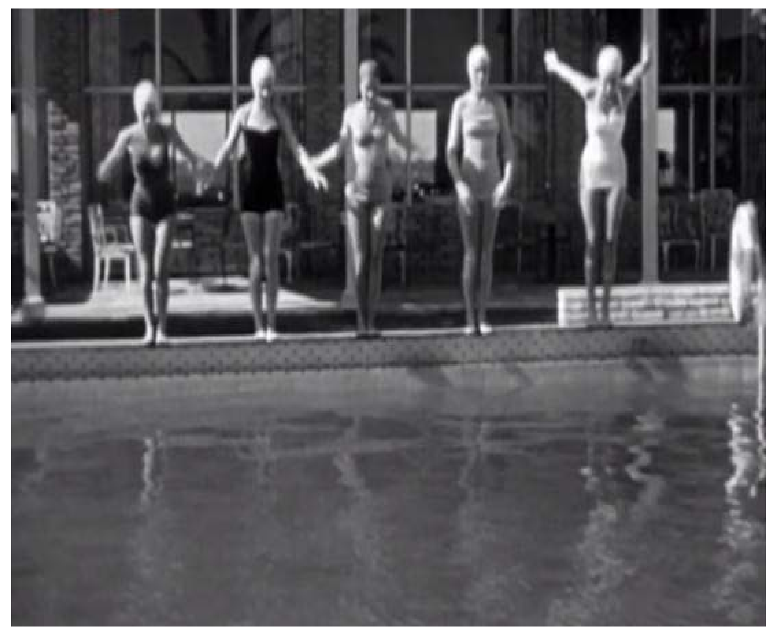


- In 1908, John L. Leal developed the first regular disinfection for public drinking water supplies with chlorine in New Jersey.
- A court initially allowed the chlorination of drinking water for 3 months.
- Dramatic decline in waterborne diseases such as typhoid, cholera and dysentery.
- Developed the combination of filtration and chlorination.
- First dosing system for calcium hypochlorite.



Disinfection with chlorine

- The treatment of water using the process combination of filtration and chlorination also enabled swimming pool water to be treated efficiently.
- After World War II, about 2000 public baths were built in the USA.



Applications of Chlorine

- As a disinfectant in swimming pools

- As a disinfectant for drinking water and industrial process water

- In the chemical industry, where it is used in end products
  e.g. PVC and bleach

Selected Differences Swimming Pool

	Free chlorine [mg/l]	Bound chlorine [mg/l]
USA (ANSI APSP-11)	1,0 – 4,0 (2,0 – 5,0 Spa)	< 0,2
France (Arrêté)	0,4 – 1,4	< 0,6
Switzerland (SIA)	0,2 – 0,4	< 0,2
Austria (BHV)	0,3 – 1,2	< 0,3
Austria (ÖVS)	0,3 – 0,5	< 0,2
Germany (DIN 19643)	0,3 – 0,6	< 0,2
Turkey (UHE)	0,3 – 0,6	< 0,3
Belgium	0,3 – 1,5	< 0,8
Spain (A.T.E.P.)	0,5 – 2,0	< 0,4
England (PWTAG)	0,5 – 2,5	< ½ of free chlorine; max. 1
Russia (СанПиН)	0,3 – 0,5	< 0,1
The Netherlands (WHVBZ)	1,0 – 1,5	< 1,0
WHO	< 3,0	< ½ of free; ideally < 0,2

Quelle: A. Reuss, DIN NASport

Comparison of treatment volume flow in Europe

Example: **Swimming pool, 20 m x 10 m x 1.5 m**
Treatment volume flow ("classical" treatment: k = 0.5) = 0.222 x 20 m x 10 m / 0.5 = **88.8 m³/h**
Treatment volume flow (ultrafiltration: k = 1.0) = 0.222 x 20 m x 10 m / 1.0 = **44.4 m³/h**
basin volume flow: 1.0 m³/m*h x (2 x 20 m + 2 x 10 m) = **60 m³/h**
It means: 200 m² x 1.5 m = 300 m³/h, 300 m³/88.8 m³/h = **3 hours 23 minutes**

Germany	89 m³/h
England	109 m³/h
Switzerland	80 m³/h
Spain	150 m³/h
Franc	75 m³/h
Flanders / Belgium	75 m³/h
Netherlands	75 m³/h

Basins with overflow gutter or skimmer?

Germany	no
Austria	no
Switzerland	no
Spain	possible
Italy	possible
Sweden	possible

Requirements for chemical dosing

For disinfection and pH correction of the pool water, the disinfection and dosing technique described below must be used:

- The disinfectant and the substances for pH correction must be added in such a way that a constant water quality is achieved.
This can be done with dosing pumps, control valves or for disinfection with flow electrodes.
- When selecting the chemicals, the quality is to be applied according to their appropriate standards.
- For every swimming and bathing pool, an automatic chlorine dosage or chlorine production and pH control system is needed.
Equipment is needed for the continuous measurement and registration of the auxiliary hygiene parameters like free chlorine, redox voltage and pH
- For cold-water immersion basins with a volume ≤ 2 m³ and stepping basins, automatically controlled chlorination systems must be operated.

Chlorination process according to DIN 19643

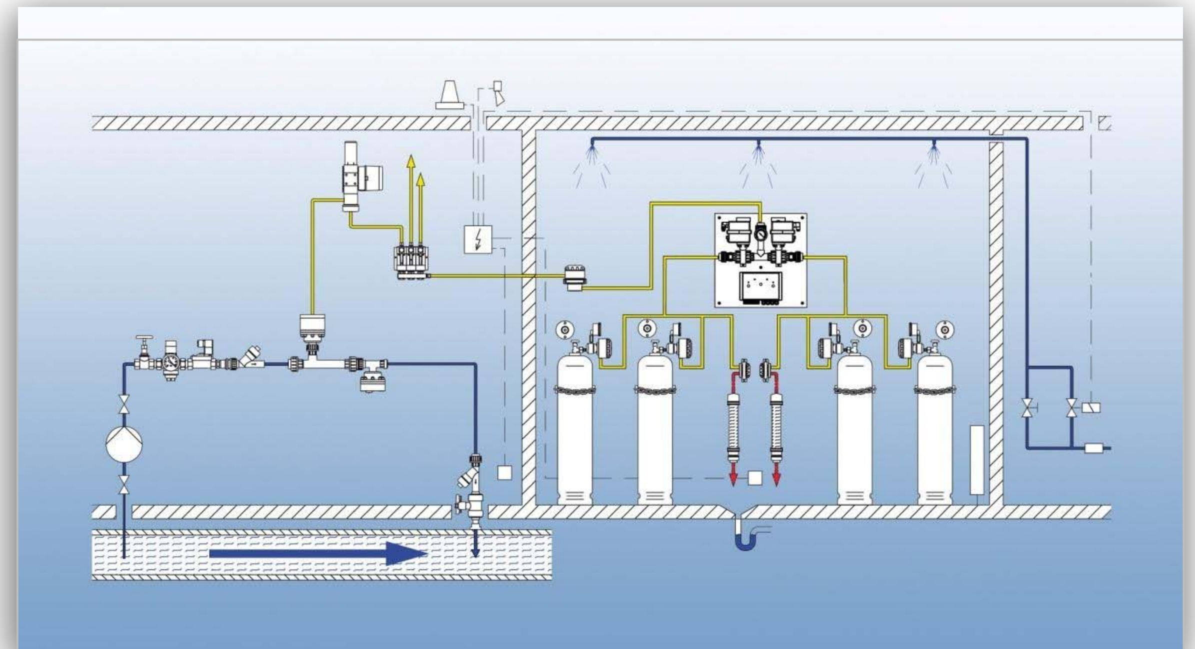
The following disinfectants may be used:

- **Chlorine gas** according to DIN EN 15363, filled in pressure vessels
- **Chlorine gas** produced at the place of use by electrolysis of sodium chloride solution (Saline, seawater, brine) or hydrochloric acid
- **Sodium hypochlorite solution** according to DIN EN 15077
- **Sodium hypochlorite solution**, 0.2-3.5 % solution, prepared at the place of use by electrolysis of sodium chloride solution (saline, sea water or natural brine) or saline water
- **Calcium hypochlorite** ($Ca(OCl)_2$) according to DIN EN 15796 as granules or in tablet form
- **Hypochlorous acid / hypochlorite solution** produced by chlorine electrolysis in in-line operation of chloride-containing filtrate.

Disinfectant / precursor	Standard for pool water	Standard for drinking water
Chlorine gas	DIN EN 15363	DIN EN 937
Salt for electrolysis	DIN EN 16401	DIN EN 16370 / DIN EN 14805
Sodium hypochlorite solution	DIN EN 15077	DIN EN 901
Calcium Hypochlorite	DIN EN 15796	DIN EN 900

Disinfection Systems with Chlorine Gas according to DIN EN 15363

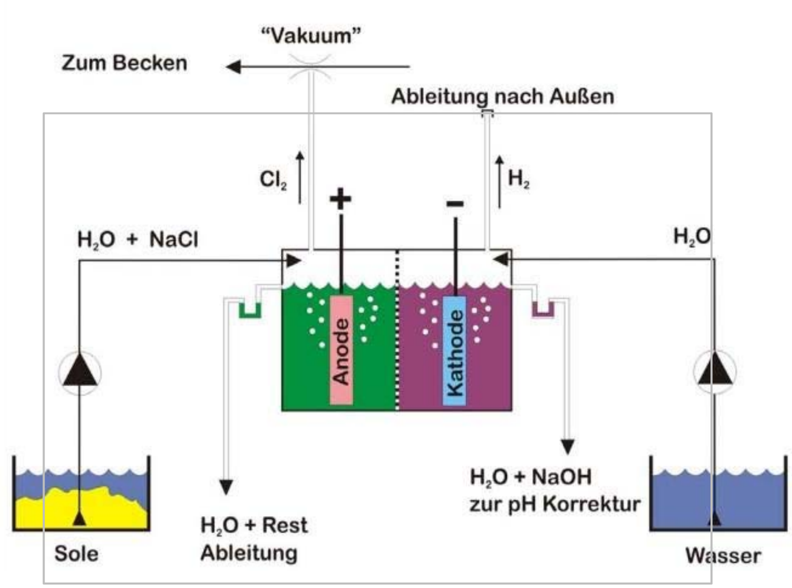
- For the equipment and the structure as well as the installation DIN 19606 and BGR / GUV-R 108 apply
- The uninterrupted chlorine gas addition must be ensured
- The addition of chlorine gas forms hydrochloric acid (HCl) in the water; it causes a reduction of the pH value as a function of the acid capacity present in the water
- To avoid undesirable pH decreases, the chlorine solution can be run over a reaction vessel filled with calcium carbonate (e.g. marble gravel or Jura limestone with high purity) with high acid capacity



Disinfection Systems
with Chlorine Gas, assembled at the place of use

- In these systems, the electrolysis chamber is divided by a membrane. The resulting lye is reused or disposed of, so that only chlorine gas is measured.
- This chlorine gas is to be introduced into the vacuum process.
- BGR / GUV-R 108 applies to the equipment and the structure as well as the installation. It must be ensured that the hydrogen produced can not released into the room.
- The addition of chlorine gas forms hydrochloric acid (HCl) in the water; it causes a lowering of the pH value according to the acid capacity present in the water.
- To avoid undesirable pH decreases, the chlorine solution can be run over a reaction vessel filled with calcium carbonate (e.g. marble gravel or Jura limestone with high purity) with high acid capacity.

Quelle: Ospa Schwimmbadtechnik

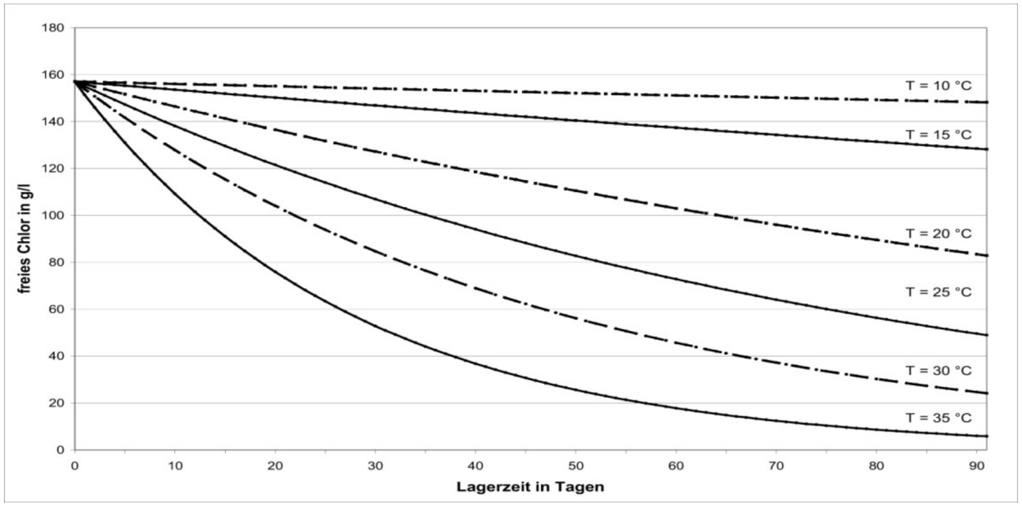


Quelle: Wapotec

Source Wapotec

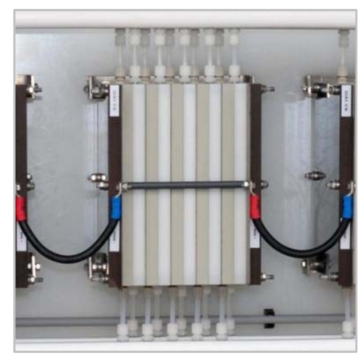
Disinfection Systems
with Sodium Hypochlorite Solution

- Disinfection plants with sodium hypochlorite solution according to DIN EN 15077
- The addition of the sodium hypochlorite solution to the filtrate is to be done by dosing pumps
- The dosage can be done from a container or from the delivery pack
- The dosing systems are to be equipped with dry run protection and empty alarm devices
- The dosage of sodium hypochlorite causes an increase of pH. As a result, flocculation and disinfection can be impaired, so that attention must be paid to the pH control.



Disinfection Systems
with Electrolysis of Sodium Chloride Solution

- Disinfection units with sodium hypochlorite solution, assembled at the place of use
- The concentrations of the solution are between 2 g / L and 35 g / L Cl_2
- BGR / GUV-R 108 applies to the equipment and the structure as well as to the installation. It must be ensured that the hydrogen produced can not release into the room
- The dosage of sodium hypochlorite causes an increase of pH. As a result, flocculation and disinfection can be impaired, so that attention must be paid to the pH control



Disinfection Plants with Calcium Hypochlorite

- Calcium hypochlorite ($Ca(OCl)_2$)is dosed as solution after dissolution of granules or tablets. For this purpose, preparation vessels with stirrers are to be provided, in which typical concentrations of 1 % to 2 % are prepared.
- When handling the slurries deriving from the dissolution process of the calcium hypochlorite appropriate base and preparation vessels are to be used
- Safety measures to protect operating personnel from calcium hypochlorite dusts are to be taken
- The dosage of calcium hypochlorite causes an increase in the pH. As a result, flocculation and disinfection can be impaired, so that attention must be paid to the pH control.

Disinfection with Chlorine Electrolysis Plants in Online Operation

- For the application of this method, a chloride concentration of more than 1200 mg/ L in pool water is required. This corresponds to a salt content as NaCl of more than 2000 mg / L.
- The particular technical requirements in terms of increased corrosivity are observed.
- The filtrate passes completely or partially an undivided electrolysis cell. Part of the chloride contained in the pool water reacts at the anode to chlorine. The generated chlorine still reacts in the cell with water depending on the pH to hypochlorous acid and hypochlorite ions.
- Caustic soda and hydrogen gas are produced at the cathode. The caustic soda causes an increase in the pH, thereby flocculation and disinfection may be impaired. This should be taken into account in the pH control.
- At the cathode it can lead to lime precipitation, which must be removed regularly by suitable cleaning, e.g. by reversal of polarity.
- The chlorine electrolysis plant in inline operation produces hydrogen. This escapes over water surfaces. An adequate supply of outside air ensures that no flammable mixture can form in the operating rooms and in the swimming pool area and the resulting hydrogen is safely discharged into the open air. With the chlorine electrolysis plant in in-line operation, the water flow of the electrolysis cell must be monitored by a flow switch, which switches off the system in the absence of flow, in order to prevent further generation of hydrogen.
- The control of the disinfectant production is carried out by controlling the cell current.
- For each pool, a separate electrolysis unit must be used.

For questions we are gladly available in personal conversations.

Thank you for your attention!

Dosieren | Flüssigkeiten
Fördern | Gase
Regeln | Systeme